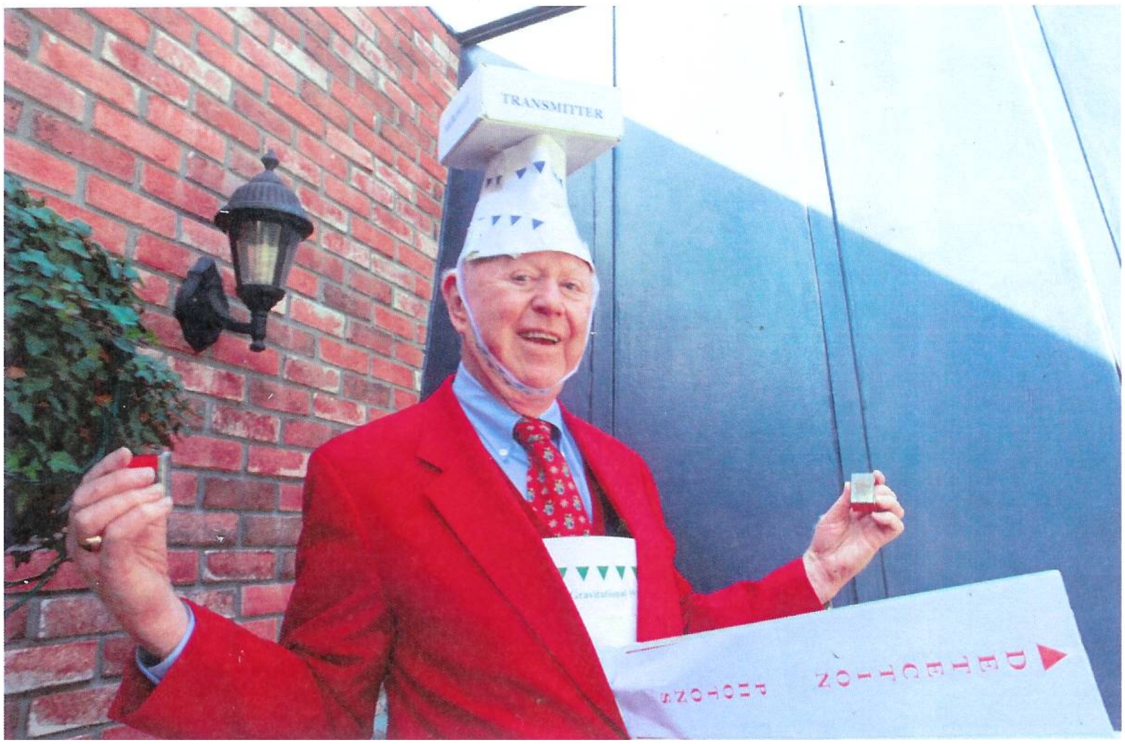
“Can I explain it?”

A compendium of talks and papers
by
Robert M L Baker, Jr.

January 27, 2012



(FOR MY GRANDCHILDREN)

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For my Grandchildren – when you are ready!

A good portion of my life has been in the area of education, first as a teacher at UCLA and then in the administration of *West Coast University*. Therefore, I believe strongly in passing along knowledge or even communicating plain old "Food for Thought." For the past ten or so years I have belonged to a group that meets at *The California Club* most Thursday mornings called the *Economic Round Table.* Basically its members are responsible to give one talk per year on a subject of interest to the group. I have addressed the group on several occasions and I believe that it may be useful to you three grandchildren to be aware of my remarks. I start out with my most recent talk: "Can I Explain it?" (Hence the title of this compendium) and then present my other talks in no particular order. I also include my most recent and most philosophical talk I gave on January 26th, 2012, entitled "Who goes there ?"

Only if you study science or engineering would you be interested in the three papers referenced after the index that are **not** contributions to the *Economic Round Table*, but rather examples of my scientific writing. The first is a peer-reviewed paper on "Applications of High-Frequency Gravitational Waves to the Global War on Terror" and the second is a paper I prepared under contract to Bigelow Aerospace Corporation entitled "High-Frequency Gravitational Wave Communications Study (GravCom®)." I include this second paper because even if you wind up with no scientific background you might be interested in the last few pages that deal with my projections of some communication technology in section 4 on FUTURE POTENTIAL and in subsection 4.1, concerning a Developmental Roadmap to 2050. In this same regard, just in case you have interest, The third paper has a content similar to the second paper but is in the form of a 2011 Keynote address I gave to a combination of three international organizations that held a Joint Conference in Orlando Florida. I have also included a list of my publications and communications many of which are available in the archived scientific journals cited.

Have fun! Grandfather

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Applications of High-Frequency Gravitational Waves to the Global War on Terror
After peer review accepted for Publication in the *Proceedings of the Space, Propulsion and Energy Sciences International Forum (SPESIF 2010)***,** February 23-26, 2010, John Hopkins University Applied Physics Laboratory, Laurel, MD, U.S.A., Edited by Glen Robertson. (Paper 001), American Institute of Physics Conference Proceedings, Melville**.** NY, USA Volume **1208**.
Please go to:
http://www.drrobertbaker.com/docs/War%20on%20Terror%20Applications.pdf

High-Frequency Gravitational Wave Communications Study
Transportation Sciences Corporation, December 7, 2009 Revision
Special Report prepared for: Bigelow Aerospace Corporation
Please go to:
http://www.gravwave.com/docs/com%20study%20composite%20.pdf

The Utilization of High-Frequency Gravitational Waves for Global Communications, Technical Keynote Address at the *Information and Communication Technologies and Applications ICTA 2011, held jointly with The 17th International Conference on Information Systems Analysis and Synthesis: ISAS 2011, November 29th - December 2nd, 2011 –* Orlando, Florida, USA. **PowerPoint presentation, peer reviews and manuscript available at:**
http://www.drrobertbaker.com/keynote2011.html.

Publications and Communications of Robert M L Baker, Jr.
Please go to:
http://www.drrobertbaker.com/docs/Dr.%20Baker's%20Bibliography.pdf

Economic Round Table, The California Club
Robert M L Baker, Jr., January 28, 2010

CAN I EXPLAIN IT?

Albert Einstein once said “It should be possible to explain the laws of Physics to a barmaid.” Well, as much fun as that might be, I think I better start with you folks.

There are many ways to explain or understand something. Let us consider gravity itself. Most of us don’t need an explanation, we are ***comfortable*** with the idea that we all “stick to the floor.” Like Einstein himself we wonder a little about when we ride in an elevator and stick to its floor a little more when we are going up than when we are going down, but we don’t worry about it much. The fact that 2 + 2 = 4 and not 3 or 5 also doesn’t concern us much since we are used to this trivial outcome of number theory. We “know” that ten years is a decade and that a century is 100 years and that a thousand thousand is a million. We do not worry that 60 seconds makes a minute and 60 minutes makes an hour or that there are 360 degrees is a full circle, We are, again, comfortable with these concepts and need no explanation. We also don’t need to have an explanation why a triangle has three sides – well it is simply by definition isn’t it? So why then would we need an explanation of a detector of high-frequency gravitational waves in the fabric of four-dimensional spacetime? Raise your hand if you would understand such a device and be able to explain it to another. You are not alone since there is probably no one, even Einstein in his day, who really understands such a device or even the high-frequency gravitational waves in the fabric of spacetime that it measures! I might ask the same question at the end of this tutorial. Again you probably won’t raise your hand – but, hopefully, you will hesitate a little and, equipped with the figures I will now distribute, be able to explain a little about the measuring device to a friend. Right now, of course, we are mystified by such a device and not ***comfortable*** with it and we could not now explain it to friend.

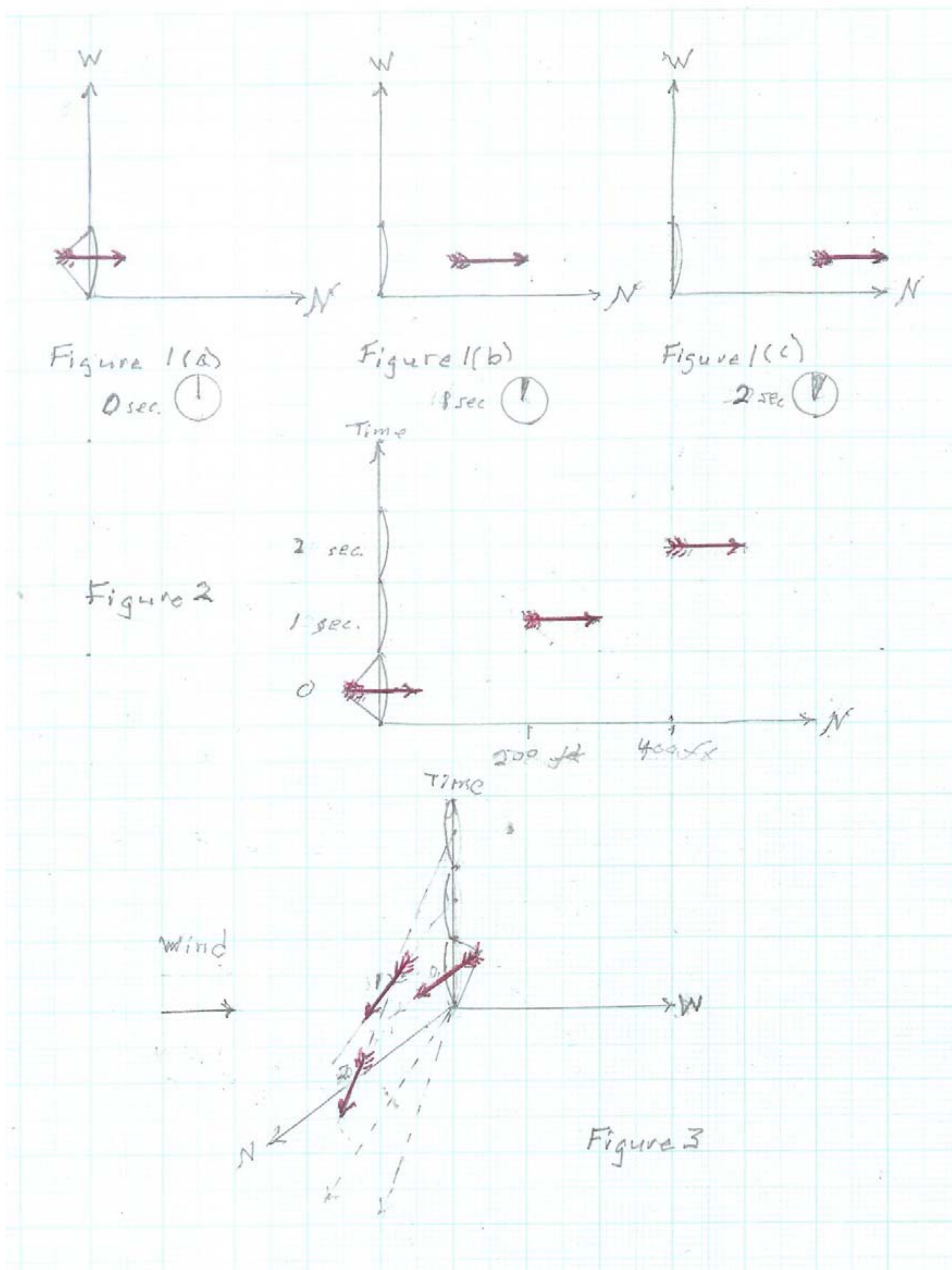
At the outset I must warn you that I will be dealing with the confluence of two extremely vexing and mystifying concepts: waves and spacetime. Like teaching new concepts in the classroom, the best way is to take it step by step. The smaller the steps the better!

OK; let’s first all consider what a wave is. Probably you think that the concept of a wave is neither vexing nor mysterious. We are comfortable with the concept of an ocean wave, a ripple or a wave in a flag or sail and probably with a sound wave and possibly even comfortable with a radio wave and a microwave. Wait a minute here – we are talking about two distinct kinds of waves. Water waves and waves in flags or sails are moving in some perceptible medium – liquid and fabric – sound waves, light waves and microwaves are moving in something we can’t see. We are comfortable with a sound wave because we sense it with our ears and someone has told us (or even displayed it on an oscilloscope) that it is a “sound wave.” Likewise for a light wave that we sense with our eyes or with a microwave that we sense when we touch a resulting cup of hot coffee. But their medium, that is something else. OK sound goes through the medium of invisible air – on the other hand light, microwaves and radio waves go through the empty void of outer space – no medium at all! One of the hardest things to accept in modern physics is that waves can propagate **without** a medium. On the other hand how can we visualize a wave without a medium? The answer is that we cannot. A medium is simply an idea or mental aid to help us be comfortable with the concept of a wave.

But, aside from the absence of a medium, what exactly is a wave? Simply speaking a wave is a moving “bump” that exhibits a height (called “amplitude”), a length (called “wavelength”) and, if there are a series of such bumps, then how often they occur (called “frequency”). For a typical ocean wave its amplitude is measured in feet (about three feet or more for an ocean wave near shore) and the crests of such waves can be as little ten to over one hundred feet apart (their wavelength) and their frequency might be 10 seconds between their crashing on shore. Frequency is usually measured in terms of how many occurrences per second. So in this case it would be about one-tenth of an occurrence per second or a tenth of a “cycle” per second. The meaning of the term “cycle” is the rate of occurrences per second or, in this case, one-tenth of an occurrence per second or one-tenth of a cycle. As we will see later, “low-frequency” gravitational waves can be generated by orbiting masses and if the time it takes for them to get around each other is measured in seconds, for example ten seconds, then the frequency of the gravitational waves they generate could be on the order of one-tenth of a cycle per second.

The term “high-frequency wave” is established “by definition” just like we define a triangle as a figure having three connected straight lines -- it has three sides. The definition of high frequency for gravitational waves was given in a book coauthored by the famous Theoretical Physicist Stephen Hawking. In this case the term pertains to waves having frequencies greater than 100,000 cycles per second. A thousand cycles per second is defined as a “kilocycle” so one would say that the frequency of high-frequency gravitational waves is greater than one-hundred kilocycles. Actually the frequency of gravitational waves created during the beginning of our Universe (the “Big Bang”) could have frequencies measured in “gigacycles’ where a gigacycle is defined as a billion cycles per second. As an aside, the frequency of the microwaves in a conventional microwave oven is about two and one half gigacycles. In this case microwave crests impinge on your coffee cup in such an oven two and one-half billion times a second and the molecules in the coffee in the cup are so shaken up that the coffee heats up.

But let’s get back to “spacetime.” Here we have our second vexing and mysterious concept. It is very important to realize that for most if not all of us we are entering uncharted territory. We are three-dimensional creatures. Like waves without a medium we cannot visualize things in more than our three dimensions. But let’s try anyway. The easiest way to explain spacetime is by considering simple examples. In our case let’s consider archery, a bow and arrow. In the plan view of Figure 1a we see the bow drawn back and aimed in the North direction (the West direction is off to the left of the archer). After one second the situation is as shown in Figure 1b and after two seconds as is shown in Figure 1c. OK so far so good.



Let us now get to the "dimension" of time. Considering time as a dimension may be new to many of us – so let's go a little slow. We next stack the a, b and c of Figure 1 on top of each other as in Figure 2. The West direction of Figure 1 has been replaced by the Time "direction" in Figure 2 (0 to 2 seconds). This "direction" is the Time "dimension." There are some analogies here. We are probably all familiar with the heart-beat oscilloscope display of a patient's heart beat in a hospital setting … then suddenly the graph goes flat ("flat liner") and the patient dies – in this rather morbid analogy the time dimension is along where the wiggly heart line goes (usually to the right) while the patient is still alive.

So far we have worked in two dimensions only: North-West in Figure 1 and North-Time in Figure 2. Now let's go to three dimensions. We assume that a wind is blowing out of the East sending the flight-path of the arrow off to the West. The situation is shown in Figure 3 in which the Time direction is drawn perpendicular to the North and West directions. I hope that everybody understands these three dimensions. We understand them because we can draw them even on a two-dimensional piece of paper, BUT four dimensions is going to be very difficult to visualize in fact almost impossible!

One way to visualize four dimensions is to think of taking the flat portrayal of three dimensions of Figure 3 and simply replicating it on a paper as in Figure 4. In this case we have added the third space dimension up-**Down.** Essentially, like all real arrows, if it doesn't hit something like a target, then the arrow falls "down" to the ground (shown in green at the bottom of the figure) dropping from four feet to two feet to zero (hitting the ground). There you have it, but still difficult to visualize I'll bet. It's like a strange creature called a "flat worm." Its whole "Universe" has only two dimensions of space. When confronted with a three-dimensional barrier it is confused and stops.

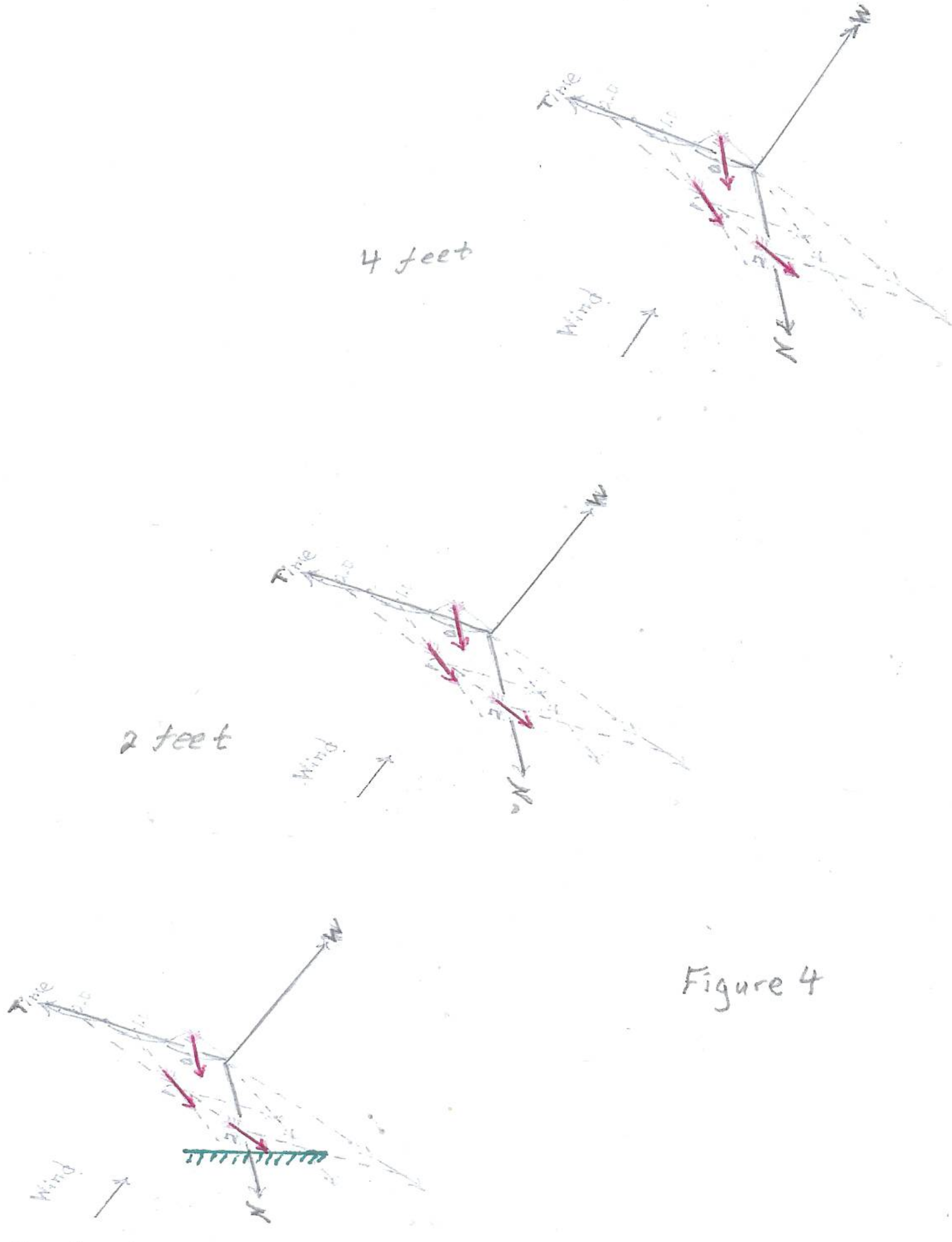
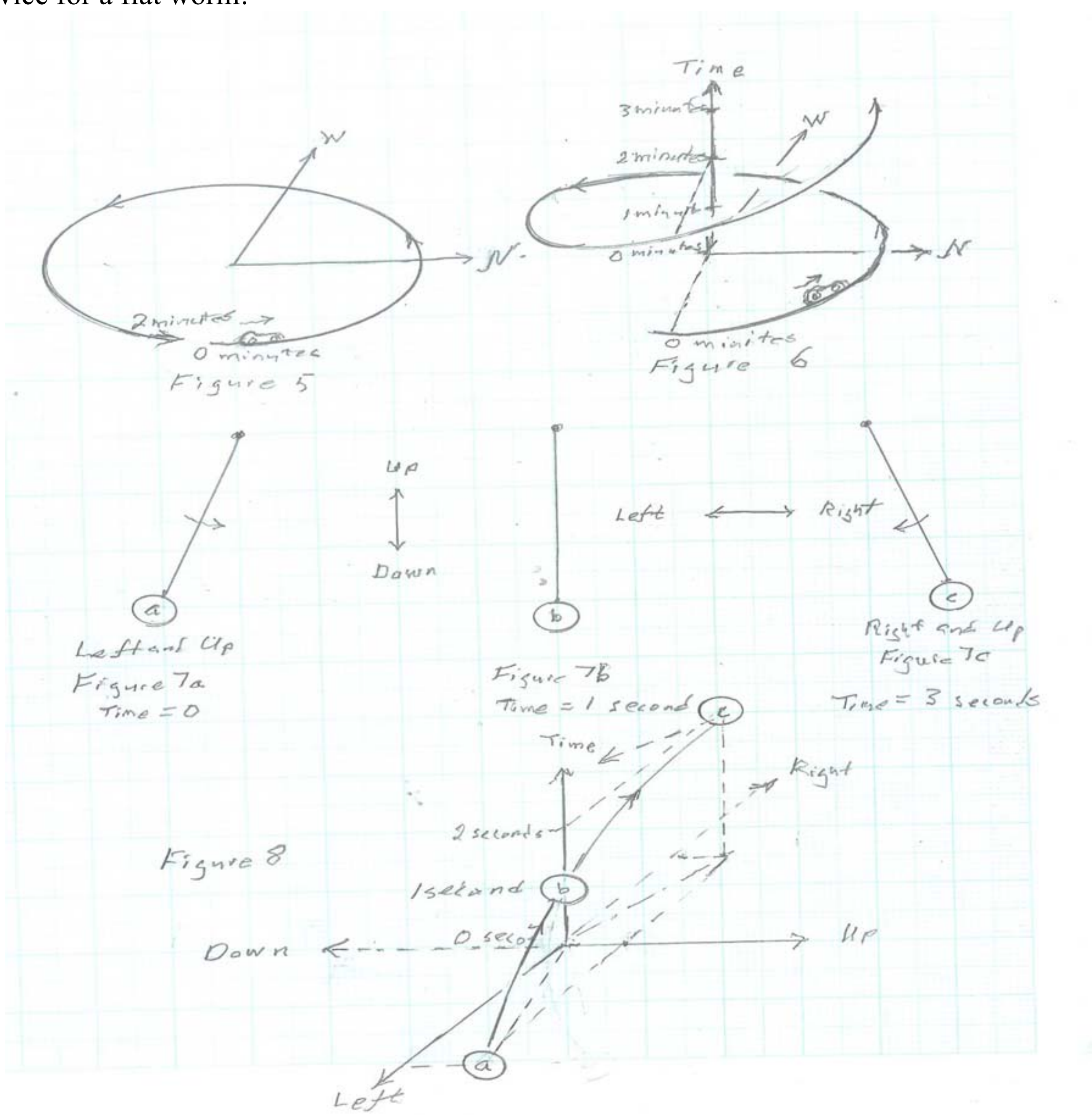


Figure 4

Down ↓

It may help clarify the matter to look at a second example. This time let's consider a sports car going around a circular track as exhibited in Figure 5 in which we show the North and West directions or dimensions. It takes the sports car about two minutes to get around the track Again we will take the vertical axis to be Time. In Figure 6 we see that in North, West and

Time dimensions, the sports car follows a spiral or helical path in spacetime. But where is the forth dimension: Up-Down? In this case the forth dimension is in the sports car itself! Whenever the driver adjusts his seat up or down he utilizes motion in the forth dimension. Can you visualize it? Possibly not, so let's consider yet another example. We take the motion of a pendulum as in Figure 7 in dimensions left-right and up-down. Figure 7a is the pendulum at time zero, Figure 7b at 1 second and Figure 7c shows the pendulum at 2 seconds. Figure 8 shows the movement of the pendulum bob during this time interval in the three dimensions of Left-right, Up-down and Time. Note that at a the bob is Left and Up, but at time level 0. At b the bob is neither left nor right nor Up or Down – it is at zero space coordinates but at a time level of 1 second and at c it is Right and Up and at time level 2 seconds. Again the question is: where is the forth dimension? Well this is a trick question because a pendulum's motion can be completely defined in only the three dimensions shown in Figure 8. That is its path is totally defined in two space dimensions , left-right and up-down, and time. A pendulum is a perfect device for a flat worm!



Unlike the flat worm, however, we humans have the capacity to imagine things and that is the key to understanding both waves and spacetime. Visualize the luffing of a sail as a sailboat comes about or tacks – the cloth is two dimensional with waves or ripples in a third dimension with motion perpendicular to the face of the sailcloth. The waves in the sail's fabric are similar in many ways to gravitational waves, but instead of sailcloth fabric, gravitational waves move through a fictional, yet mind-pleasing, "fabric" of space. Einstein called this fabric the "space-time continuum" in his 1916 work known as General Relativity. Although his theory is very sophisticated, the concept is relatively simple. As we have discussed this fabric is four-dimensional: it has the three usual dimensions of space—for example, east-west, north-south, and up-down—plus the fourth dimension of time – like in Figures 4 and 6. However it is important to recognize that space and time are not tangible "things" in the same way that water, woven sailcloth and air are. It is really incorrect to think of them as a 'medium' at all. No physicist or astronomer versed in these issues considers spacetime to be a truly physical medium; however that is the way in which our minds prefer to conceptualize this idea of spacetime. This "fabric" is exactly what is sketched in Figures 4 and 6. It is difficult to think of these sketches as representing a fabric, but this mind-satisfying fiction describes exactly what they do – move in a four-dimensional "fabric." As I have said before, we can't "see" this "fabric," just as we can't see wind, sound, or gravity for that matter. Nevertheless, those elements are real, and so is this "fabric." If we could generate ripples in this space-time fabric, then many valuable applications would become available to us. For example, much like radio waves can be used to transmit information through space, we could use gravitational waves to transmit information right through the Earth itself!

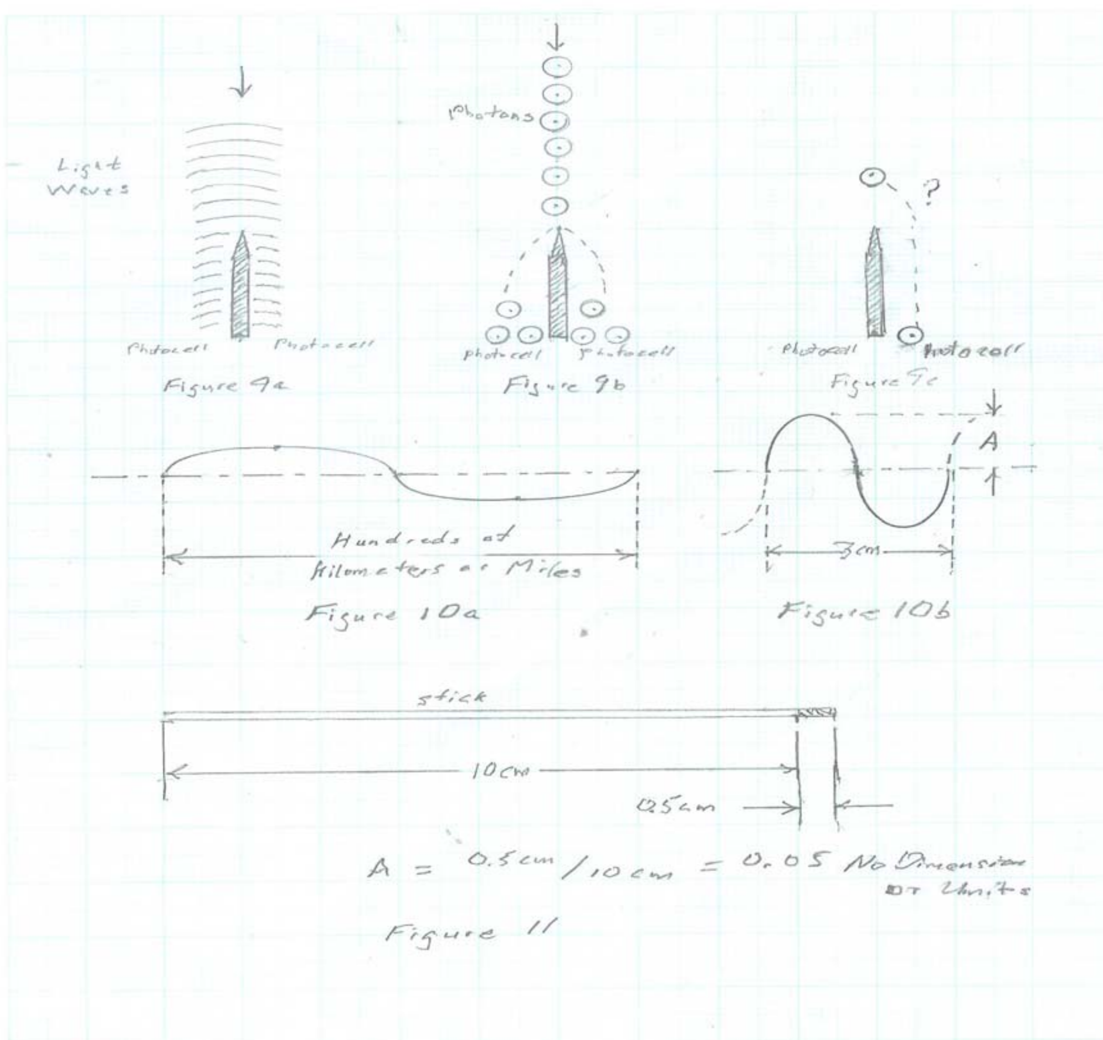
So let's summarize what we have learned, but under the proviso that we really use our imaginations. When asked what was more important than knowledge, Einstein replied that imagination was since knowledge has limitations, but imagination is unlimited. To drive this point home, I will digress with two imaginative ideas conceived by famous scientists to help visualize a concept: "Maxwell's Demon" and "Schrödinger's Cat."

Maxwell's demon is a thought experiment, first formulated in 1867 by the Scottish physicist James Clerk Maxwell, intended by Maxwell primarily to "show that the 2nd Law of Thermodynamics has only a statistical certainty," and commonly used for imagining the possibility of violating the second law. The concept was named by Lord Kelvin. The second law of thermodynamics states that the disorder of an isolated system, termed "entropy," which is not in equilibrium, will tend to increase over time, approaching a maximum value at equilibrium. This law ensures that two bodies of different temperature, when brought into contact with each other and isolated from the rest of the Universe, will evolve to a thermodynamic equilibrium in which both bodies have the same temperature. This seems like common sense, but in Physics sometimes common sense is wrong. Any way, suppose that you have a box filled with a gas at some temperature. This means that the average speed of the molecules is a certain amount depending on the temperature. Hot molecules go fast and cold molecules go slow. Some of the molecules will be going faster than average and some will be going slower than average. Suppose that a partition is placed across the middle of the box separating the two sides into left and right. Both sides of the box are now filled with the gas at the same average temperature. Maxwell imagined a molecule sized trap door in the partition with his minuscule creature, the demon, poised at the door who is observing the molecules. When a faster than average molecule approaches the door he makes certain that it ends up on the left side (by opening the tiny door if it's coming from the right) and when a slower than average molecule approaches the door he makes sure that it ends up on the right side. So after these operations he ends up with a box in which all the faster than average gas molecules are in the left side and all the slower than average ones are in the right side. So the box is hot on the left and cold on the right. Then one can use this separation of temperature to run a heat engine by allowing the heat to flow from the hot side to the cold side. Well it sounds like perpetual motion. And how does the demon operate? For instance where does the energy for it to open and close the trap door come from and how does he sense the speed of the molecules and how is he instructed what to do? And you thought visualizing four dimensions was difficult and a real stretch!

Schrödinger's Cat is also a thought experiment, often described as a paradox, devised by Austrian physicist Erwin Schrödinger in 1935. It illustrates what he saw as the problem of an interpretation of quantum mechanics applied to everyday objects. (As technical background, one could read: *Nature* Volume **454**, pages 8-9, 2008, published online 2 July 2008, **"**Reincarnation can save Schrödinger's cat**.")** This is a hypothetical experiment in which we put a cat inside a box with some equipment which releases poisonous gas on detection of electrons that may enter the box at random and have a 50:50 chance of entering the box in one hour. In this case, after an hour, one would say that he doesn't know whether the cat is dead or alive, and this can be known only by looking inside the box. But according to quantum theory, it is better to say the cat is half dead or half alive, until we check on it. Confused! Look at it this way, we have no idea at all whether or not an electron has entered the box, set off the poison and killed the cat. But if each of us would bet, since the odds are even half of us would bet that the cat is alive and half that it is dead. Not so with quantum mechanics – here we must assume that the cat is half alive and half dead and that with a large number of boxes (and cats) half would be alive and half dead. With standard microscopic quantum mechanics it is required that macroscopic objects, such as cats, do not always have unique classical descriptions. The purpose of the thought experiment is to illustrate this apparent paradox. Our intuition says that nothing can be in a mixture of states; yet the cat, it seems from the thought experiment, can be such a mixture. Is the cat required to be an observer, or does its existence in a single well-defined classical state (dead or alive) and require another external observer? Each alternative seemed absurd to Albert Einstein, who was impressed by the ability of the thought experiment to highlight these issues. In a letter to Schrödinger dated 1950, he wrote and I paraphrase:

"You are the only contemporary physicist, besides who sees that one cannot get around the assumption of reality, if only one is honest. Most of them simply do not see what sort of risky game they are playing with reality—reality as something independent of what is experimentally established. Their interpretation is, however, refuted most elegantly by your system of radioactive atom + electron + amplifier + poison gas + cat in a box, in which the system contains **both** the cat alive and dead. Nobody really doubts that the presence or absence of the cat is something independent of the act of observation."

Confused? Yes, and I look at the concept or paradox a little differently. A beam of light is focused directly at a knife edge as in Figure 9a. If we place photocells on each side of the knife edge, then each will detect exactly half of the light waves impinging on the knife edge. But in the quantum theory of light we do not have waves, but a series of photons hitting the knife edge as shown in Figure 9b. Again the photocells will detect exactly half of the photons impinging on the knife edge. But lets suppose that there is only **one** photon impinging on the knife edge as in Figure 9c. It cannot be split and must either go to the right side or the left side of it. But while heading toward the knife edge was there something intrinsic in the photon that made it a “right going” or “left-going” photon? No there is nothing “in” the photon that tells it that it is even going toward a knife edge! So “how do it know?” That is the question and the paradox of quantum mechanics! That is what Schrödinger’s Cat is all about; before opening the box how do you know the cat is either dead or alive? You don’t.



This reminds me of a well-known story – perhaps you have heard it before. Several people are seated around a campfire speculating on the greatest invention of all mankind. One says “It’s the steam engine – started the industrial revolution” another says “The radio – lead to all modern communication” another said “the Airplane – lead to all modern travel’ another exclaimed “Nuclear Energy!” Then one person spoke up and said ”Of course, it must be the

Thermos Bottle." "Why the Thermos Bottle?" "Well," he replied, "… in the winter when it's cold and you put hot soup in it, it says warm and in the summer when it's hot and you put cold lemonade in it stays cold. " "So?" another replied. "Well, how do it know?" And how does the observer of the box containing Schrödinger's Cat or of the photon know?

Back to my explanations. So now we need to combine the mysterious concept of "waves without a medium," which I discussed at the outset, with the even more mysterious concept of the fabric of four-dimensional "spacetime." Here we must use another analogy or imagery to visualize a gravitational wave. One of the consequences of the passage of a gravitational wave through the fabric of spacetime is that it actually changes the dimensions of an object; but very, very, very slightly (another consequence is that a high-frequency gravitational wave also can interact with microwaves, but we will discuss that later). It is like a shimmer that we might see in looking at a desert panorama during a hot day – a "heat wave" or perceived periodic changing of an object's shape or size or a "mirage." This effect is the basis for the Laser Interferometer Gravitational Observatory or LIGO. The LIGO instruments consist of kilometer-long evacuated tunnels whose lengths are continuously measured by sensitive interferometers. These interferometers are instruments sensitive to a change in the tunnel's lengths even to a small fraction of the diameter of a proton … and that is really small! Low-frequency gravitational waves (as mentioned previously, exhibiting a fraction of a cycle per second up to a few hundred cycles per second frequency) can be detected by LIGO and exhibit wavelengths that can be hundreds of kilometers or miles long. The source of such low-frequency gravitational waves could be the coalescence of a pair of **black holes** on orbit about one another. There are other detection instruments similar to LIGO in Europe called Virgo and GEO600. But we are interested here in high-frequency gravitational waves having frequencies greater than one hundred kilocycles. We will discuss the sources of such high-frequency waves in a minute, but let's review the description of waves.

First, consider wavelength. In Figure 10a we see a long wavelength of, say hundreds of kilometers or miles. In Figure 10b we see a short wavelength. This drawing is actually to scale and exhibits the gravitational-wave wavelength of high-frequency gravitational waves from the Big Bang or beginning of our Universe. The wavelength here is three centimeters or 1.2 inches and the frequency is about 10 gigahertz or ten billion cycles per second. I also had earlier mentioned the amplitude of a wave. I show it as *A* in Figure 10b. But what is its dimension or units – cm, inches, kilometers or miles? No it has **no** units, it is a ratio of the length of an object, say a ten-centimeter long stick as in Figure 11, to the change in the stick's length due to the passage of a gravitational wave, say half a centimeter. Thus the amplitude equals 0.5/10 = 0.05 or five hundredths.

In 1992 a brilliant Chinese scientist, Dr. Fangyu Li, developed a new theory concerning high-frequency gravitational waves at Chongqing University, called the "Li-Effect." He had accomplished graduate work in Russia at the Gravitational-Wave Department of Moscow State University under the tutelage of Professor Valentin Rudenko. Rudenko was one of the leaders of the high-frequency gravitational wave research effort in the Soviet Union during the Cold War. Professor Li's theory was quite different from, but built upon the 1962 theory of another Russian scientist and high-frequency gravitational wave pioneer, M. E. Gertsenshtein. Gertsenshtein had discovered that gravitational waves of high frequency could produce electromagnetic waves, such as light, in the presence of a magnetic field. The effect was very weak but theoretically present. Dr. Li found that if one had a beam of electromagnetic radiation, such as microwaves having the same frequency and direction as the high-frequency gravitational waves, and if a magnetic field was applied, then other microwaves would be generated that not only were much stronger than those generated by the Gertsenshtein effect, but went off in a different direction than the direction of the microwave beam and the magnetic field. During the 1990's I studied Dr. Li's theory and applied it to the detection of high-frequency gravitational waves. In 2001 I applied for a Chinese Patent of the instrument and it was granted in 2007. It is now called the "Li-Baker High-Frequency Gravitational-Wave Detector." It is not, however, the first such detector of high-frequency gravitational waves. At Birmingham University, England and at a major Italian laboratory in Genoa such detectors were actually constructed and recently, in 2008, a detector for such high-frequency gravitational waves was built at the National Gravitational Observatory of Japan. None of these detectors, however, are nearly sensitive enough to detect the waves from the Big Bang or for practical global communication use, whereas the Li-Baker Detector is! By the way, Dr. Li's theory has been validated by some eight technical journal articles, peer reviewed by scientists presumably well versed in General Relativity, published since his original article in 1992.

A schematic of the Li-Baker detector is shown in Figure 12. The "Hour-Glass" shaped image in the center labeled "**S**ynchro--resonant EM GB" is the microwave beam exhibiting the same direction and frequency as the high-frequency gravitational wave (HFGW) signal from the Big Bang or from a HFGW communications transmitter. The green disks represent the poles of the magnetic field. The blue plates in the center are actually represent microwave-reflecting "mirrors" that focus the "detection photons" produced according to the Li-effect at two microwave receivers (#1 and #2). Too fast again? Let's slow down. Suppose you are standing up and high-frequency gravitational waves from the sky are directed right down your body from head to toe. Put a microwave transmitter on your head pointed down in the same direction as the high-frequency gravitational waves and also having their frequency. Now extend your arms. Place the South Pole of a magnet in your left hand and the North Pole in your right hand. The magnetic field will go right through your body and cross both the high-frequency gravitational wave beam and the microwave beam in your chest. Due to the Li-Effect detection photons, that is microwaves due to the high-frequency gravitational waves, will come out of your chest and back and be focused at sensitive microwave receivers in front and behind you. OK – you **are** the Li-Baker high-frequency gravitational wave detector now – Congratulations you are now a new eye to the Universe!! **(Please see me doing this on the cover color photo.)**

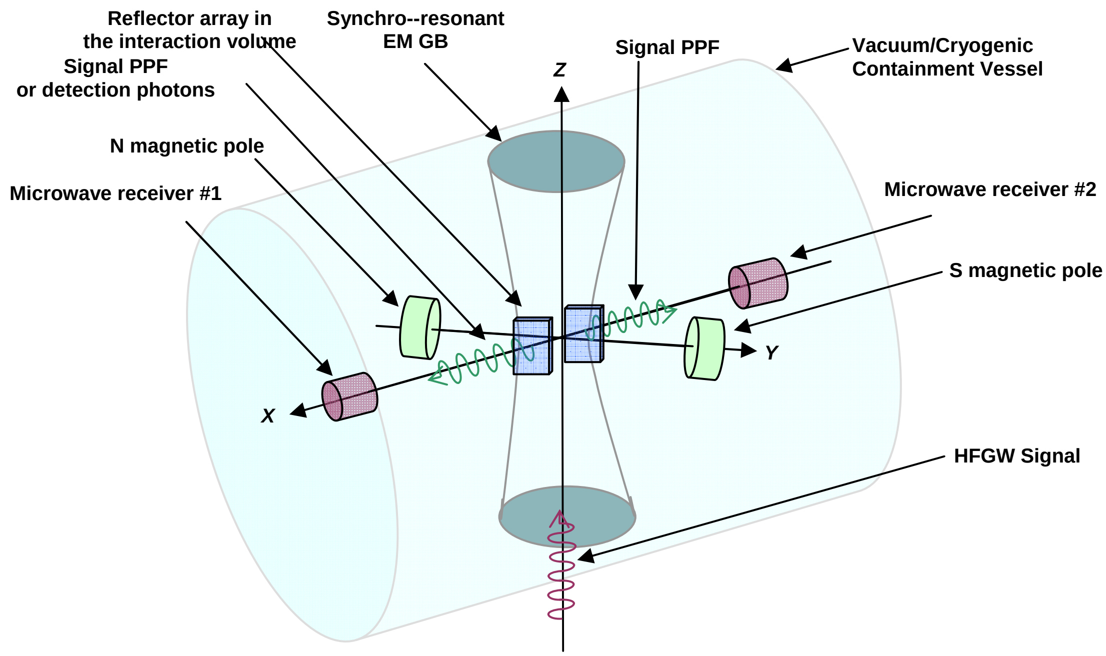


Figure 12

Li-Baker High-Frequency Gravitational Wave Detector

All this is well and good, but how do we know that gravitational waves of any frequency actually exist? As Bob Tranquada remarked in his recent talk here, a "Scientific Theory must be testable to be believed." Since LIGO and other low-frequency gravitational wave detectors and the three existing high-frequency gravitational-wave detectors have not sensed gravitational waves so far, what proof of their existence is there? For that we must take a look at how gravitational waves are generated and again I must call upon your vivid imaginations.

One way we can generate wind waves is by the motion of fan blades. Likewise, gravitational waves (GWs) can theoretically be generated by the motion of masses. As Einstein theorized, two orbiting masses generate gravitational waves. Visualize, if you will, holding two buckets of water, one in each hand, and starting to swing them in a circle and raise them up off the floor. Interestingly enough no water spills out, but seems still to "stick" to the bottom of the buckets. This is an example of what we call "centrifugal force." When the buckets are on the floor gravity holds the water down (the water would float around the cabin of a spacecraft exhibiting "zero g's" or no gravity). When rotated by you, on what amounts to an orbit with you at the center, centrifugal force pushes out and holds the water in place. Now here is where I must call upon your imagination and extreme imagery: the centrifugal force can be represented by what we call a "vector." A vector is like an arrow as shown in Figure 1 that has some direction and magnitude (say the magnitude is the speed of the arrow). Now I want you to work hard to really visualize this arrow at the bottom of each of the orbiting buckets pointed out away from you. OK? In the case of centrifugal force the magnitude of this arrow is not speed but force – say pounds, pushing the water toward the bottom of the buckets and not allowing the water to spill.

Now comes the really hard part: the arrow moves as you orbit the water buckets. In fact it assumes different directions as you rotate your arms and the arrowhead traces out a little arc. The tangent to this arc can be represented by another vector. I'll slow down here. The arrowheads trace out a little curved line every fraction of a second during rotation or orbiting. What does this little curved line or arc represent? Well certainly the magnitude of the centrifugal force remains unchanged as long as you keep rotating the buckets at a constant rate, but the direction of the centrifugal-force arrow or vector keeps shifting. This shift represents a CHANGE in the force – not its magnitude but its direction. Once again I call upon your imagination. In Figure 13 is a drawing of the situation. We have a force arrow or vector at one particular time at, say, time zero and other at a later time say time one-hundredths of a second later. There is a little "change" arrow or vector shown at the top of the Figure 13. To be specific we take the magnitude or length of the two centrifugal force vectors to be ten pounds and the little force-change to be one-tenth of a pound. Note that this little change vector is nearly perpendicular to the other two centrifugal force vectors. In our particular example the force change vector is generated over one-hundredth of a second. We establish its magnitude of the force-change vector BY DEFINITION (can't argue with it) as "force per unit time" or in this example 0.1 pound divided 0.001 seconds = 0.1/0.001 or 10 pounds force per second. Finally, I will come to the point: Einstein theorized that gravitational waves are generated by such a force **change**. So it is not the size of the orbiting masses that really counts, but the change in force as they orbit and that force change generates gravitational waves! Whew – a real challenge to understand I know. Perhaps Figure 14 will help.

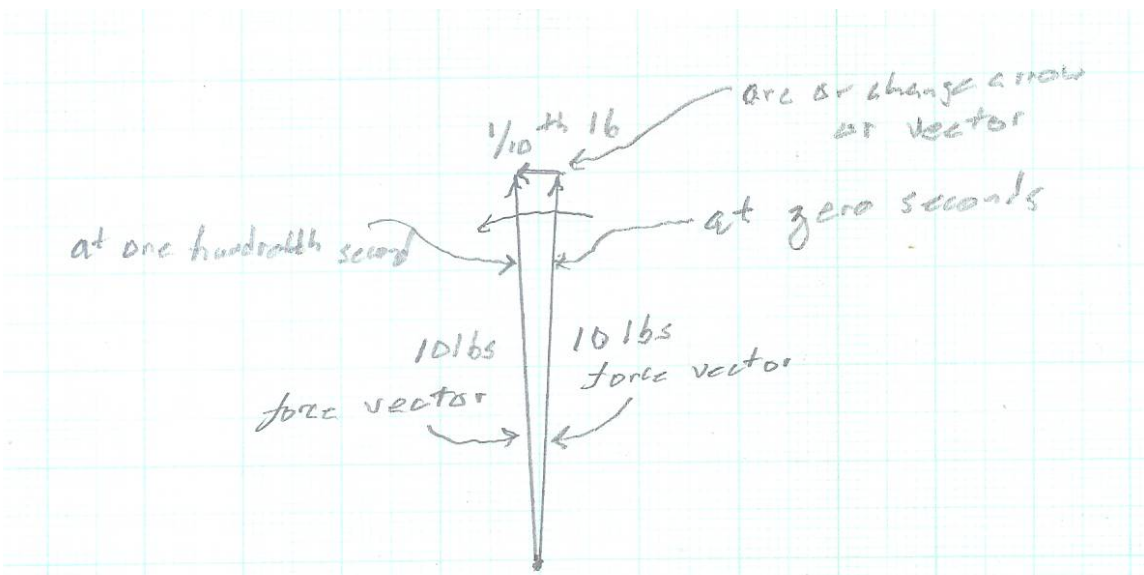


Figure 13

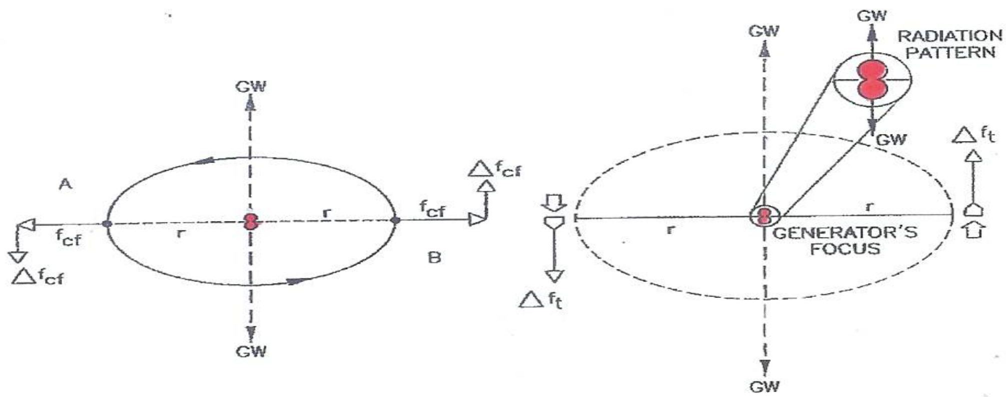


Figure 14

In this figure we find some strange symbols. There is f_{cf} that stands for the centrifugal force vector that we discussed and a Δf_{cf}. This Δf_{cf}. is the symbol for the change in centrifugal force at points A and B on an orbit of two masses. In the middle is a little **red** symbol that is what is known as a radiation pattern, that is a graphical representation of the gravitational-wave (GW) radiation generated by the change in force pairs, Δf_{cf}, that we also have discussed, I will get to the right side of Figure 14 shortly. Besides two masses on orbit around each other gravitational waves can be generated by other activities. During the Big Bang high-frequency ones are generated in a complicated fashion that I won't even try to explain. The mechanism for their generation is like the generation of the cosmic microwave background that was first found accidentally by Arno Penzias and Robert Woodrow Wilson in 1964 as they were experimenting with a supersensitive, 6 meters (20 ft) horn antenna originally built to detect microwaves bounced off echo balloon satellites. When Penzias and Wilson reduced their data they found a low, steady, mysterious noise that persisted in their receiver. This residual noise was 100 times more intense than they had expected, was evenly spread over the sky, and was present day and night (at one point they thought the noise was from pigeon droppings or "the sound from bird shit" as they said at the time). Scientists from Princeton University had reasoned that the Big Bang must have scattered not only the matter that condensed into galaxies, but also must have released a tremendous blast of radiation. With the proper instrumentation, this radiation should be detectable and it was – by accident! Likewise, high-frequency "relic" gravitational waves were theorized by the Russian scientist Leonard Grishchuk in 1975 to be generated during the Big Bang, somewhat before these microwaves appeared.

Now to the experimental evidence of gravitational waves: Two astronomers – Russell Hulse (a student) and his professor Joseph Hooton Taylor were studying a radio star pair (two neutron-star pulsars) at the huge Arecibo radio observatory in Puerto Rico. Hold on! Let's define some new terms here. "Neutron star pair": a neutron star has an incredibly high density – they have a mass of about 1.4 times the mass of our Sun, but are only about ten or twenty kilometers across. This means that a neutron star is so dense that on Earth, one teaspoonful would weigh a billion tons! By pair I mean two on orbit about each other. A "Pulsar" is a rotating neutron star. It is also like a spinning "Lighthouse," whose radio beams sweep around and are seen by our earth-based radio telescopes (like Arecibo). Although the binary companion to the pulsar is usually difficult or impossible to observe visually, the timing of the pulses from the pulsar can be measured with extraordinary accuracy by radio telescopes. Thus it is possible to measure the time it takes the Neutron stars to orbit and to determine if their orbits are coalescing. As I said, they were coalescing and losing energy. This energy must come from somewhere – it was coming from gravitational radiation carrying energy away from the orbiting neutron-star pair! The energy it was loosing during this coalescence was **exactly** as predicted by Einstein due to the radiation of gravitational waves. They received the Nobel Prize in 1993 and from then on the skepticism evaporated and all scientists believed that, due to this indirect evidence, gravitational waves do indeed exist. However, the low-frequency gravitational waves generated by this star pair are miniscule and undetectable, so the LIGO is hoping to detect gravitational waves from more robust sources such as the coalescence of orbiting pairs of **black holes**.

The question arises as to how one could generate gravitational waves in a laboratory setting – certainly a necessity for any practical application of the technology. It's obvious we cannot have two black holes orbiting in a laboratory, but it turns out we really don't need to. The trick is that we **don't require gravitational force** to generate gravitational waves! As we have seen it is really the motion of the mass that counts (their change in force per unit time), not the kind of force that produces that motion. How do we obtain a large force change? To make it practical we need a force that is much larger than the force of gravitational attraction. Let's do a thought experiment and think of two horseshoe magnets facing each other (North poles facing South poles). They will attract each other strongly. If we reverse the magnets, put them down back-to-back with their poles facing outwards, then primarily their gravitational force acts due to their masses and we sense little or no attractive pull. As a matter-of-fact, magnetic, electrical, nuclear and other non-gravitational forces are about 1,000,000,000,000,000,000,000,000,000,000,000,000,000 times larger than the gravitational force! So, if we have our choice, we want to use "electromagnetic force" as our force, not weak little gravity. How could we make use of this analysis and generate GWs in the laboratory? Instead of the change in "centrifugal force" of the two orbiting black holes, let us replace that force change with a change of non-gravitational force, the much more powerful one of electromagnetism. One way to do this is to strike two laser targets with two oppositely directed laser pulses (a laser pulse is essentially an electromagnetic wave). As depicted on the right side of Figure 14, the two targets could be small masses, possibly highly polished tungsten. Each laser-pulse strike imparts a force on the target mass acting over a very brief time, Δf_t, commonly defined as a "jerk" or a shake or an impulse. Einstein says, according to his broad concept of "quadrupole formalism," that each time a mass undergoes a change or buildup in force over a very brief time; gravitational waves are generated – **in the laboratory!** Other means of generating gravitational waves in the laboratory include crystal oscillators, such as those found in your cell phone, and energizing sub-microscopic particles such as molecules. The Russians, Germans, Italians and Chinese have all proposed such laboratory high-frequency gravitational wave generation means.

Well, I may not have fully explained high-frequency gravitational waves, but I hope that you come away from this tutorial with the realization that scientists rely primarily on imagery to understand and explain things. But so do most of us three-dimensional humans!

Thank you all.

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Economic Round Table Talk
The California Club, December 11, 2008

"What's my line?"

The term "**what's my line**" refers to a question about one's a line of work or business. The origin of the term is not easy to find. Some believe it has to do with being in the same line or queue with other similar workers. Alternatively it may refer to a line in an organization chart or a line of similar tasks. So it was interesting to me to look at other origins and meanings of "line."

First, consider the term "**Dead Line**." It began as a real line, drawn in the dirt or marked by a fence or rail, restricting prisoners in Civil War camps. They were warned, "If you cross this line, you're dead." To make dead sure this important boundary was not overlooked, guards and prisoners soon were calling it by its own bluntly descriptive name, the *dead line*. An 1864 congressional report explains the usage in one camp: "A railing around the inside of the stockade, and about twenty feet from it, constitutes the 'dead line,' beyond which the prisoners are not allowed to pass." Nothing could be more emphatic than *dead line* to designate a limit, so we Americans happily applied the term to other situations with strict boundaries. For example, the storyteller O. Henry wrote in 1909 about crossing "the dead line of good behavior." But it was the newspaper business that made *deadline* more than just a historical curiosity. To have the latest news and still get a newspaper printed and distributed on time requires strict time limits for those who write it. Yet many are the excuses for writers to go beyond their allotted time: writers' block, writers' perfectionism, or just plain procrastination. (Perhaps the writer is a deadbeat (1863) -- another *dead* word invented by Americans during the Civil War.) Seeking the strongest possible language to counter these temptations, editors set deadlines, with the implication that "Your story is dead--*You* are dead--if you go beyond this time to finish it."

Our urgent twentieth century has made such deadlines essential not just for reporters and other writers but in every kind of activity; there are deadlines for finishing a job or assignment, for entering a contest, for ransoming hostages, or for buying a product at the special sale price.

Next let's look at the terms "**Toe the line**" and "**Walk the line**" expressions both mean to "behave," or take care not to deviate from the "straight and narrow." To put your toes literally on a line in front of passport inspector, bank teller, a customer queue of almost any kind where the privacy of the person in front of you is to be respected.

Party line: In modern usage, it appears often in the context of partisan or factional politics, as in, "He's toeing the party line." One documented origin of the phrase is as an athletics analogy that originated in the early 19th century. Other suggested origins are the center line in boxing which boxers were instructed to toe at the start of each round, or the lines created by deck planks on ships which naval crews used to "**fall in line**". The longest-running use of the phrase, often mentioned by tourist guides, is from the British House of Commons where sword-strapped members were instructed to stand behind lines that were better than a sword's length from their political rivals. Thus the cry to "**toe the line!**" was echoed to return order to the House and to quell a potential mortal conflict.

"**Toe the line**" has implications of obedience, and is often more specific. "I Walk the Line" is a Johnny Cash song, of course, and in it he reassures June Carter Cash that he is not going to "stray."

Sometimes it's difficult to "walk a **fine line**" when the criteria for good behavior are ambiguous. At times your choices even conflict, especially where pleasing two different people is the goal-- you may have to "walk a tightrope," a difficult feat of balance.

And when you drive, of course you have to keep your car on the road on the correct side and not on the shoulder or ditch or the berm. Divided highways have lanes marked off with painted lines-- lines, lines, everywhere a line. Blocking out the scenery, and "… breaking my mind..." (to paraphrase those notable one-hit wonders, the Five Man Electric Band). Do this, don't do that-- can't you see the line? But such road lines have an interesting history ….the first painted traffic lane line was reported by the Trenton Evening Times Friday, August 13, 1915 on Market Street in Trenton New Jersey: "Conditions at the Four Corners have materially improved since, they have established for the first time the 'dead line' that is, a broad white strip painted in the middle of the street …"

A field sobriety test is another good example of "walk the line" One evening while driving my wife back from "The Corkscrew Bar" on San Vicente in Brentwood, I was pulled over because I was winding even more than Barrington Avenue was winding. Wife, Bonnie is so competitive that she started pounding on the side window: "Officer ... please, please I want to take the field sobriety test too!!!" Well, the older of the two police men said that there was too much traffic to walk the line in the street so he took me down to a garage and said "Now do exactly as I do when I walk this line here." He started to put one foot after the other with his arms outstretched … then tripped and fell against a car. I immediately put one foot after the other with arms out stretched and made myself fall against the same car. The younger officer cracked up laughing and the older officer said: … "Oh, just get the hell outta here!!!… …

A **rope line** is a type of barrier which is intended to protect prominent celebrities or politicians from the general public. Rope lines are also used to organize crowds, especially in crowded clubs and other public places. When a rope line is used in a celebrity context, it is often covered in velvet and it may be decorated with ornaments like tassels to make it more elegant. The side of a rope line on which one stands can be an indicator of social status or clout. For politicians, “walking the rope line” after an event is a useful publicity tactic. People who are unable to get into the event may wait at the rope line in the hope of meeting a politician, shaking his or her hand, and exchanging a few brief words. For high profile politicians like national leaders, access to the rope line is tightly controlled to ensure the safety of the politician, and people may not be permitted to directly touch the politician. Of course on board a boat or ship a “line” is simply a rope. Following this definition a “fishing line” is, quite obviously, any cord made for fishing.

“put it on the line” to risk failure. “Athletes put it on the line every day — in sports, you don't get to do something over.” Often used in the form *put something on the line*: “The lawyer put his reputation on the line when he agreed to defend this man.” One possible origin is from gambling when you put your bet on a line in craps or other games of chance.

Parallel lines are infinite lines in the same plane that do not intersect. If two lines are parallel to a third line, then the two lines are parallel to each other.

1. In Euclidean geometry, there is one and only one shortest path between any two points. We call this "shortest path" the "straight" path, and this path lies along the line segment joining the two points.
2. In Euclidean geometry, two points determine a unique line. In-other-words, given any two points, there exists a line that passes through those two points. Additionally, there does not exist any other line that will pass through both of those two points.
3. In Euclidean geometry, light, in a vacuum, travels along a Euclidean Line.

Now I have been accuse of being too theoretical, too unclear and as we discuss parallel lines I do not want to be obtuse. Thus I want to **distribute the following handout to clarify matters:**

EXPLAINATIONS AND CLARIFICATIONS

$$\tilde{E}_x^{(1)} = i2A_{\text{Ä}}\hat{B}_y^{(0)}cQ\sin(\frac{np}{b}z)\exp(-\ i\omega_g t),$$

$$\tilde{B}_y^{(1)} = 2A_{\text{Ä}}\hat{B}_y^{(0)}Q\cos(\frac{np}{b}z)\exp(-\ i\omega_g t), \qquad (3)$$

$$\tilde{E}_y^{(1)} = -\ 2A_{\text{Ä}}\hat{B}_y^{(0)}cQ\sin(\frac{np}{b}z)\exp(-\ i\omega_g t),$$

$$\tilde{B}_x^{(1)} = -\ i2A_{\text{Ä}}\hat{B}_y^{(0)}Q\cos(\frac{np}{b}z)\exp(-\ i\omega_g t), (0 < z < b),$$

(4)

$$\tilde{E}_y^{(1)} = A_{\otimes}\hat{B}_y^{(0)}cQU(t)\exp[i(k_g z - \omega_g t)],$$
$$\tilde{B}_x^{(1)} = A_{\otimes}\hat{B}_y^{(0)}QU(t)\exp[i(k_g z - \omega_g t)], \qquad (7)$$

where *U(t)* is a step function defined by the following form:

$$U(t) = \begin{cases} 1, & t_1 < t < t_2, \\ 0, & t < t_1 \ \ and \ \ t > t_2, \end{cases}$$

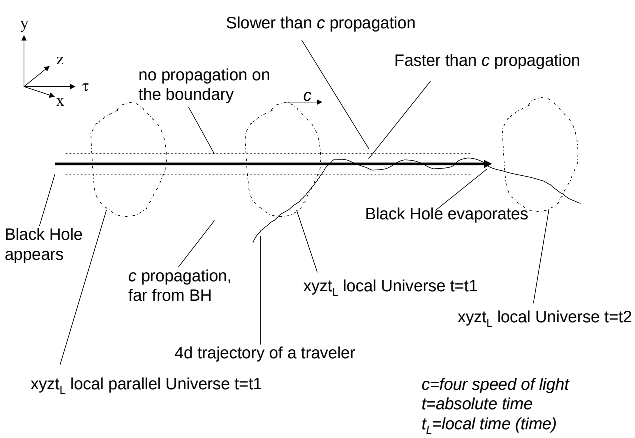
$$n_{x(G)}^{(1)} \approx \frac{1}{\mu_0 \hbar \omega_e} \frac{A\hat{B}_y^{(0)}\psi_0}{\left[1 + \left(z/f\right)^2\right]^{\frac{1}{2}}} \exp(-\frac{r^2}{W^2}),$$

$$N_x^{(1)} = N_{x(c)}^{(1)} + N_{x(G)}^{(1)}, \qquad (12)$$

where:

$$N_{x(c)}^{(1)} = \iint_{\Delta s} n_{x(c)}^{(1)} dydz,$$

$$N_{x(G)}^{(1)} = \iint_{\Delta s} n_{x(G)}^{(1)} dydz, \qquad (13)$$



$$F_{GW} = 1.6 \cdot 10^{-5}\left(\frac{0.47 \cdot 10^{24}}{100}\right)^2\left(\frac{2.8 \cdot 10^{-16}}{10^{-22}}\right)^2 W\,m^{-2} = 4.7 \cdot 10^{51} W\,m^{-2}.$$

EVERYTHING NOW SHOULD BE CLEAR TO EVERYONE!

Non-Euclidian Geometry: In mathematics, non-Euclidean geometry describes hyperbolic and elliptic geometry, which are contrasted with Euclidean geometry. The essential difference between Euclidean and non-Euclidean geometry is the nature of parallel **lines.** Euclid's 5th postulate is equivalent to Playfair's Postulate, which states that, within a two-dimensional plane, for any given line *l* and a point *A*, which is not on *l*, there is exactly one line through *A* that does not intersect *l*. In hyperbolic geometry, by contrast, there are infinitely many lines through *A* not intersecting *l*, while in elliptic geometry, any pair of lines intersect.

Another way to describe the differences between these geometries is as follows: Consider two straight lines indefinitely extended in a two-dimensional plane that are both perpendicular to a third line. In Euclidean geometry the lines remain at a constant distance from each other, and are known as parallels. In hyperbolic geometry they "curve away" from each other, increasing in distance as one moves further from the points of intersection with the common perpendicular; these lines are often called ultra-parallels. In elliptic geometry the lines "curve toward" each other and eventually intersect.

Now I am quite sure that you thoroughly understand this material based upon the self-explanatory handout – especially if you “read between the lines.”

A **lifeline** is a line or rope used to support a person who is in physical difficulty, or to prevent someone from getting into physical difficulty. For example, a lifeline may protect a person who is at risk of drowning. Life line also refers to a line on the human palm used in chiromancy (palm reading). A palm reader in Las Vegas looked at my lifeline and exclaimed “My God .. you died years ago!” Hope she was wrong.

Pay the line is a stick call in craps. For example “winner seven, take the donts and pay the line” The line being most of the bets, the “donts” are the bets on the “Don’t Pass Bar” or the “Don’t Come Bar.”

Over-the-line is a game related to baseball and softball. Like those games, you have the batter, pitcher and fielders Because a game requires only three people per team, it's considerably easier to get a good informal game going. Equipment consists of a rope (or lines marked in the sand), an "official" softball bat and a rubber softball. No ball gloves are allowed except in women's games, however golf gloves may be used when batting. Game play, however, is very different. The name "over-the-line" is a registered trademark of the Old Mission Beach Athletic Club (OMBAC) of San Diego, California, which organizes an annual tournament that is one of the city's largest summer social events.

Fifty-yard line denotes the center of the field of play. Back in the forties I was a student at Emerson Junior High School in Westwood. I joined a school service organization called the “Emersonians” and wore a neat blue sash across my chest. One of my jobs was to go out on the school play yard where two kick-ball teams of eleven players each were waiting to start their noon-time game. I thought I was pretty hot! It was War time and there were two high-school gangs – very unpleasant kids. One group mainly Mexicans was called the “Pachukos” and the other gang mainly blacks (plus a number of whites) was called the "soot suitors." Well, they didn't like each other very much and were always having knife and Billy-club fights. I took my position at the fifty-yard line and prepared to blow my whistle, drop the game ball and start the game. I looked at one team of Pachukos gathered at one end of the field brandishing knives and other weapons – at least 50 of them – not eleven, then I looked at the other end of the field – 50 soot suitors equally well armed. – a race riot was in the making! I blue my whistle, dropped the ball and ran all the way home. Yes it was a race riot I started and it was reported on for days in the papers – never mentioned my name however.

Outline: Ideally, you should follow these 4 suggestions to create an effective outline.

1) Parallelism - How to accomplish this?

Each heading and subheading in an outline should preserve parallel structure. If the first heading is a noun, the second heading should be a noun. As an Example consider an outline of going to College:

I . Choose Desired Colleges

II. Prepare Applications

("Choose" and "Prepare" are both verbs.)

2) Coordination - How to accomplish this?

All the information contained in Heading 1 should have the same significance as the information contained in Heading 2. The same goes for the subheadings (which should be less significant than the headings). Example:

I. Visit and evaluate college campuses

II. Visit and evaluate college websites

   A. Note important statistics
   B. Look for interesting classes

(Campus and websites visits are equally significant, as are statistics and classes found on college websites.)

3) Subordination - How to accomplish this?

The information in the headings should be more general, while the information in the subheadings should be more specific. Example:

I. Describe an influential person in your life

   A Favorite high school teacher

B. Grandparent

(A favorite teacher and grandparent are specific examples of influential people.)

4) Division - How to accomplish this?

Each heading should be divided into 2 or more parts. Example:

I. Compile resume
  A. List relevant coursework
  B. List work experience
  C. List volunteer experience

Trunk line: Originally a passenger ship line connecting ports whose cargo included “steamer trunks.” Alternatively, from the main stem of a tree apart from limbs and roots – a trunk - the principal channel or main body of a system or part that divides into branches – that are bundled together. Now extended in meaning to the main line of transportation system (main supply channel) or a communications system such as a direct line between two telephone switchboards or the main route or routes on a railway.

Byline: a printed line accompanying a news story, article, or the like, giving the author's name.

Most **hardline** music can also be referred to as hardcore/punk. For musical groups with similar names, for example Hardline (band) or Hardliner (band). For the ecological philosophy, hardline (subculture). In politics, hardline refers to the doctrine, policy, and posturing of a government or political body as being absolutist, or authoritarian. Hardline movements are usually extremist, militant, and uncompromising. Hardline movements range across the entire political spectrum, including black nationalism, objectivism, neo-Nazism, radical feminism, conservatism and anti-revisionism.

Bee line: The phrase derives from the behavior of bees. When a forager bee finds a source of nectar it returns to the hive and communicates its location to the other bees, using a display called the *Waggle Dance*. The other bees are then able to fly directly to the source of the nectar, i.e. 'make a beeline' for it. This dance is a surprisingly sophisticated means of communication for a creature with such a small brain. The forager bee performs a short wiggling run - hence the name, with the angle denoting the direction of the nectar-laden flowers and the length of time denoting the distance. A team of British scientists tracked honeybees by radar to solve an enduring controversy in zoology: whether bees communicate the source of food to each other by performing a waggle dance.

In the 1960s, Nobel Prize-winning Austrian zoologist Karl von Frisch proposed that bees use a coded dance to indicate the direction, distance and type of food to hive mates.

But although indirect evidence has supported von Frisch's theory, it has never been tested directly.

Bees certainly dance, but there is typically a time lag between performance of the dance and other bees' arrival at the food source. The time lag led scientists to suggest that the bees were actually finding the food on their own, possibly by following a scent of the original bee when it returned to the food source.

But now a team at Rothamsted Research, an agricultural research center, has tracked bees by radar as they flew to a food source.

"We've solved it for once and for all," said professor Joe Riley, the team leader.

After finding food, scout bees returning to the hive dance on the vertical walls of the honeycomb. A round dance indicates the food is very close, within 35 yards or less. A figure-eight pattern indicates that the food is farther away. The bee indicates the distance to the food by how long it dances; it indicates the food's richness by how vigorously it dances; and it indicates the food's direction by the angle the dance deviates from an imaginary line drawn from the current position of the sun to the dance floor. The code is complex and detailed.

The controversy, said Riley, was created by von Frisch himself when he said that recruits read the dance and flew directly to the food source.

But "they take five to 10 minutes, not one minute," said Riley.

Because of this discrepancy, opponents like Adrian Wenner have suggested that while the bees dance, it's not to convey information. Instead, he said bees are guided to the food source by odor conveyed by the scout bee.

Riley's team members have worked with radar tracking since 1996, when they were trying to help a British aid program in Zimbabwe control tsetse flies.

The team's results show that bees do read the dance and fly off immediately in the direction indicated. In addition, the bees correct for wind drift by looking at the ground and the angle of the sun and correcting any lateral shift.

But "they very rarely get it absolutely right," said Riley. "The mean error is about 5 to 6 meters."

Once the bees get to the end of the flight, they change their flight pattern and start circling, looking for the food they've been instructed to find. That takes time, Riley said, and bees can loop back and forth for up to 20 minutes.

"This is where the missing time went," said Riley.

When they near their destination, bees use odor to help find the food source. To make sure bees weren't following a scent, a control group of bees was transported 250 meters after seeing a waggle dance. When released, the bees flew off in the direction indicated by the dance, the team found.

To track bees by radar, the researchers first had to create a transponder small and light enough that a bee could carry it. It took approximately two years, Riley said, to come up with a system that worked efficiently and was small enough for the insect to carry. It had to be omnidirectional, and robust enough to survive being attached to the insect and to stay on during grooming. The final version weighs approximately 10 to 12 milligrams, a fraction of the pollen load bees are accustomed to carrying.

The final product, he said, "looks like a whisker with a lump in the middle" and is essentially a nonlinear antenna made of steel wire with a small chip in the middle. To attach the transponders to the bees, handlers stick them to the insects' backs as they leave the hive. (Here's a What's my line? "Oh, I stick little transponders on the back of bees as they leave their hive.")

Once the bees are airborne, they are tracked by radar just the way you see in old movies: dots on a screen that are recorded and later converted to graphs. Because there are no batteries small enough to power them, the transponders derive power from the 20-kilowatt signal the radar sends out, replying with a new signal that identifies each transponder uniquely.

The work was just published May 12, 2008 in the Journal Nature. "It's a wonderful paper because the results are so clear and they did some very nifty controls," said Thomas Seeley, a biology professor at Cornell who peer-reviewed the paper for *Nature*.

But questions remain, said Seeley. "We don't know yet how a bee standing next to a dancer in the darkness of a beehive is able to get all this information from the dancer," he said. "And we also don't know how it evolved."

The phrase "Bee line" is certainly American and all the early citations of it come from the USA. The earliest that I can find is from *The Davenport Daily Leader*, January 1808:

"Gustav Stengel Sr., of Rock Island, was thrown from his sleigh on Third Avenue in that city yesterday afternoon, the horse becoming frightened and turning abruptly, ripping the cutter. The horse made a bee line for home."

Given the colloquial usage in that citation, the figurative phrase and certainly the original literal meaning of bee-line must have already been in use for some time at that date.

Line of demarcation marking a boundary, originally, applied to the division of the New World in fifteenth century between the Spaniards and the Portuguese.

Line of Scrimmage: A place for a tussle a slight battle. From the obsolete name of a French fencer. It has the same root as our word skirmish. Scrimmage was first used in popular English literature: sometime before 1615. The term "line of scrimmage" is utilized in football, soccer, etc. A “Scrimmage Vest” can be apart of a hockey player’s outfit.

The **Maginot Line** was named after French Minister of Defense André Maginot, was a line of concrete fortifications, tank obstacles, artillery casemates, machine gun posts, and other defenses, which France constructed along its borders with Germany and Italy, in the light of experience from World War I, and in the run-up to World War II. Generally the term describes either the entire system or just the defenses facing Germany, while the Alpine Line is used for the Franco-Italian defenses. The French established the fortification to provide time for their army to mobilize in the event of attack and/or to entice Germany to attack neutral Belgium to avoid a direct assault on the line. The success of static, defensive combat in World War I was a key influence on French thinking. The fortification system successfully dissuaded a direct attack. However, it was an ineffective strategic gambit, as the Germans did indeed invade Belgium, flanked the Maginot Line, and proceeded relatively unobstructed. It is a myth however that the Maginot line ended at the Belgian border and was easy to circumvent. The fortifications were connected to the Belgian fortification system, of which the strongest point was Fort Eben-Emael. The Germans broke through exactly at this fortified point which made it possible for them to invade France.

The **Mason–Dixon Line** (or "Mason’s and Dixon's Line") is a demarcation line between four U.S. states, forming part of the borders of Pennsylvania, Maryland, Delaware, and West Virginia (then part of Virginia). It was surveyed between 1763 and 1767 by Charles Mason and Jeremiah Dixon in the resolution of a border dispute between British colonies in Colonial America. Popular speech, especially since the Missouri compromise of 1820 (apparently the first official usage of the term "Mason's and Dixon's Line"), uses the Mason-Dixon Line symbolically as a cultural boundary between the Northern United States and the Southern United States (Dixie). Maryland and Pennsylvania both claimed the land between the 39th and 40th parallels according to the charters granted to each colony. The 'Three Lower Counties' (Delaware) along Delaware Bay moved into the Penn sphere of settlement, and later became the Delaware Colony, a satellite of Pennsylvania. In 1732 the proprietary governor of Maryland, Charles Calvert, the 5th Baron of Baltimore, signed an agreement with William Penn's sons which drew a line somewhere in between, and also renounced the Calvert claim to Delaware. But later Lord Baltimore claimed that the document he signed did not contain the terms he had agreed to, and refused to put the agreement into effect. Beginning in the mid-1730s, violence erupted between settlers claiming various loyalties to Maryland and Pennsylvania. The border conflict between Pennsylvania and Maryland would be known as Cresap's War. The issue was unresolved until the Crown intervened in 1760, ordering Frederick Calvert, the 6th Baron of Baltimore to accept the 1732 agreement. As part of the settlement, the Penns and Calverts commissioned the English team of Charles Mason and Jeremiah Dixon to survey the newly established boundaries between the Province of Pennsylvania, the Province of Maryland, Delaware Colony and parts of Colony and Old Dominion of Virginia.

Lines to pick up girls:

"Hello there! I hate to bother you, but you are so very attractive I just wanted to ask you something. My daughter could really profit from your advice since her mother, my wife, recently met an untimely death and can no longer advise her. My daughter, who lives across the country in my Park Avenue Apartment in New York, wants to be a model. You are so very beautiful yourself that you must be a model or at least you may know something about a career for a gorgeous woman. It would be my pleasure to discuss it with you over dinner. Would you be so very kind to accept my invitation?"

Advertisement written on a napkin for the *Paris Match:* "Very attractive Private Secretary wanted for a position near Hollywood, California in the United States. All relocation expenses will be paid in advance. Salary negotiable, but at least 50% higher than the average for the region. Contact Dr. Robert Baker at the George V for an appointment." It was 1961 (I was living separately from my first wife and had not yet met Bonnie.) … on a jet headed for Paris … After having several drinks I was asking each stewardess if she wouldn't mind showing me around Paris !!! Until one stewardess exclaimed "why don't you just advertise Doctor Baker!?!?" Being a nerd I did not view this as an insult but as a great suggestion. That night, after the flight I was cleaning out my pockets and found the note on a napkin in my pocket. Well, I called *The Match* but they said that their advertising Department "… gone to bed," but said that the Paris Edition of the *New York Times* might still be open – they were and I placed the add and went to bed. The next morning at 7:00 am I was awakened by the phone "Doctor Baker, I read the advertisement in the paper this morning and want apply for the job." I had forgotten all about it, but said "Let's get together lunch and I'll interview you." She asked how she'd recognize me and I said that I had just written a textbook and I'd flash it and that would be me. I put down the phone …just got back in bed and it rang again … same thing and I arranged for a dinner interview.

During that morning I received over fifty responses! I had three appointments each for breakfast, lunch, cocktails and dinner FOR TWO DAYS. I would go to the lobby, pick out the best looking girl waiting for me, flash my book and head out. The concierge said to me: "I have been here at the George V for 26 years and I have never seen so many girls lined up for anyone like this before – what is your secret?". I said "Oh just an American in Paris I suppose." **One gorgeous blond French girl**, Rejhanne, was my choice (I **was** actually looking for a private secretary then), I almost convinced my best friend, Fred Nason, Jr. whose Dad owned *Beverly Hills Transfer and Storage*, to move her over here for free – but she nixed the deal! Later after Bonnie was hired as an Executive Assistant by my number two, Dr. Merifield, Bonnie rifled through my desk …threw out my love letters to Rejhanne and about $100 worth of French Franks that I was going to send to her!

Another line:

“High Honey! My wife doesn’t understand me. I buy her furs and jewelry – gave her a Rolls Royce, but no appreciation. She doesn’t even like my private jet or my yacht! I’d really like to meet a nice girl like you – how about getting together tonight?”

Or lines girls use to pick up guys:

Having already downed a few power drinks, she turned around, faced him, looked him straight in the eye and said, “Listen here good looking, I screw anybody, any time, anywhere, your place, my place, in the car, front door, back door, on the ground, standing up, sitting down, naked or with clothes on, dirty, clean . . . it doesn't matter to me. I've been doing it ever since I got out of college and I just love it.”

Eyes now wide with interest, he responded,

”No kidding. I'm a lawyer too. What firm are you with?”

.

Now I’ve reached my “Dead Line” and for me it’s “the end of the line” so thank you for listening to my line!

Economic Round Table

The California Club; Fireside Room,

8:00 am, December 4, 2003:

"Infinity"

Cosmology is the scientific study of the large scale properties of the Universe as a whole. It endeavors to use the scientific method to understand the origin, current state, evolution and ultimate fate of the entire Universe. Like any field of science, cosmology involves the formation of theories or hypotheses about the universe which make specific predictions for phenomena that can be tested with observations. The field of cosmology has been revolutionized by many discoveries made during the past century. Thus as Ned Wright of UCLA so aptly puts it, cosmology will be Quote: "... under construction ..." for the foreseeable future as new discoveries are made. In this talk I will discuss a rather new conjecture concerning a cosmological model, two experiments that could be employed to test the conjecture, and even delve into time travel.

A prerequisite for studying cosmology is to, as they say, “think outside the box.” But first a brief historical sketch of cosmology:

According to astronomical historian *David Wands*, four thousand years ago the Babylonians were skilled astronomers who were able to predict the apparent motions of the Moon and the stars and the planets and the Sun upon the sky, and could even predict eclipses. But it was the Ancient Greeks who were the first to build a cosmological model within which to interpret these motions. In the fourth century BC, they developed the idea that the stars were fixed on a celestial sphere which rotated about the spherical Earth every 24 hours, and the planets, the Sun and the Moon, moved in the “ether” between the Earth and the stars.

Despite its complicated structure, *Ptolemy* produced an epicycle model so successful at reproducing the apparent motion of the planets that when, in the sixteenth century, *Copernicus* proposed the much maligned heliocentric or Sun-centered system, he could not match the accuracy of *Ptolemy*'s Earth-centered system. *Copernicus* constructed a model where the Earth rotated and, together with the other planets, moved in a circular orbit about the Sun. But the observational evidence of the time favored the more accurate, albeit far more complicated, Ptolemaic epicycle system!

There were other practical reasons why many astronomers of the time rejected the Copernican notion that the Earth orbited the Sun. *Tycho Brahe* was, perhaps, the greatest observational astronomer of the sixteenth century. He realized that if the Earth was moving about the Sun, then the relative positions of the stars should change as viewed from different parts of the Earth's orbit. But there was no evidence of this shift, called parallax. Either the Earth was fixed, or else the stars would have to be fantastically far away. It was only with the aid of the newly-invented telescope in the early seventeenth century that *Galileo* could deal a fatal blow to the notion that the Earth was at the center of the Universe. He discovered moons orbiting the planet Jupiter. And if moons could orbit another planet, why could not the planets orbit the Sun?

At the same time, *Tycho Brahe's* assistant *Kepler* discovered the key to building a heliocentric model. The planets moved in ellipses, not perfect circles, about the Sun. His was a conjecture with out in specific theoretical basis – a pragmatic view of the universe that satisfied the observational evidence of *Tycho Brahe*. *Newton* later showed that elliptical motion could be explained by his inverse-square law for the gravitational force – *Newton* provided the theoretical basis for planetary motion.

But the absence of any observable parallax (stereoscopic effect by we the observers being carried around on the Earth’ orbit) in the apparent positions of the stars as the Earth circled the Sun, then implied that the stars must be at a huge distance from the Sun. The cosmos seemed to be a vast sea of extremely distant stars. With the aid of his telescope, *Galileo* could resolve thousands of new stars that were invisible to the naked eye. *Newton* concluded that the Universe must be an infinite and eternal sea of stars, each much like our own Sun.

It was not until in the nineteenth century that the astronomer and mathematician *Bessel* finally measured the distance to the stars by parallax, that is by using the diameter of the Earth's orbit as a baseline and observing the stars at six-month intervals. **As shown in Figure 1**, one can project the position of a nearby star on the field of the much more numerous distant stars. However, as seen in **Figure 2**, with the six-month measurements the position of the nearby stars shift back and forth (blue and red lines and dots). The nearest star (other than the Sun) turned out to be about 25 million, million miles away! (By contrast the Sun is a mere 93 million miles away from the Earth.)

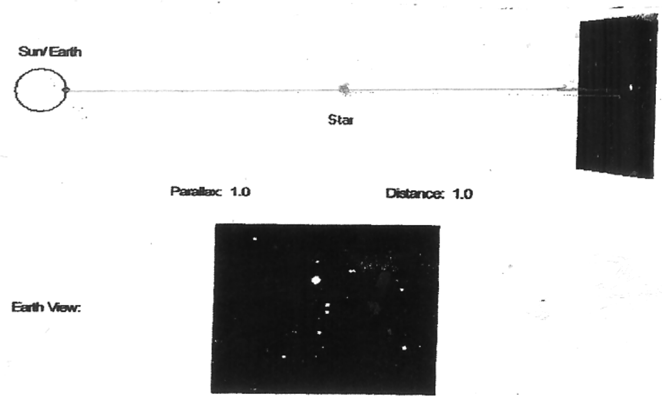


Figure 1

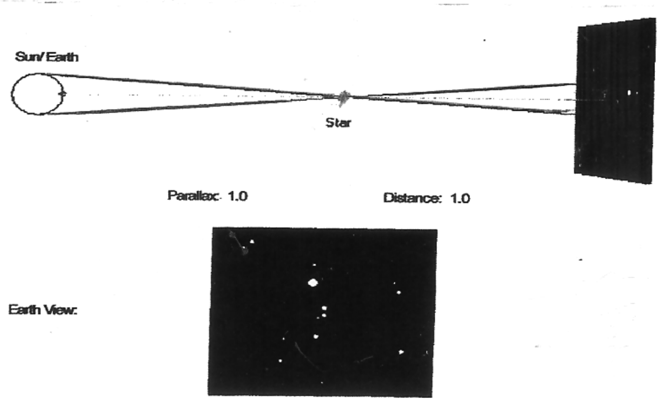


Figure 2

Most of the stars we can see are contained in the Milky Way - the bright band of stars that stretches across our night sky. *Kant* and others proposed that our Milky Way was in fact a lens shaped "island universe" or galaxy, and that beyond our own Milky Way must be other galaxies.

In addition to stars and planets, astronomers had noted fuzzy patches of light on the night sky, which they called nebulae. Some astronomers thought these could be distant galaxies. It was only in the 1920's that the American astronomer *Hubble* established that some of these nebulae were indeed distant galaxies comparable in size to our own Milky Way. **Figure 3** is an especially beautiful picture of the Andromeda galaxy

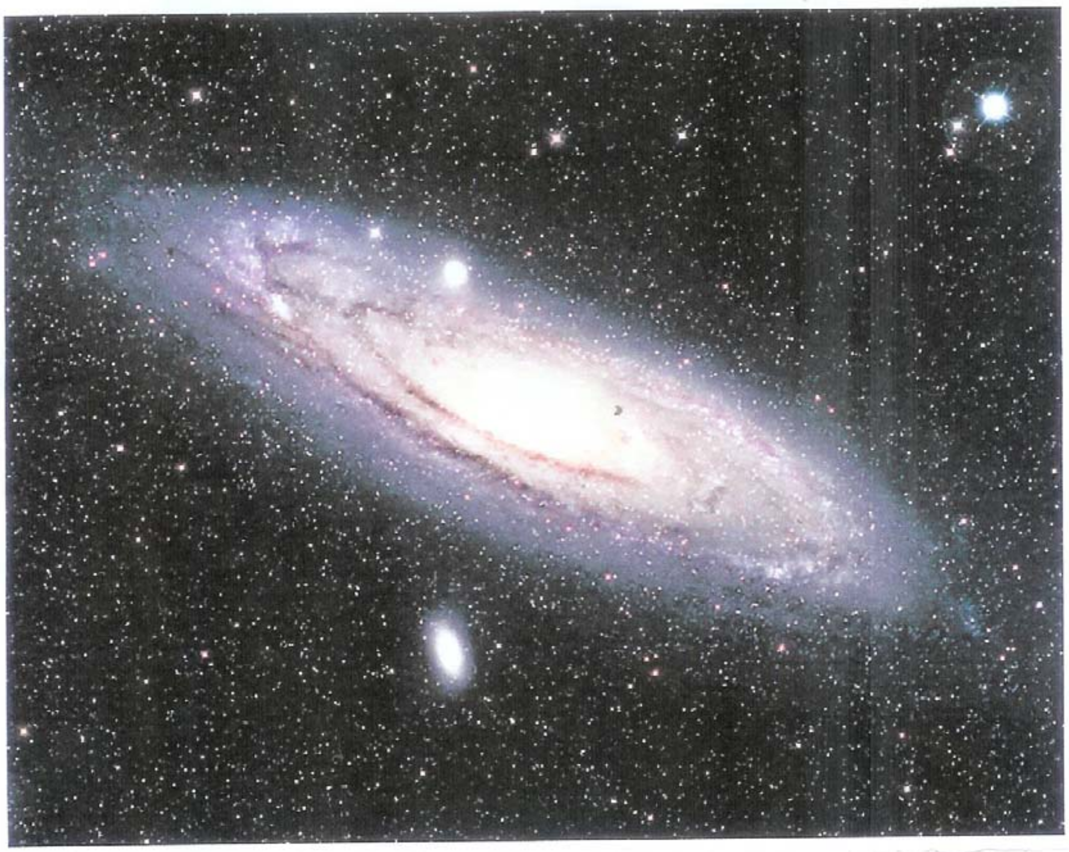


Figure 3

Hubble also made the remarkable discovery that these galaxies seemed to be moving away from us, with a speed proportional to their distance from us. It was soon realized that this had a very natural explanation in terms of *Einstein*'s recently discovered (1915) General Theory of Relativity: our Universe is expanding!

In fact, *Einstein* might have predicted that the Universe is expanding after he first proposed his theory in 1915. Matter tends to fall together under gravity so it was impossible to have a static universe. However, *Einstein* realized he could introduce an arbitrary constant into his mathematical equations, which could balance the gravitational force and keep the galaxies apart. This became known as the "cosmological constant." After it was discovered by *Edwin Hubble* that the Universe was actually expanding, *Einstein* declared that introducing the cosmological constant was the greatest blunder of his life!

The Russian mathematician and meteorologist *Friedmann* had realized in 1917 that the *Einstein* equations could describe an expanding universe. This solution implied that the Universe had been born at one moment, then thought to be about ten thousand million years ago in the past and the galaxies were still traveling away from us after that initial burst. All the matter, indeed the Universe itself, was created at just one instant. The British astronomer *Fred Hoyle* dismissively called it the "Big Bang," and the name stuck.

There was a rival model, called the Steady State theory - advocated by astrophysicists *Bondi*, *Gold* and even *Hoyle* - developed to explain the expansion of the Universe. This required the continuous creation of matter to produce new galaxies as the Universe expanded, ensuring that the Universe could be expanding, but still unchanging in time.

For many years it seemed a purely academic point, whether the Universe was eternal and unchanging, or had only existed for a finite length of time. But a decisive blow was dealt to the Steady State model when in 1965 *Penzias* and *Wilson* accidentally discovered a cosmic microwave background radiation. This was interpreted as the faint afterglow of the intense radiation of a Hot Big Bang, which had been predicted by *Alpher* and *Hermann* back in 1949. As an aside, there also is predicted to exist a primordial cosmic background of high-frequency gravitational waves that I will bring up later. Following on from earlier work by *Gamow*, *Alpher* and *Herman* in the 1940's, theorists calculated the relative abundances of the elements hydrogen and helium that might be produced in a Hot Big Bang and found it was in good agreement with the observations. When the abundance of other light elements was calculated these too were consistent with the values observed.

Since the 1970's almost all cosmologists have come to accept the Hot Big Bang model and have begun asking more specific, but still fundamental, questions about our Universe. How did the galaxies and clusters of galaxies that we observe today form out of the primordial expansion? What is most of the matter in the Universe made of? How do we know that there are not black holes or some kind of *dark matter* or "dark energy" out there which does not shine like stars? In a surprising turn of events, in 1998 two groups of astronomers discovered that not only is a universe expanding (as already noted, a fact discovered by *Edwin Hubble* in the 1920s), but the expansion is **accelerating**. This discovery came as a total shock, since astronomers naturally assumed that, due to gravity, the expansion should be slowing down. In the same way that a ball thrown upward on Earth continuously slows down because of gravity's pull (and eventually reverses its motion), the gravitational force exerted by all the matter and universe should cause the cosmic expansion to decelerate. The discovery that the expansion is speeding up rather than slowing down suggests the existence of some form of "dark energy" that manifests itself as a repulsive force, which in our present-day universe overcomes the attractive force of gravity.

With regard to *dark matter*, for each of the stellar, galactic, and galaxy cluster/supercluster observations the basic principle is that if we measure velocities in some region, then there has to be enough mass there for gravity to stop all the objects from flying apart. When such velocity measurements are done on large scales, it turns out that the amount of inferred mass is **much more** than can be explained by the luminous stuff. Hence we infer that there is also *dark matter* in the Universe.

Dark matter also has important consequences for the evolution of the Universe. According to general relativity, the Universe must conform to one of three possible types: open, flat, or closed. In the absence of a cosmological constant, a parameter known as the "mass density" - that is, how much matter per unit volume is contained in the Universe - determines which of the three possibilities applies to the Universe. In the case of an open Universe, the mass density (denoted by the Greek letter *Omega*) is less than unity, and the Universe is predicted to expand forever. If the Universe is closed, *Omega* is greater than unity, and the Universe will eventually stop its expansion and re-collapse back upon itself. For the case where *Omega* is exactly equal to one, the Universe is delicately balanced between the two states, and is said to be "flat" or, as we have said, "steady state." In the case of a non-zero cosmological constant, or some other *dark* or "funny" *energy* that causes acceleration, currently believed to be the case, this relation between the mass density, spatial curvature of spacetime and the future of our Universe no longer holds. It is then no longer true that the mass of our Universe, including especially dark matter, will pull back or decelerate our Universe. Instead, to find out what will happen one needs to calculate the evolution of the expansion factor of the universe for the specific case of matter density, spatial curvature and *dark ener*gy to find out what will happen.

According to data collected by the Wilkinson Microwave Anisotropy Probe (WMAP) launched on June 30th, 2001, the composition of our Universe (assuming a flat, steady state) is:

Visible matter 4%

Dark Matter 23%

Dark Energy 73%

Physicists are still struggling to understand the source and nature of this "*dark energy*." One suggestion is that this energy is associated with some quantum mechanical field that permeates the cosmos, a bit like the familiar electromagnetic field. Borrowing from *Aristotle's* invisible medium, this field has been dubbed the "quintessence." Frankly, I believe it is the result of our Universe's interaction with other osculating or tangent universes. But more on that later. General relativity tells us that matter curves space-time and that matter is interchangeable with energy, so what shape is the Universe? (Results from WMAP suggest the Universe is shaped like a 12-sided dodecahedron and an infinite number of them might be packed together – please see **Figure 4**) Is there a cosmological constant after all? Are we actively interacting with other universes?

Science
October 2003

COSMOLOGY

Polyhedral Model Gives the Universe An Unexpected Twist

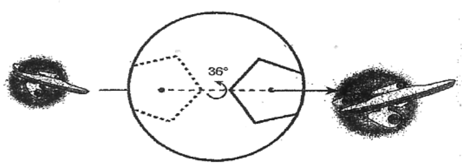
A team of scientists from France and the United States has sifted through measurements from the Wilkinson Microwave Anisotropy Probe (WMAP) satellite to reach a surprising conclusion: The universe might be finite and 12-sided. Although the hypothesis is already being challenged, its proponents say it matches the known facts. "You really get a good fit" to WMAP data with a dodecahedron, says Jeffrey Weeks, a mathematician based in Canton, New York, who coauthored a paper in this week's issue of *Nature* laying out the evidence.

A fit is precisely what physicists have been having for months over an anomaly in the WMAP data. In February, the satellite produced an incredibly detailed picture of the cosmic microwave background (CMB): the ubiquitous cold light that the universe gave off when it was about 400,000 years old. The sizes of hot and cold spots in the CMB revealed the age and composition of the cosmos (*Science*, 14 February, p. 991) but showed that on the very largest scales, there aren't as many temperature fluctuations as expected. If the shortage isn't a mere statistical fluke, it could imply that the universe has a finite size that doesn't leave room for the largest fluctuations.

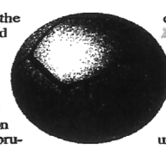
Earlier this year, some physicists speculated that a finite universe in the shape of a higher-dimensional doughnut called a 3-torus could account for the lack of large-scale structure. Now Weeks and his French colleagues have shown that a dodecahedral universe in a slightly curved space can also explain the anomaly. Imagine that you're sitting in the middle of a dodecahedron, a 12-sided object whose faces are made of pentagons. Opposite faces of the dodecahedron are associated; they are actually the same thing, so a spaceship zooming out one side of the universe winds up flying right back in the other. (This sort of thing is common in mathematics; for example, mathematicians often peel and flatten the two-dimensional surface of a torus into a rectangle whose opposite sides match up in an analogous way.)

Different topologies for the universe suppress fluctuations of different sizes, so the CMB in a dodecahedral universe will look slightly different from the CMB in a less exotically configured one. Weeks and his colleagues tried a number of possibilities. "The plain old 3-torus fit isn't that precise," says Weeks, but the dodecahedral space works rather well. "It's not exact, but it's pretty close."

If the dodecahedral picture is correct, then there are some odd consequences. Because opposite faces of a dodecahedron are rotated with respect to each other, a spaceship flying out one pentagon would acquire a roll as it flew in the other (see diagram). Light would behave the same way. As a result, Weeks says, "there would be a handedness to the universe." More important for experimentalists, the large-scale shape of space-time has to be slightly curved to get the sides of the dodecahedron to fit together, rather than flat as most cosmologists prefer. If the error bars on the WMAP data come down a bit more, the satellite might be able to spot the curvature if it exists.



On a roll. In a 12-sided universe, objects framed in one pentagonal face appear, slightly skewed, in its opposite-side counterpart.



"The nice thing about their result is that it makes very testable predictions," says Neil Cornish, a physicist at Montana State University in Bozeman. Nevertheless, says Cornish, other data already might belie the dodecahedral hypothesis. His team's analysis of the WMAP data, which will be submitted to *Physical Review Letters* shortly, shows no sign of duplicate features in the sky that would be the hallmark of a finite, periodic universe (*Science*, 22 June 2001, p. 2237).

Even if the dodecahedral universe falls apart, as seems likely, physicists will still have to explain the puzzling lack of large-scale structure in the WMAP data. Cosmologists hope the anomaly will tell us whether we're bounded by a nutshell or whether we can count ourselves kings of infinite space.

—CHARLES SEIFE

CREDIT: (BOTTOM) J.-P. LUMINET ET AL., NATURE 425, 593 (2003)

Figure 4

We are only beginning to find answers to some of these questions. The cosmic microwave background radiation plays a key role as it gives us a picture of the universe as it was only a hundred thousand years after the Big Bang. It turns out to be remarkably uniform; in fact, it was only in 1992 that NASA's Cosmic Background Explorer satellite detected the first anisotropies (irregularities) in this background radiation. There are slight fluctuations in the temperature of the radiation, about one part in a hundred thousand, which may be the seeds from which galaxies formed. There is also an anisotropic (non-uniform) texture to the high-frequency gravitational wave (HFGW) background that allows for the concentrating and imaging of its primordial effect. As will be seen this imaging may allow for the observational validation of one of my proposed conjectures through the use of a HFGW Telescope.

Since the early 1980's there has been an explosion of interest in the physics of the early universe. New technology and satellite experiments, such as the Hubble Space Telescope, have brought us an ever improving picture of our Universe, inspiring theorists to produce ever more daring models, drawing upon the latest ideas in relativity (including gravitational waves) and particle physics. I will now discuss one of those daring models.

To start this “daring out of the box thought process” let’s look at numbers. Some numbers are by definition – a dozen, 12, but why not 13 a Baker’s dozen? Our base 10 counting system (10, 100, 1000, etc.), but why not by sixes – 60 seconds, 60 minutes, 360 degrees? One can count by twos – the binary system, the base eight system, for example an octave. Why 11 on a football team and 9 on a baseball team? Why 10 commandments? It goes on and on. Numbers are not absolute except perhaps three: *zero, one, and infinity*: that is, the absence, presence or infinite set of something. So here is where our story of **infinity** begins.

Several years back a theoretical physicist questioned whether there could be more than three space plus one time dimension – four dimensions in all. He believed that there could be little tiny curled up dimensions. Dimensions that are there, but are two small for us to perceive in our day-to-day activities. Few paid much attention to this idea until recently when a whole new approach to particle physics was proposed: the *string theory*. This theory, which is now embraced by hundreds of physicists, requires 11 dimensions including little curled up ones. Other theoreticians propose even more dimensions. String theory postulates that the universe is made from tiny, vibrating, string-like particles, which can be closed loops like rubber bands or open ended like bits of twine, and multidimensional membranes or “branes.” In **Figure 8.1** we see how a one-dimensional object (a rubber hose) when viewed from afar is in reality a two dimensional object when magnified. **Figure 8.2** shows the actual garden hose coordinates. **Figure 8.4** shows an array of such coordinates and **Figure 8.3** shows how they might be hidden unless greatly magnify. **Figure 8.7** shows two extra dimensions curled up into the shape of a sphere and **Figure 8.8** the two are curled up into donuts. **Figure 8.9** is a representation of a very strange six-dimensional space. But there is really no limit to the number of dimensions so it is reasonable to conjecture that there might be an infinite number of dimensions. It is mind boggling, of course, since like so many things in cosmology, such as relativity, we cannot readily visualize it in the context of our day-to-day experience.

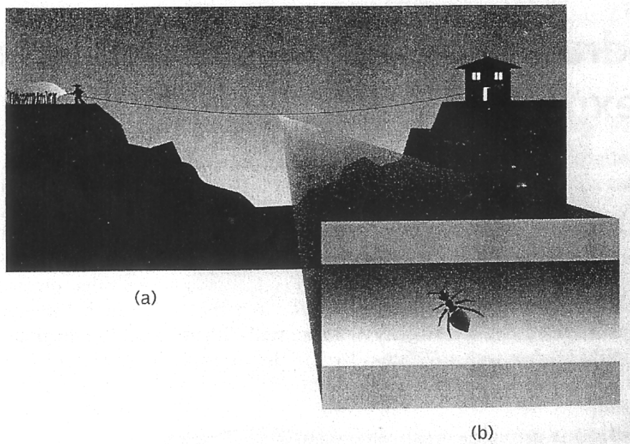


Figure 8.1 (a) A garden hose viewed from a substantial distance looks like a one-dimensional object. (b) When magnified, a second dimension—one that is in the shape of a circle and is curled around the hose—becomes visible.

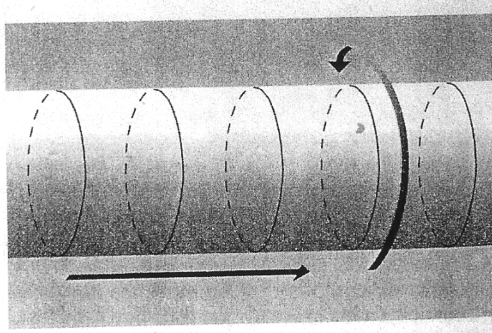


Figure 8.2 The surface of the garden hose is two-dimensional: one dimension (its horizontal extent), emphasized by the straight arrow, is long and extended; the other dimension (its circular girth), emphasized by the circular arrow, is short and curled up.

Next let me take a look at our Universe and a few peculiar things that we observe about it. The first is not so peculiar: we realize that our Universe is not chaotic. There is cause and effect. It is not like when we sometimes dream and jump back and forth in space, time and situation. Dreams can be very chaotic, but they are not like the world we live in -- at least for most of us. The next thing is very peculiar, but only particle physicists can "observe" it. To consider this peculiarity we must take a little journey in magnification. Let's look at the floor here. If we start magnifying we will see fibers, then molecules of which the fibers are composed, then atoms. Up to now all these things are well behaved, that is they are substantive. But let us magnify more, a lot more. Now we see something very peculiar, particles appear, and then disappear – they pop in and out of existence! Amazing, but true. Theoretical physicist call this “...the roiling frenzy of quantum foam." A third peculiar thing or things are black holes – where do they go? *Kip Thorne,* a well-known Caltech physicist once suggest that they could be the portal to another universe – “worm holes”; but the laws of physics prevented such a journey! More recently, a well-respected astrophysicist, *Matt Visser* (now down in New Zealand) and his associates showed that such a journey might be possible – Wow!

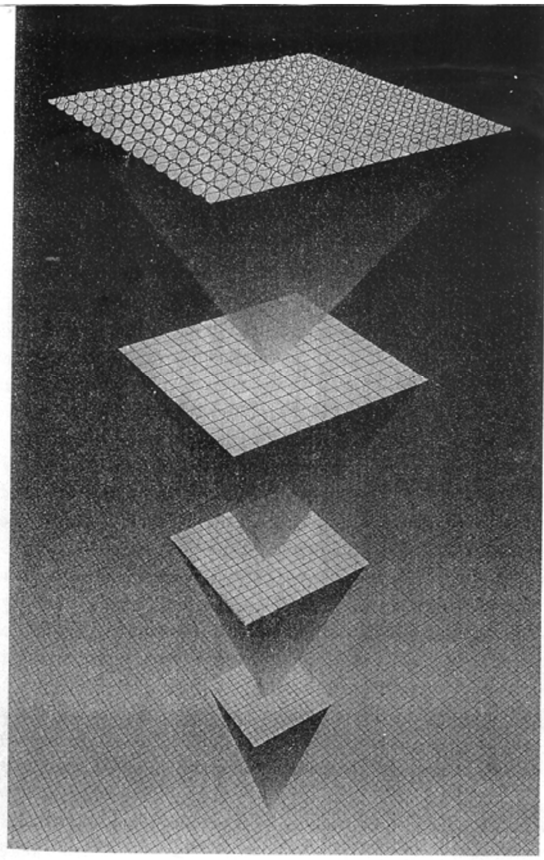


Figure 8.3 As in Figure 5.1, each subsequent level represents a huge magnification of the spatial fabric displayed in the previous level. Our universe may have extra dimensions—as we see by the fourth level of magnification—so long as they are curled up into a space small enough to have as yet evaded direct detection.

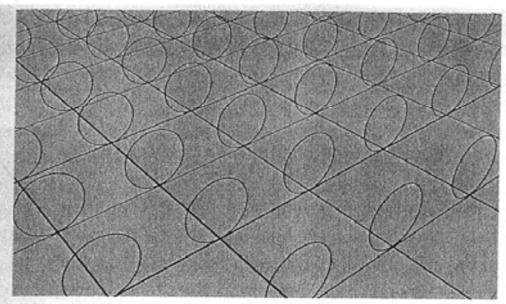


Figure 8.4 The grid lines represent the extended dimensions of common experience, whereas the circles are a new, tiny, curled-up dimension. Like the circular loops of thread making up the pile of a carpet, the circles exist at every point in the familiar extended dimensions—but for visual clarity we draw them as spread out on intersecting grid lines.

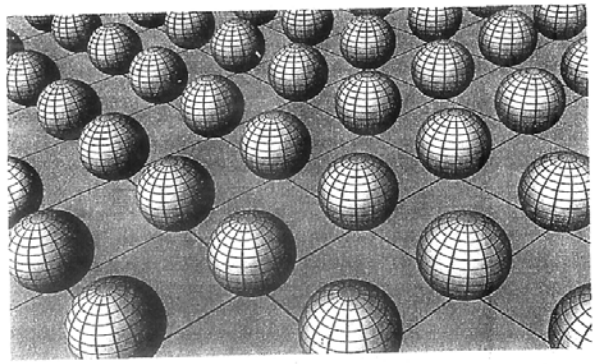


Figure 8.7 Two extra dimensions curled up into the shape of a sphere.

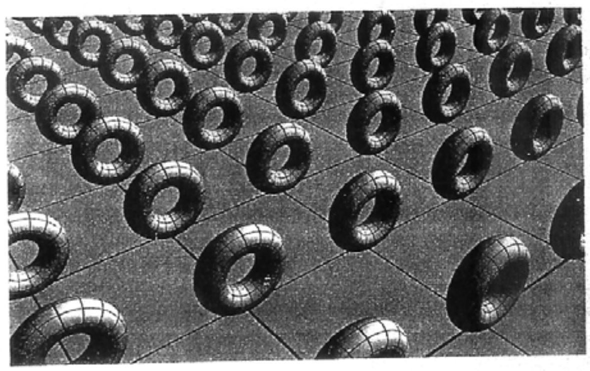
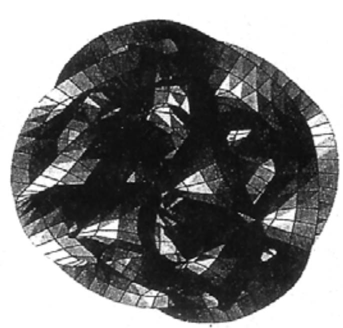


Figure 8.8 Two extra dimensions curled up in the shape of a hollow doughnut, or torus.

In Figure 8.9 we show an example of a Calabi-Yau space.[9] As you view this figure, you must bear in mind that the image has built-in limitations. We are trying to represent a six-dimensional shape on a two-dimensional piece of paper, and this introduces significant distortions. Nevertheless, the image does convey the rough idea of what a Calabi-Yau space looks like.



Calculations Pop the Cork on Travel Through Spacetime Tunnels

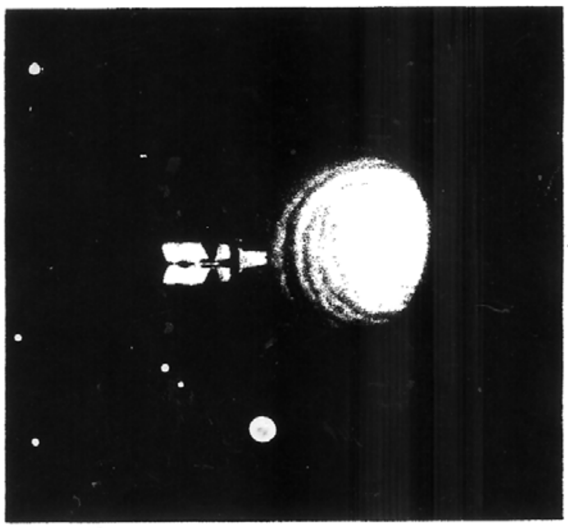
It's not hard to work your way out of a hole ... a wormhole, that is. In science-fiction movies, wormholes—bridges between two regions of spacetime—are handy devices for traveling halfway across the universe in the blink of an eye. Scientists have long pondered whether they were physically plausible (probably, many concluded) and if so, whether spaceships would be able to cross the bridge (probably not). Now, a team of physicists concludes, it might be surprisingly easy to make a wormhole traversable.

Don't book your tickets to Andromeda yet. "We are not going to build a wormhole with current technology or even with presently foreseeable technology," says Matt Visser, a physicist at Victoria University in Wellington, New Zealand, who took part in the work. But he says that studying wormholes allows physicists "to take theories we more or less understand [general relativity and quantum physics], put them together, and see what breaks."

Relativity, oddly enough, stands up just fine. As outlandish as it might seem to move ships and people faster than the speed of light, Einstein's rules permit it because wormholes provide shortcuts across the fabric of space and time. Even so, theorists suspected that spacetime bridges would have to exact a heavy toll.

banish the event horizon and make the wormhole passable. The rules of quantum mechanics require that such exotic matter is forever being created and annihilated on tiny scales. Unfortunately for sci-fi buffs, however, those quantum doses seemed inadequate to get rid of that pesky event horizon. "This made large wormholes prohibitively difficult to even contemplate," says Visser.

Now it seems that the cosmic censor could be defeated. As they report in the current issue of *Physical Review Letters*, Visser and his colleagues investigated a wormhole that is very symmetric and chugged through



Into the breach. A plunge down a wormhole need not be a kamikaze mission, if you bring your negative-energy matter.

Figure 9

Figure 9 exhibits a picture of a spaceship moving into a worm hole as part of a *Science* magazine article.

Then there is the strangeness of the primordial or cosmic-relic background from the Big Bang and dark matter that we can't see, but permeates our visible Universe. The list goes on and on but these are the main peculiarities.

Let us begin where *Thorne* and *Visser* left off – travel from one universe to another, but why just two universes – why not an infinite number of them! Actually this is not a new idea. As noted by *Max Tegmark* I quote: "... another possibility is that the Planck density (a density that was sufficient to initiate a universe) was never attained and that there was no beginning, just an eternal fractal mess of replicating inflating bubbles (universes) with our observed space-time (universe) merely being one in an infinite ensemble of regions where inflation has stopped." Also Ian Osborne, Linda Rowan, and Robert Coontz remark on Steinhart's "... pulsating-universe model posits that pairs of branes may trigger a series of big bangs as they collide again and again ..." thereby generating an infinite number of universes. In my U. S. Patent, 6,160,336, filed in 1999, I discuss "... an infinite, continuum of universes ..." and index them according to a "...'time' location vector..." In Brian Greene's book, *The elegant universe,* one finds references to a "multiverse" system, which although not specified by him as infinite in number could be so construed. Thus the idea of an infinite number of universes is not really new. But using time to index them may be new – we will take up the issue of time in a moment. All of this is, of course, aloof, theoretical, intangible.... so peal out the little string and be prepared to start **a tangible universe of your own ...** you can produce your own Big Bang, but wait until I say "Go" since I am playing Master of the Universes here and you are playing God. ***GO!*** (**Now discuss the "dawn" of light, 10^{-42} seconds, relic galaxies and black holes, the emergence of galaxies, space dimension right and left, time dimension down the rollout, and where we are 13,700,000,000 years later, and infinity)**

Now is the time to look at time itself. At the interface among the continuum of universes, time may no longer have a straightforward meaning. Three quotes set the scene for this contemplation: I Quote:

"Consider a world in which cause and effect are erratic. Sometimes the first precedes the second, sometimes the second the first. Or perhaps cause lies forever in the past while effect in the future, but future and past are entwined."
Alan Lightman, "Einstein's Dreams"

'I don't understand you,' said Alice. 'It's really dreadfully confusing.'
'That's the effect of living backwards,' the Queen said kindly. 'It always makes one feel a little giddy at first.'
'Living backwards!' Alice repeated in great astonishment. 'I never heard of such a thing!'

'But there's one great advantage to it, that one's memory works both ways.'
'I'm sure mine only works one way,' Alice remarked. 'I can't remember things before they happen.'
'It's a poor sort of memory that only works backward,' the Queen remarked.

Lewis Carroll, "Through the Looking-Glass"

"Time possesses a quality that creates a difference between causes and effects evoked by directionality or patterns. This property establishes the difference between the past and the present. Causes and results are separated by space and time."

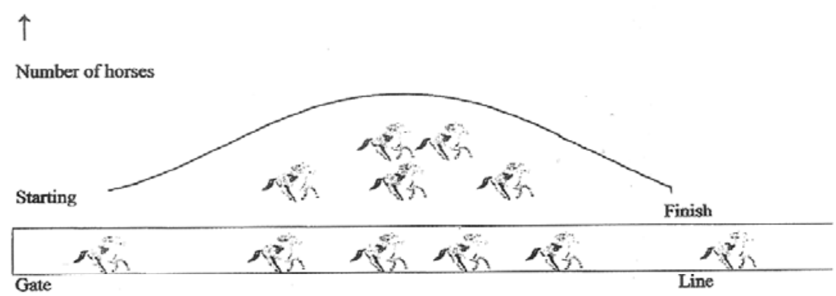
Paul Murad, “It’s All Gravity ...” STAIF 2003.

In our day-to-day experience we accept an infinite continuum of successive or “current” or “present” times and an infinite continuum of “locations” or “positions” in all components of **our three-dimensional space.** It is proposed that we initially extend this concept to an infinite continuum in **time, t.** And **t** is the multiple dimension “time” location vector, including increasing time through the infinite, continuum of universes or the multiverse discussed, for example, by *Brian Greene*.

Continuing with the thumb-nail-sketch conjectures of what I call the Space Time Universe or STU continuum at the most elementary level, the equivalence of the inability to define position and velocity simultaneously and the inherent uncertainty in position and (called *Heisenberg’s Uncertainty Principal)* is simply a reflection of the fact that you can't "see" the entire STU panorama from any one single vantage point. It is an important experimental restriction. As *Osborne* remarked: “... theory reveals that our ‘field of view’ may be limited to a lower dimensional membrane or brane...” This limitation is in contrast to what is seen within the practical, experimental inability to define position and velocity simultaneously within a reference universe. Also as *Carver R. Mead* pointed out “Einstein’s basic point was that unpredictability does not mean intrinsic uncertainty.” Thus there can be complete determinism, cause and effect can prevail, and "God does not have to play dice.” *Einstein’s* fears are not justified. Everything is within the STU fabric with absolute certainty. For example, in different universes at different times everything cannot be "seen.” A "line" cannot connect all "points" in the STU fabric, but the "points" are still there and their resulting "motion" on the fabric should be entirely predictable. Thus it is unfortunate that they can't be "seen" or predicted simultaneously from an outside our reference universe. A more conventional space-time continuum is embedded within the multi-dimensional STU, which we also conjecture may include a multidimensional manifold. As *Mead* so aptly points out “In the end, science is all in how you look at things.”

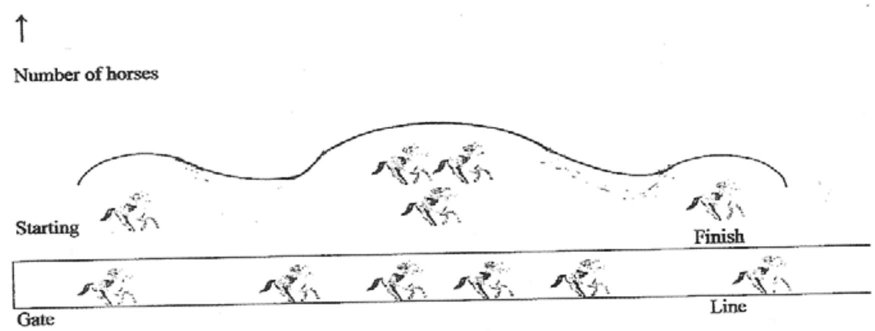
Consider a hypothetical in which a sequence of events is represented by an imaginary horse race involving 1,000 thoroughbreds (actually this analogy came to me while attending opening day at Del Mar in 1999). All horses come out of the starting gate at the same instant of time and their progress (measured in our “nominal” universe) is followed thereafter in a statistical fashion. That is, although individual horses may change their relative position in the “pack” there will be a moving histogram of the distribution of the horses about some median point that moves along the track. Please see the curve above the horses in **the horse-race figures after figure 9 (the worm-hole picture).** Assuming no interaction among the horses and that their capabilities are randomly distributed, the moving histogram of relative horse location will be assumed Gaussian or on a bell curve. He figure on the reverse is a snapshot of an idealized horse race half way through the race.

Horse Race without Time Travelers



Let us now hypothetically warp the STU fabric by a continuous gravitational-energy flux created by a high-intensity HFGW generator. Let us suppose that in a random fashion 20 percent of the horses (200) are *Time Travelers*: 100 will travel to various future times in the same universe and 100 will travel back in time to a different, osculating universe(s). Assuming that the conservation of mass prevails during the universe-to-universe, time-traveling events, an equal number of horses will appear on the track from the past of the same universe or from the future of an osculating universe. Since the universes originating the replacement horses are either the same or tangent to the nominal universe in our horse race, those from the past will tend to appear behind in the pack (closer to the starting gate) and those from the future will appear to be leading the pack (closer to the finish). Thus a statistical study of the race histograms with and without the intense gravitational-energy flux should reveal the percentage of the imaginary time-traveling horses and at what times they are "plucked" from the current and past universes. Thus there would be a trimodal statistical distribution as shown by the three bumps in the second horse-race figure.

Horse Race with Time Travelers



Several different real-physical-event proxies could be utilized in lieu of the imaginary horse race. These include the dispersion of a light pulse, radioactive decay prompted by some triggering mechanism, dispersion of pulses of a particle beam, etc. Statistical measures are utilized to test the concept in order to average out quantum jitters and allow for a "view" of the activity of the wave/particles on very small scales **without** actually "viewing" them as individuals. It will, of course, be important to analyze whether or not the "replacement horses" will, in fact, show up in different places along the pack histogram or whether they will simply fill-in the same positions as the original time-traveling horses that are "plucked" from or "squished" off the racetrack and, therefore, provide no useful information. An object of the present concept will be to determine whether or not such histograms and/or dispersion changes with and without the presence of an intense continuous gravitational-energy flux represents an example of the use of the HFGW in studying physical theories, concepts and conjectures.

As an experiment, under the "stress" of HFGW radiation the actual time reversal among universes might be perceived. For example, assuming an infinite, continuum of universes, there could be a vacillating or "tunneling" from one universe to another on a small scale. It is to be emphasized that the idea presented in this talk is of a natural-philosophical concept or conjecture and **not** a rigorous new physical theory. Since time reversal as opposed to time advancement, violates the fundamental law of cause and effect, each time reversal must spawn a new universe (or "tunnel" to a parallel or layered universe) that is nearly (due to quantum jitter) tangent (osculating) in all dimensions at the time of the reversal. It is hypothesized (along with Greene) that since the smaller particles have a more detailed structure they are more fragile and susceptible to STU geometry warp or tear caused by gravitational stress related to a large gravitational-energy or HFGW flux. Thus smaller scale entities (possibly strings) would pop into existence and be created in our current universe from a slightly future (nearly tangent or osculating) different universe or appear from the past in the current universe. Such smaller scale entities would vanish or disappear into the past into a slightly earlier (nearly tangent or osculating) spawned or parallel universe or into the future in the current universe. In this fashion the rule of cause and effect will not be violated, and we will not have chaos. It is anticipated that the warp of the STU, which is a subset of the conventional space-time continuum or geometry, can be created by a relatively strong HFGW flux. Such a flux can be created from the HFGW generation devices that I have described in some of my papers. **Figure 12.1** shows a cylindrical stack of jerking rims or rings and **Figure 12.2** shows the cross section or one of the rings that represent one of the gravitational wave generators.

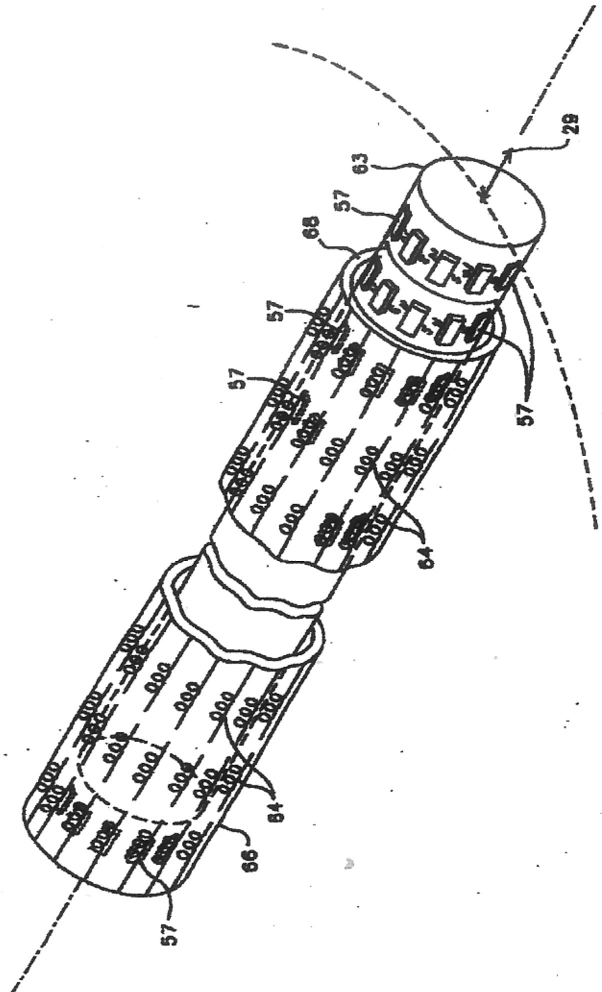


Figure 12.1

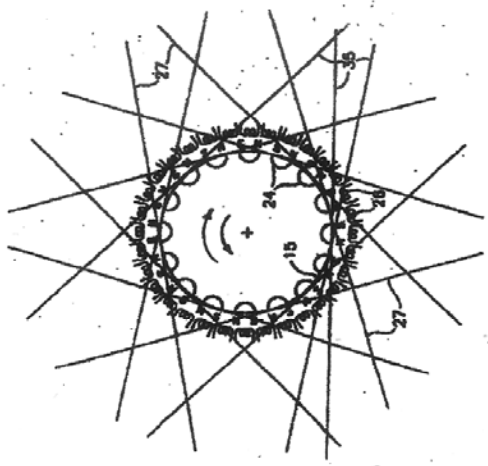


Figure 12.2

Another experiment would involve the HFGW telescope. This instrument utilizes the GW refractive properties of a High-Temperature Superconductor (HTSC). Such an instrument might allow observations of the relic cosmic background and may indeed provide qualitative experimental insights into the concept of an infinite manifold of universes. For example, such observations might glimpse the "fading in and out" of the anisotropic cosmic pixels. An extended source, such as ripples or other anisotropic features of limited angular extent in the relic or primordial cosmic background, can be intensified or concentrated by the HFGW telescope about 10,000 times.

We suppose we are able to transfer (travel or tunnel using Morris and Kip Thorne's (of Caltech) or Visser's wormholes or Coleman's quantum-sized wormholes connected to other universes) from one universe to another at, say, an STU osculation or touching point. Let us consider such a point as a region of tangency between the two different realities. Our purpose might be to travel to a galaxy one million light-years distant or to go backward or forward in time one million years from now. In order to preserve cause and effect to prevent having a chaotic universe, such space travel would not be allowed, but we can do the next best thing. Suppose that we have available two identical universes. Let's call them A and B. Suppose, however, that the spawned or parallel (or layered) universe B is "slightly" different from universe A in that it is either offset by one million light-years distance or by one million years time (whichever destination we wish to achieve). At first A and B will be identical from "the beginning of time" to the osculation point and then B will become different (for all times before and after the osculation point). We first make the transition from A to B at the osculation point (or tunnel – a process akin to that proposed hypothetically by Morris and Thorne and, more recently, by Visser) and collect all the observations that we wish and then transit forward in time one million years in universe B (no violation of cause and effect -- suspended animation, simply put: we go to sleep) to the "time when" the transition took place in universe-A-reference time. Except for the result of our disturbing things as the result of our being earlier in universe B, the situation will be much like universe A at transition time.

IV. Conclusions

It is difficult to find and document suitable evidence that relates to or even finds a passage that connects the past, present, and future within a current reality. The reason is that the technology or the concepts are not there to perform such a task. My intention here is to take an initial step and look at these possibilities and determine a potential gate or portal keeper that would allow inter-dimensional and/or inter-universe space-travel. At this point we can only suggest that in order to analyze our conjecture we must answer several questions such as:

- How do we cross or tunnel into other sequences of realities – other universes?
- What about the fundamental difference between mass or gravity currents or waves of gravity and gravitational waves in the STU?
- What kinds of mathematics and mathematical physics can analytically deal with these conjectures and produce quantitative results? Can we utilize the "Fuzzy Logic' discussed in Bob Toms talk?

And this list of questions is only the beginning!

From the *New Yorker's* July 28 issue some cosmological thoughts by Woody Allen: I Quote: "My advice to anyone has always been to avoid black holes because, once inside, it's extremely hard to climb out and still retain one's ear for music. If, by chance you do fall all the way through a black hole and emerge from the other side, you'll probably live your entire life over and over but will be too compressed to go out and meet girls.

"And so I approached Ms. Kelly's gravitational field and could feel my strings vibrating. All I knew was that I wanted to wrap my (instantons) around her (gravitons), slip through a wormhole and do some quantum tunneling. It was at this point that I was rendered impotent by Heisenberg's uncertainty principle. How could I act if I couldn't determine her exact position and velocity? And what if I should cause a singularity, that is, a devastating rupture (in the fabric) of spacetime? They're so noisy. Everyone would look up I'd be embarrassed in front of Ms. Kelly. Ah but the woman has such great dark energy. Dark energy, although hypothetical, has always been a turn-on for me, especially in a female who has an overbite. I fantasized that if I only get her into a (gravitational wave generator) for five minutes with a bottle of Chateau Lafitte, I'd be standing next to her, with our (gravitational waves) approximating the speed of light and her nucleus colliding with mine. Of course, exactly at this moment I got piece of (dark matter) in my eye and had to find a Q- tip to remove it."

So much for Woody Allen and so much for my talk on cosmology; thank you. Bob Baker

The *Economic Round Table*, The California Club; Fireside Room, 8:00 am, December 12, 2002: Some of this material was abstracted or paraphrased from *Wind Energy Comes of Age* by Paul Gipe, John Wiley and Sons, Inc., New York, 1995.

"Round and round they go!"

Inventive minds have long-sought to harness the wind. Early Egyptians may have been the first when they sailed up the Nile against the current. Crude vertical-axis windmills ground grain in the Afghan highlands since the 7th century. (Please see Figure 1.) By the 17th-century, windmills were such a commonplace technology that the fictional Don Quixote was tilting at them on the plains of La Mancha. According to the French historians, as many as 500,000 windmills were being used in China by the 19th-century and possibly an equal number were scattered across Europe. Traditionally, a history of Western wind technology begins with the first document appearance of the European or "Dutch" windmills in the year 1180. Presumably, the vertical-axis windmills of Persia spread from Middle East across the Mediterranean to Europe and in so doing probably evolved into horizontal-axis windmills. From France, the technology spread across the Channel to Southern England (1199), in nearby Flanders (1190), then on into Germany (1222), and subsequently north to Denmark (1259). Finally, "Dutch" windmills reached Poland in the 14th century.

An English Post Mill (circa 1200) is shown in Figure 2. It is believed to be the forerunner of the better known tower mills common in northern Europe. Just as the sail liberated slaves from the Mediterranean galleys, the proliferation of post mills across the English countryside put power into the hands of those who were previously powerless and liberated women from grinding grain by hand. "The wind was an instrument of social progress" says the historian, Edward Kealey, "It enlarged the community of skilled mechanics and lightened the workload of countless women." Kealey describes the English Post Mill as "appealing, productive, and even mysterious," but the windmill was above all a triumph of ingenuity over toil.

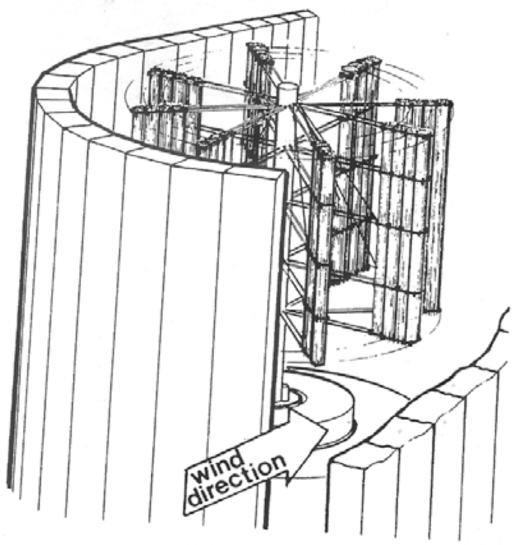


FIG. 1
Persian Wind Machine

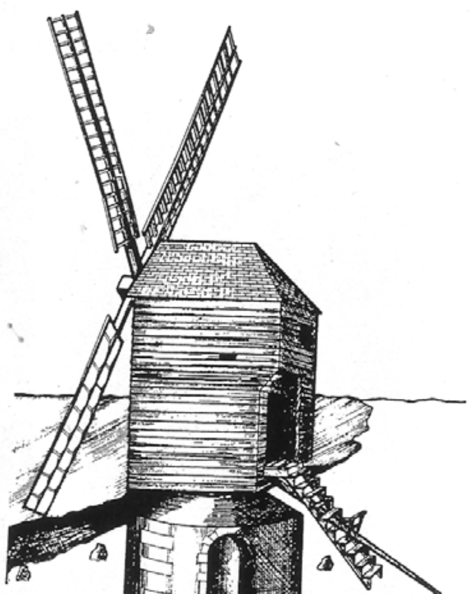


FIG. 2
English Post Mill

The challenge to the growth of wind energy in the twentieth century was, as it is today, not due to the technology's limitations but to resistance from those with the most to lose. The land, the forests, and the water: all were part of the feudal estate. The wind, however, was not. The Church and feudal lords feared losing their lucrative milling rights to commoners who harnessed the free power of the wind.

According to historians, the windmill provided a technology for the "liberation theology" of the era, and devotees went forth spreading the word. Early wind advocates including an obscure cleric, "broadcast an invention" says Kealey, "which challenged the foundations of medieval society." Their proselytizing spread windmills across central England.

The technology took root at a time of rebellion against the tyranny of feudal monopolies. Often, windmills were built in direct opposition to the feudal lord who controlled nearby water mills. Water power was never free of conflicting claims, even at the time of the Magna Carta, which gave the rights of passage and other uses of stream courses to the nobility, but limited the nobility's rights to build structures in water ways.

To an entrepreneur, wind was advantageous on several counts. There were more sites available for windmills than there were for water mills and users were not tied to the river courses, where most prime sites had already been developed. The lower cost of windmills compared to water mills encourage the proliferation at a time when a growing urban population needed new energy sources. The advent of the windmill filled the void and the growth of cities simultaneously breached the hold of the feudal lords.

Feudalism eventually adapted to the threat. During the period 1162-1180, for example, the archbishop of southern France regulated windmills by demanding 5 percent of the grain ground there. In England lords sometimes destroyed windmills that were a commercial threat to their water mills, seized a windmill on a pretext. Yet despite the setbacks to their owners, the modest English-Post windmill flowered, jumped the Channel, and grew to the towering windmills of the lowlands especially in Holland.

The English-Post was reassembled in Holland, and the wind's hey day in the Netherlands contributed to the country's golden age. Windmills "fit" the rural Dutch landscape because they were the available power source during the 17th century. Windmills belonged to Dutch landscape to such an extent that one cannot imagine this landscape without them.

Only by tapping the wind could the engineers drain the polders (areas below sea level, reclaimed or pumped out for agricultural and other purposes) and make the Netherlands what it is today. As late as 1850, 90 percent of the power used in the Dutch industry came from the wind. Steam supplied the rest. The 700 windmills in the district north of Amsterdam formed the core of what would become the center of Dutch manufacturing.

Only in the late 19th century did the use of wind wane. Yet in 1904 wind still provided 11 percent of the Dutch industrial energy. The switch from wind to steam was based on more than cost; reasons included changes in social condition, agricultural practices, and the mood of the rural populace. This could be a harbinger of why wind's star may be in the ascendancy now that it has become economical once again. Wind offers other attributes now considered important such as its ability to generate electricity renewably without combustion or the creation of radioactive waste.

In 1896, at the height of the industrial revolution, wind still pumped 41 percent of the polders in the Netherlands. Only after cheap coal became available from the nearby Ruhr Valley did steam pumping erode wind's dominance. Even then steam was not a clearly superior alternative. Steam required larger polders to perform optimally, and individual polder mills were cheaper than equivalence steam pumps to operate (needed economy of large scale) through the turn-of-the-century.

Just as it is today the capital costs of wind were higher than those of coal. Although the wind was free, capital is not, and much as it is today, once publicly constructed infra structure was available (publicly constructed canals connected the Netherlands with the Rhine and the Ruhr) steam was favored. Steam also required less than one-third the labor used by wind to drain a larger polder. Steam was also available upon demand; wind was not. A long lull could delay spring plant planting until the windmill pumped the polder dry. The steam engine put control over drainage into the hands of the community. For the first time, farmers could manage the water level to maximize crop yields, something not possible with the polder windmills. In addition, steam engines could be placed where ever they were needed, whereas the polder windmills needed sites well exposed to the wind. For these reasons, the European windmill began a long decline in which was not arrested until the late 1970s by preservation societies.

Windmill performance increased greatly between the 12th and 19th centuries with the introduction of metal parts. In the 17th century theses parts were some of first examples of the standardization that eventually led to mass production. By the time the "Dutch" or European windmills began to fall out of favor at the turn-of-the-century, the typical machine used a rotor spanning 80 feet. The stocks in some reached 100 feet in length, the length of the tallest tree that could be shipped. Interestingly, one of the largest windmills ever built was erected in San Francisco's Golden Gate Park early in the 20th century. With a diameter of 114 feet this giant could pump 40,000 gallons of water per hour. Most mills of that time were capable of producing the equivalent of 25 to 30 kW in a mechanical form suitable for grinding grain, shredding tobacco, milling flax, pressing oil, or pumping water for polder drainage.

Three technological innovations made settlement in the Great Plains of the United States possible: the Colt 45, barbed wire, and the farm windmill, wrote historian Walter Prescott Webb. He also warned: "No woman should live in this country who can't climb a windmill or shoot a gun." Promoters extolled the virtue of a land where "the wind pumps the water and the cow chops the firewood." Evidently referring to homesteaders who seldom could find firewood for their hearth on the treeless landscape and instead burned cow chips from their "bovine lumberjacks."

In the semiarid lands west of the Missouri River, the wind did indeed pump the water. Unlike the eastern United States, few streams coursed across the surface of the prairie, and seldom was water within reach of simple hand-dug wells. Water was there, but required pumping by machines -- wind machines. "

T. Lindsay Baker traces the fascinating development of the farm windmill in his exhaustive *Field Guide to American Windmills*. In 1854, Daniel Halladay invented the first fully self-regulating windmill. Until then, turning the spinning rotor out of the wind or reefing the rotor had to be done manually. Halladay changed all that by constructing a multiblade roller (similar to today's farm windmill) made of seven movable segments. Instead of attaching the segments to the hub directly, he pivoted them about a ring. In high winds the segments would swing back into a cylindrical shape or furl. Halladay's patented windmills were immediately popular with the farmers and ranchers for watering livestock. Because the mills could be left unattended, they were ideal for remote pastures where water was scarce. But the fledgling industry began to grow only after the boom in railroad construction that followed the Civil War.

Water was as essential as was coal to running a steam locomotive. As the transcontinental railroad pushed westward across the plains, the water-pumping windmill came into its own. Huge windmills (even by today's standards), with rotors up to 60 feet in diameter, pumped a steady stream into the storage tanks at the desolate railroad way stations. Through skillful marketing, one particular windmill, named the “Eclipse” emerged as the "railroad" mill. Invented in 1867 by Leonard Wheeler, the Eclipse used fewer moving parts and was both cheaper to produce and easier to maintain than Halladay's windmill. Wheeler's design furled in high winds by the simple means of a pilot vane. The idea is so successful that even Halladay's U.S. Wind Energy and Pump Company began producing similar versions under the "Standard" trade name.

The stage was set. The technology existed and an industry was in place. The nation's western migration both caused and was aided by the growth of a great Midwestern industry building windmills and by late 19th century, 77 firms were assembling them in one form or another. Farm catalogs of the day bristled with choices. During the height of the farm windmill glory in 1909, manufactures employed 22,300 workers to service a mass-market program for wind pumping on the Great Plains.

Thus from the 7th century to the 19th century windmill technology and use flourished only to begin a decline in the early 20th century that was finally halted by the need for clean sources for renewable energy. Here we commence the story of modern wind turbines.

In the mid 1990s an old friend of mine, Fred Noble, asked me to develop a new design, a new design for windmill. Fred is the president of Wintec Corporation, a firm that owns about 30 percent of the windmills near Palm Springs and the Tehachapi. At the time I did not realize that the main concern in windmill design was not new technology, but an ability to achieve a large ratio of net profit divided by capital expense and good appearance of the windmills to the public—that is, return on investment and good looks are what matters. Simplicity in design appeared to be the key. Thus I began thinking about the old Persian vertical-axis windmill design. But more of that later. Let us examine the current situation. Today, wind turbines worldwide generate as much electricity as that produced by a conventional power plant fueled with either coal or uranium, and wind energy has done so with a fraction of the financial incentives heaped on those other technologies. More than half the wind-generating capacity in California has been installed since the federal energy tax credits that launched the industry in the early 1980s expired in 1985, and more than one-third of the capacity in Denmark has been installed since 1989, when the Danish subsidy program ceased.

Wind energy has made its most significant contribution in California, where the modern wind industry was reborn and where many had prematurely written its obituary. With 12% percent of the U.S. population and the world's 6th largest economy, California is both a major producer and major consumer of energy. California's serves as an example of both the best and worst in energy policy. Our Golden State produces more wind-generated electricity than any where else on Earth -- nearly half of worldwide production in 1994 -- and more geothermal, biomass, and solar energy as well. Figure 3 shows the split. At the same time, California continues to emit almost as much carbon dioxide as the entire nation of France, and California consumes as much electricity as Great Britain with only half the population.

While not without its problems, wind energy represents a remarkable success story, but the way in which this success was achieved surprises advocates and critics alike. Most had envisioned using wind energy either with small wind turbines installed on farms and at homes scattered across the countryside, or with giant machines erected by electric utilities that used blades stretching 300 feet or more in length. Neither approach succeeded in North America, although Denmark launched a small-sized windmill industry successfully by serving a dispersed rural market. Instead private developers, primarily in California such as Fred Noble's Wintec Corporation, installed medium-sized wind turbines by the hundreds in large arrays and now operate the turbines collectively as wind-driven power plants. The North American wind capacity in Megawatts installed is exhibited in Figure 4. Wind energy is no longer the sole domain of political activists. It is now a worldwide industry with billions of dollars at stake.

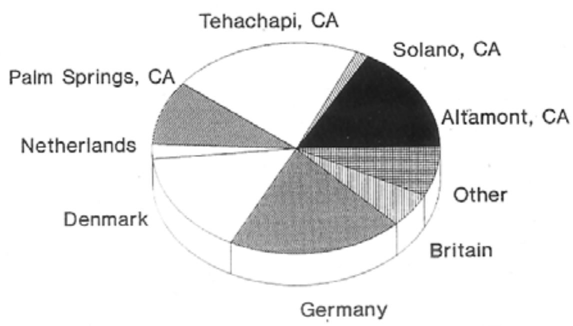


FIG. 3
World Wind Generation

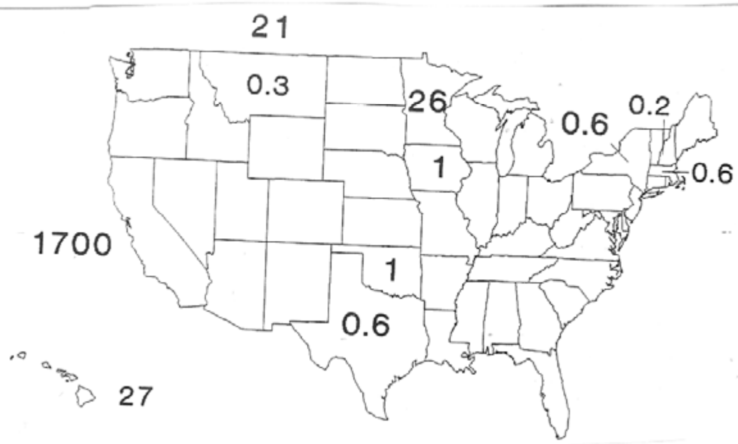


FIG. 4
North American Wind Capacity

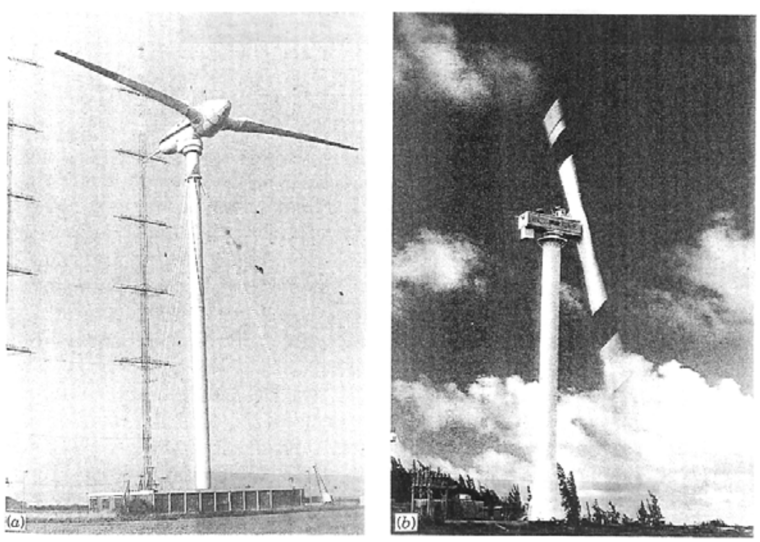


FIG. 5
Goliaths

So what optimizes a windmill design? The designer must not erroneously identify technical optimization with economic optimization. First, as to size: bigger is not better. Two goliath wind turbines are shown in Figure 5. The amount of energy extracted from the wind is approximately proportional to the area swept out by the rotor and that increases with the square of a windmill's dimension. The weight, cost, complexity, and difficulty in maintenance increase approximately with the volume of a windmill's structure, which increases with cube of a windmill's dimension. The cube overcomes the square. There are, of course, some economies of scale: a small windmill requires a relatively expensive miniaturized system for its generator, power train, and mechanism for furling in high winds. Also it is often not tall enough to intercept the higher-speed winds above the terrain's surface. The optimum size is about 80 feet or 25 meters for the diameter of the rotor area swept out. Horizontal and vertical-axis windmills are shown in Figure 6. This particular vertical axis design, shown on the right, is called a Darrieus turbine. An experimental one from the 70's is shown in Figure 7. There is also an "H" type design. Unlike the "egg beater" Darrieus, vertical blades are supported at their centers by struts extending from a central vertical axis – somewhat similar to the ancient Persian design. Such support has run into structural problems and, as shown in Figure 7, the "H" bladed windmills have reached a technological or commercial dead end.

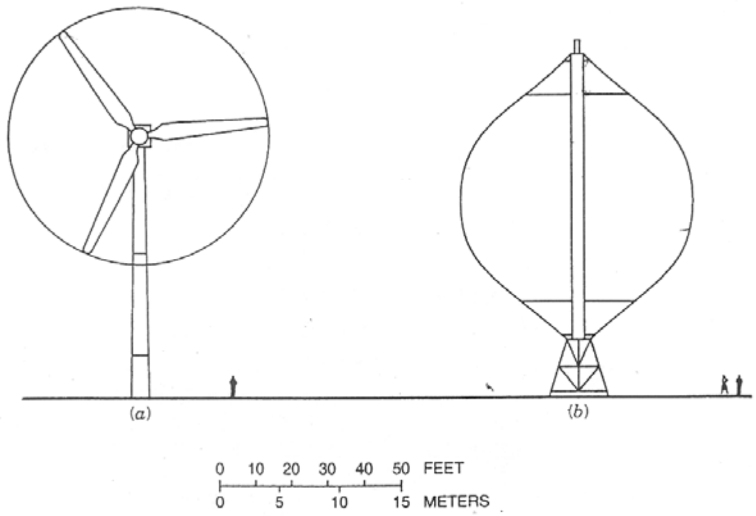


FIG. 6
Horizontal- and Vertical-axis Windmills

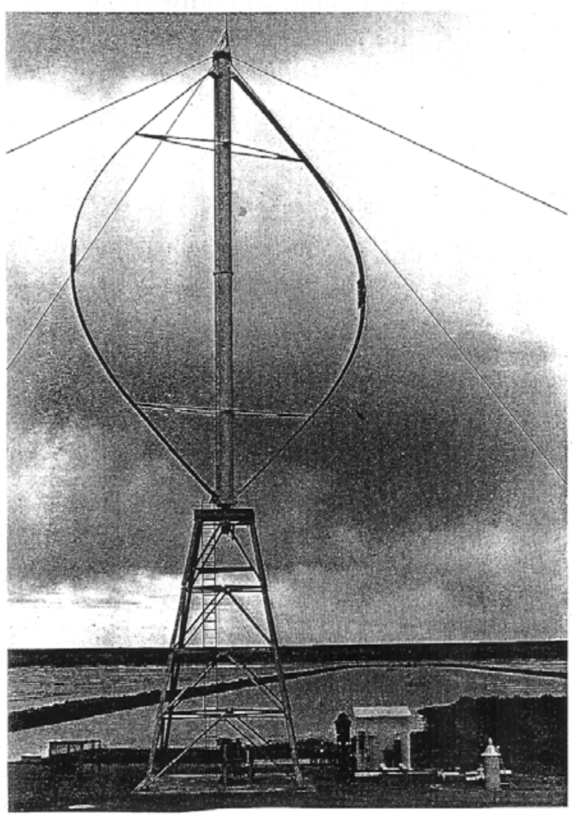


FIG. 7
Experimental Vertical-axis Darrieus

What are the operational and maintenance costs of windmills? Based upon a sampling of projects in the mid 1980’s, it costs between half a cent and one and seven-tenth cents per kilowatt hour to operate and maintain a fleet of existing wind turbines here in California. The average cost hovered around one cent per kilowatt hour. As can be seen from Figure 9, this represents about half the cost of operation, maintenance, and fuel for coal and nuclear plants, and about one-third the cost for gas-fired plants. Maintenance and replacement is an especially interesting problem for windmills. Most windmills find their demise in high, gusty winds-- winds that may not topple the windmill, but may fatally damage its power train. Thus, no windmill design can exclude a fail-safe means for furling in extremely high winds or earthquakes and some means of reducing the injury caused to its power train by gusts. The real difficulty with windmills is the cost of capital to build them. Using an installed cost of $1,050 per kilowatt (during fully operational times) and the cost of financing the machine’s construction in 1996 dollars and one computes the cost of the generated electricity (over a year of average winds in Palm Springs) to be 7.5 to 8.3 cents per kilowatt hour. As exhibited in Figure 10 such a cost compares well with other sources of energy, using other technologies, here in California. But and this is a big BUT, wind power is not available on demand. Like its competition with the steam engine in Denmark many decades ago the availability of power when and where it is needed often outweighs its somewhat lower cost.

Looking at cost of installation from another perspective, most wind plants installed in Europe and here in California during the early 1990s cost $500 to $600 per square meter and were yielding 900 to 1,100 kWh/m^2 per year at energetic sites on the North Sea coast and near Tehachapi, as well near Palm Springs. As far as nominal operating power at the designed wind speeds is concerned it is between 200 [watts / m^2] and 900 [watts/ m^2] with an average of about 450 [watts/m^2].

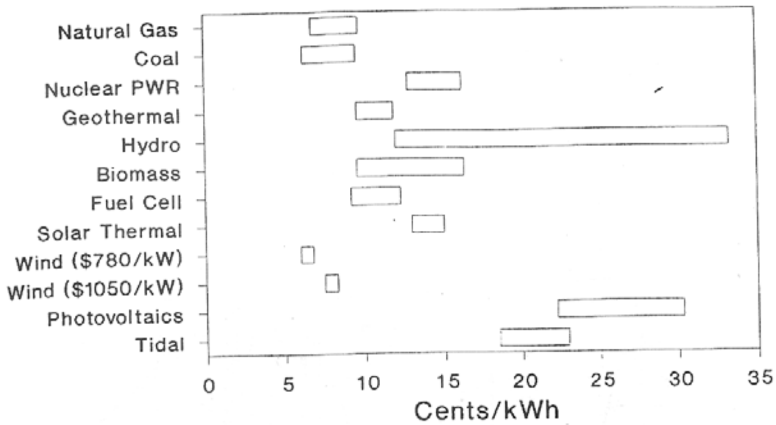


FIG. 10
Cost of Electricity in 1989 in California

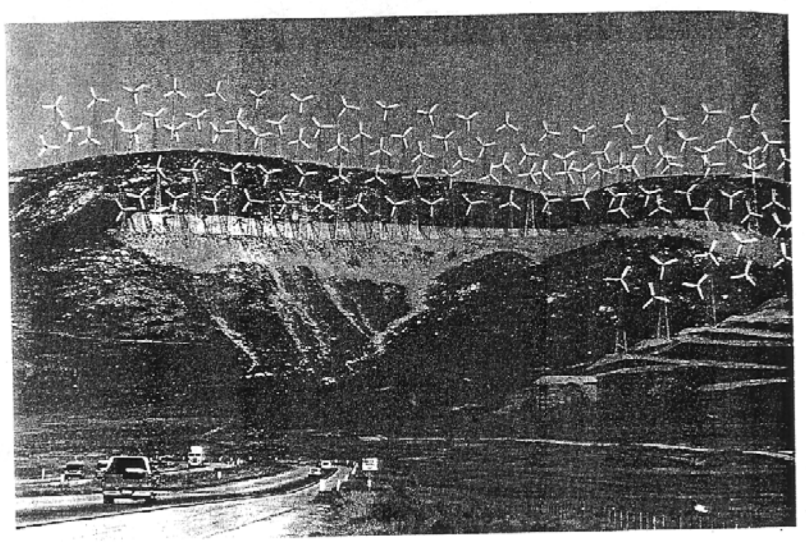


FIG. 11
Scarring

There are concern of "good appearance" and related environmental considerations. There is also a concern of the casual observers of a windmill farm that many of the windmills aren't turning -- the windmills "look" inefficient. Then there's the "scaring" of the countryside as shown in Figure 11. The windmills, especially the high-speed horizontal axis ones, are noisy. Table 1 addresses that issue. Of course there are offsetting environmental benefits of wind energy (and solar) as shown by the emission benefits exhibited in Table 2. An even more interesting statistic is the estimated deaths from power generation per Gigawatt-year estimated by Hamilton and independently by Morris. Their results are shown in Table 3. For wind the death rate has been too small to be statistically significant.

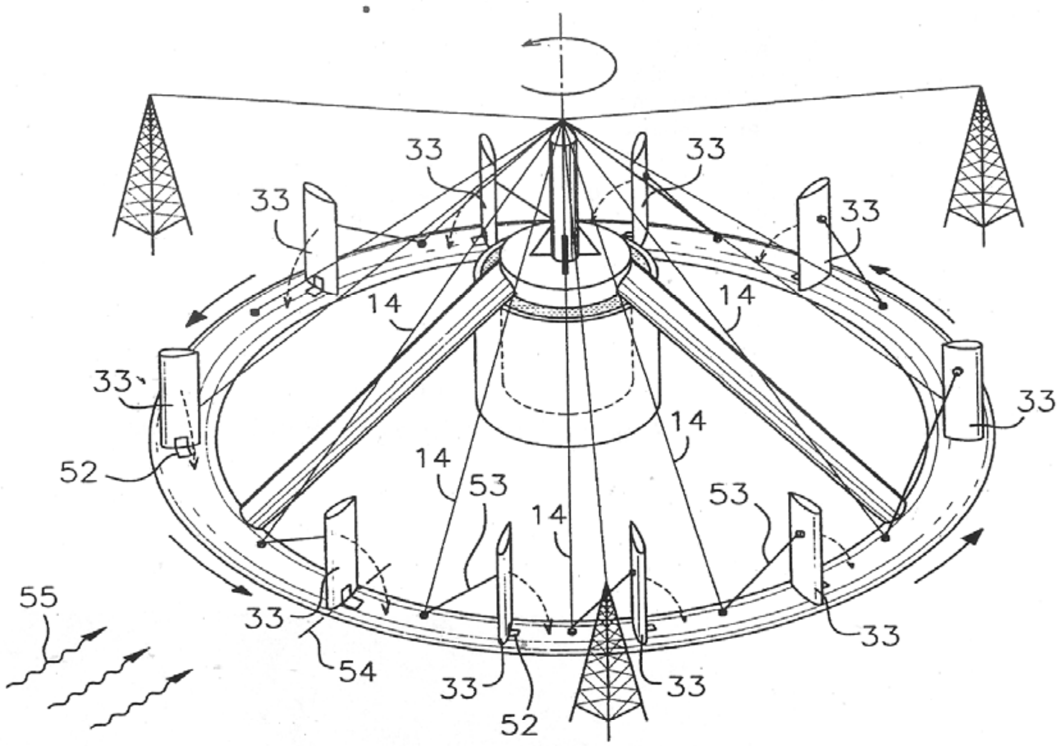


FIG. 12
Newly Designed Vertical-Axis Windmill

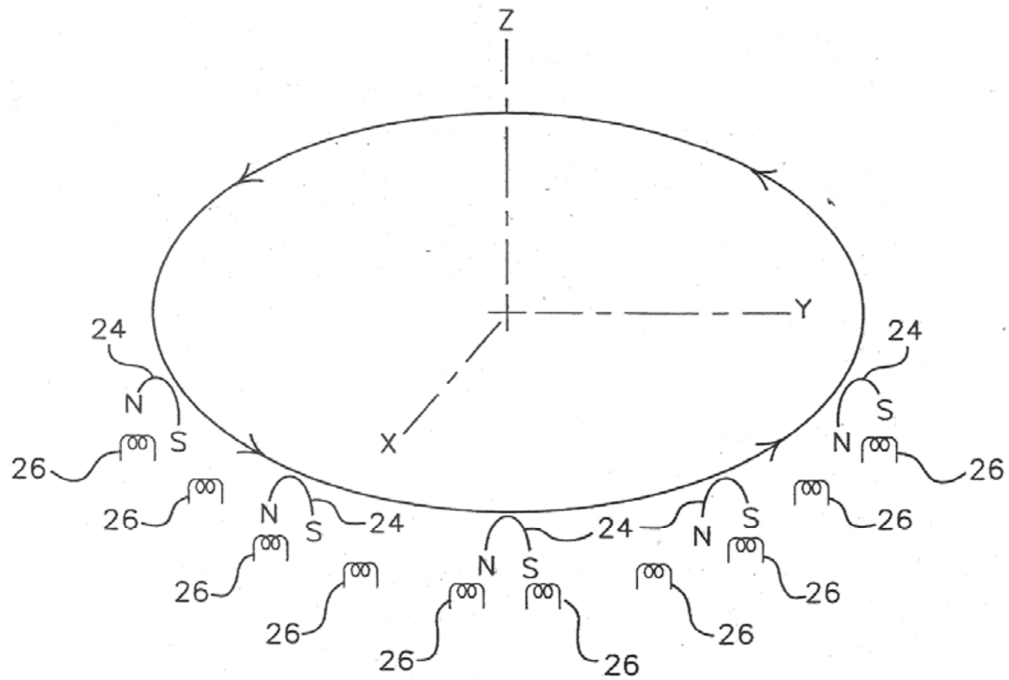


FIG. 13
Magnet and Coil Arrangement for Mechanical-Transmission-Free Operation

Source	Distance from the Source ft	Distance from the Source m	SPL dB(A)
Threshold of pain			140
Ship siren	100	30	130
Jet engine	200	61	120
Jackhammer			100
Inside sports car			80
Freight train	100	30	70
Vacuum cleaner	10	3	70
Freeway	100	30	70
Small (10-kW) wind turbine	120	37	57
Large transformer	200	61	55
Small (10-kW) wind turbine	323	100	55
Wind in trees	40	12	55
Light traffic	100	30	50
Average home			50
300-kW wind turbine	400	150	45
USW 56-100	800	243	45
30- to 300-kW wind turbines	1800	550	45
Soft whisper	5	2	30
Sound studio/quiet bedroom			20
Threshold of hearing			0

Source: Handbook of Noise Measurement, General Radio; Bergey Windpower Co.; and U.S. Windpower.

TABLE 1
Typical Sound Pressure Levels

	Per m^2 of Rotor Area at 1000 kWh/m^2		Per 25-m-diameter Turbine (500 m^2)	
	kg	lb	kg	lb
Average U.S. Emission Rate				
NO_x	4	8.8	2,000	4,400
SO_x	4	9.0	2,050	4,510
Particulates	0.23	0.5	115	253
CO_2	940	2068	470,000	1,034,000
From New Coal-Fired Power Plants in the United States (Fuel Cycle Includes Mining and Processing)				
NO_x	2.5	5.5	1,250	2,750
SO_x	3	6.6	1,500	3,300
SO_x without controls	6	13.2	3,000	6,600
Particulates	1.5	3.2	750	1,600
CO_2	908	2000	454,000	1,000,000
Trace metals	0.11	0.248	55	124
Solid waste	213	468	106,500	234,000
From New Gas-Fired Combined-Cycle Plants in the United States				
NO_x	0.07	0.162	35	81
SO_x	0.005	0.011	3	6
Particulates	0.07	0.143	35	72
CO_2	487	1071	243,500	535,500
From New Oil-Fired Combined-Cycle Plants in the United States				
NO_x	0.19	0.414	95	207
SO_x	0.25	0.55	125	275
Particulates	0.15	0.319	75	160
CO_2	647	1423	323,500	711,700

TABLE 2
Typical Emission Benefits from Wind Energy

	Hamilton				*Morris*			
	Occupational Accidents	Disease	Public	Total	Occupational Accidents	Disease	Public	Total
Coal	0.46	0–4.7	4–150	10–150	0.53–0.93	0.13–8.7	0–320	1–320
Oil	1.63		1.3–130	3–130				
Gas	0.21							
Nuclear	0.35	0.18	0.067	0.5	0.14–0.6	0–0.90	0.2	0.352

TABLE 3
Estimated Deaths from Power Generation per Gigawatt-year

There is another concern associated with the utilization of wind turbines for the generation of electricity. Most of the early wind turbines (such as the farm windmill) drove DC generators. The generated DC current was just fine for charging batteries, but had to be changed to AC through use of inverters in order to be stepped up by transformers to high voltages necessary for efficient long-distance transmission. Not only are inverters expensive, but they also waste electrical energy. For the larger windmill there are two primary approaches. First, one can utilize constant rpm generators that can produce the 60 cycle AC current utilized in most electrical grids. Often two generators can be connected alternatively to the wind turbines depending upon wind speed -- one for low- speed winds and one for higher wind speeds both producing the same 60 cycle AC electricity. In very low-wind speeds, for example below 15 knots, neither generator works and the same is true at higher wind speeds, for example, 40 to 50 knot winds. There are also mechanical-transmission problems in wind gusts as well as a reduction in the range of wind speeds at which such wind turbines can operate. Second, one can utilize variable-speed DC generators and employ inverters to match the grid's voltage, frequency, and phase. In either case the matching process is an important one. Years ago I had an engineering class at UCLA in electrical generation using steam generators. The big problem was not so much to get the generators operating, but to get their output at the proper voltage, frequency and phase to match that of the local electrical grid. Fortunately, we were able to get this accomplished early in the course and generator ran during the summer for over a month. It so happened that during that Summer a meter reader arrived at the main university electrical meter and noted that it was running backwards (he didn't realize this was because we had our generator on line and during the Summer the University was using less electricity than we were generating). He concluded that the meter leads were incorrectly wired and reversed them. A month later another checker from the DWP came to the read the University's meter. Since our generator was now off line, the meter was again running backwards, but now the meter reader took the now improperly wired meter reading literally and concluded that the University was actually generating electricity. A week later the University received a check from the DWP for that generated power!

Before getting into the specifics of a new design, a word about the hubris of American aerospace engineers. Windmills are power plants that must operate hours on end with little or no maintenance. Consider that American Airlines spends 5.5 hours of maintenance on a new low-maintenance, short-haul jet for every one hour in the air. Wind companies can afford only a few hours of maintenance on their wind turbines for every thousand hours of operation. The value of wind turbines is principally in the energy they generate, and energy is the product of power and time. A powerful and highly efficient wind turbine produces little energy if it breaks down soon after installation. New-technology, aerospace efficiency, though important, must take second place to reliability in wind turbine design. Neither aircraft wings nor helicopter blades are directly comparable to wind turbine blades. Experience and intuition taught early millwrights their craft. This resulted in a body of knowledge sufficient to build wind turbines up to 28 meters or 90 feet in diameter. Some lasted for several hundred years. For sure "... a design life is 350 years..." ain't bad! Early millwrights may have had a better understanding of the design of wind turbines than many modern aerospace engineers – including me.

OK, now that we have most of the relevant information available, what are the parameters or features that must guide the design of a "new" windmill and what values do we assign to these parameters or features for an optimum design? The parameters include:

(1) Windmill size.
(2) Annualized power generated by the windmill for its location.
(3) Windmill power at the optimum wind speed for the windmill.
(4) Capital investment or initial-cost of the windmill.
(5) Annual operating, maintenance, and prorated replacement cost or depreciation.
(6) Appearance, environmental impact, etc.

(1) Let us take the linear dimension of our designed windmill to be the aforementioned optimum size of 25 meters so that the area intercepting the wind is approximately $\pi\ (25/2)^2 = 490\ [m^2]$.
(2) In order to be competitive with other designs the annualized power should be about (1,000 kWh/m^2)x(490 m^2) = 490,000 kWh per year.
(3) At 450 [watts/m^2], the rated power of such a windmill would be (450 [watts/m^2]) x (490 [m^2]) = 220 kW.
(4) The cost or capital investment required should be about (\$550/m^2)x(490 [m^2] = \$270,000.
(5) The design should have especially low maintenance costs. Here is an area open for innovation and a floating water bearing is utilized in my optimized design that never wears out and is maintenance free. Other parts of the windmill may require some maintenance, but it would be trivial. Blade replacement and replacement of the small radial jewel bearings (only the upper one comes under much stress) might be needed; probably less than \$1,000 per year can be set aside for this purpose.
(6) As far as appearance and environmental impact is concerned, a low-speed vertical-axis windmill is indicated that resembles a carousel and makes very little noise. Also, since there is no sticksion, the windmill will rotate even in the lightest winds.

Finally, there is the problem of a wind-turbine to generator transmission --a transmission that would breakdown especially in wind gusts. Another innovation is to simply **eliminate** the transmission and make the carousel itself essentially the armature of the generator. As we will see such a device also provides a simple, computerized means to match the voltage, frequency, and phase of the electrical grid without the need for inverters or constant-speed generators..

A sketch of the preferred design is given in Figure 12. It is part of US Patent 6,160,336 that Fred Noble and I have been granted. The electrical generation aspect of the invention uses the fundament physical principle that the motion of an electrical conductor through a magnetic field generates electricity. A shown in Figure 13 there are a series of permanent magnets situated at the periphery of the carousel ring. There are situated under or at the side of these magnets, on the ground, a series of coils that can be connected in different sequences by a computer, thereby achieving a voltage, frequency and phase match with the electrical grid. As the carousel rotates, due to the action of the wind on the vertical blades, the magnets are carried around and their magnetic fields move through the fixed coils and thereby generate electricity. High wind speeds cause the flexible blades to bend and thereby automatically reduce the force on the carousel and slow it. If an earthquake or other emergency is sensed, then water is drained out of the central water-bearing tank or bay and the carousel ring quickly drops into a shallow channel of water below it and the apparatus comes to a complete halt.

What is the ultimate, environmentally friendly, energy system for our planet Earth? I'll pass around a diagram of it copied from a recent issue of the magazine, *Science.* At the very fundamental level, we are acquiring energy from the Sun. It is acquired either directly from its radiation or indirectly from the winds created by this radiation. This energy in the form of electricity will be transported by high-temperature superconductor means (using cooled liquid nitrogen from our atmosphere) and utilized directly (by motors, lights, electronics, etc.) or indirectly by generating hydrogen from water (also releasing oxygen into our atmosphere) and using the hydrogen to power fuel cells for vehicles whose exhaust is simply non-polluting water. As Henry Keck suggested when we discussed this rather utopian concept last week; practically speaking nuclear and coal electrical-generation plants will probably remain the major sources of energy on our planets for many decades to come. On the other hand, wind power is a viable energy source and will remain so using some economically advantageous windmill designs such as the one that I have demonstrated today. – Any questions?

Some sections, figures and tables of this paper were copied from *Wind Energy Comes of Age,* by Paul Gipe and United States Patent Number 6,160,336; inventors Robert M. L. Baker, Jr. and Frederick W. Noble.

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"A BIG JERK"

by

Robert M. L. Baker Jr.

Economic Round Table

November 30, 2000
(The fireside room, The California Club)

Outline

(1) Ninety-five years ago a 26-year-old acquaintance of the Irish physicist George Francis Fitzgerald had just had his Ph.D. thesis rejected -- rejected for the second time. This was not his first disappointment since he had originally failed his university entrance examination. He did have a job as a third-class technician at the Swiss Patent Office -- although at the bottom rung, it provided plenty of time for him to cogitate and develop new ideas. As the young man put it "The solution came to me suddenly with the idea that our concepts and laws of space and time can only claim validity in so far as they stand in clear relation to our experiences, and those experiences could very well lead to the alteration of these concepts of space and time." Thus Albert Einstein thirst formulated his theory of Special Relativity. A decade later came his general theory of relativity -- an even more sophisticated concept.

(2) Remember: One seldom really understands concepts and theories -- but becomes comfortable with them if they are in our range of experience; for example, **gravity**. In this regard, **please do not hesitate to interrupt me at any point if you have questions or require clarification!**

(3) General Relativity:

(3.1) Equivalence of gravity and acceleration in an "Einstein Elevator." For example, acceleration caused by gravity (weight) is the same as any force, for example, electromagnetic force. A force is a force is a force.

(3.2) Time and space disappear with material things. That is, matter (stars to atomic nuclei) are inseparably connected to time and space and vice versa. "Things" are all but hills, valleys, and holes in the fabric of *spacetime*. This is a very exotic concept and most of us are hard pressed to visualize it! It is **not** in our range of experience. Consider two explorers starting out at different points on the equator and heading due North. As they proceed North they will get closer together – they are in a sense "attracted" to each other. This "attraction" is really a property of the geometry! (Show the globe.) Geometry is everything! We observe that the planet Mercury's perihelion (closest point to the Sun) is shifting and that light is bent by the Sun's "gravity". But it's all geometry like a bowling ball on a rubber sheet with a baseball rolling around it – a ruelet ball that never comes to rest

(3.3) It is not even this "simple" though, and complicated by useful, but sophisticated mathematics, for example, tensor analysis is required in order to produce quantitative results from general relativity.

(4) One practical quantitative consequence of general relativity is "gravitational waves" (GW) and the quadrupole approximation to estimate the strength of their source.

(5) But, first, what are gravitational waves? Let us look at the poster and compare GW with other kinds of waves.

(6) Unique qualities of GW (believed by **all** theoretical physicists -- **not** an issue):

(6.1) GW have little influence on material things. It's something like heat waves seen in the desert. Changes in the light path or "geometry " due to the hot air, …it's like a shimmering ghost and essentially does not absorb the light, but deflects light and could "transmit" information if one changed the desert's surface temperature by a signal fire or some other controlled heating device.

(6.2) GW pass through matter almost unimpeded.

(6.3) GW propagate in a vacuum at the speed of light in a vacuum.

(7) Are GW controversial? Here we turn to a Literature Survey (looking at the results of others, not new theories):

(7.1) GW have never been sensed on Earth. And their generation on Earth is not controversial – *today no one in the general-relativity community believes that GW can be produced artificially on the Earth!* Professor Joseph Weber and his student, Dr. Robert Forward, experimented with what is now called a "Weber Bar" at the Hughes Malibu Research Center while I was running a Lockheed research center in Bel Air in the '60s. I invited Dr. Forward out to lecture to my staff. There was little or no success in detecting GW using the "Weber Bar". There the issue of GW rested for a decade. In the 1970s Hulse and Taylor began to study radio emissions from PSR 1913 +16 (a neutron double star; observed by the Arecibo radio telescope in Puerto Rico). They determine that this star pair was slowing down **exactly** as predicted by Einstein in his general theory of relativity due to the emission of gravitational waves! That is gravitational waves carry away energy. For this they were awarded the Nobel Prize in physics in 1993. All now believe that GW waves exist, but nevertheless no one accepts the possibility that GW can be generated terrestrially.

(7.2) Laser (long baseline) Interferometer GW Observatory (LIGO) is being built at Cal Tech. It has been funded to detect extraterrestrial GW by a 500 million-dollar grant from the National Science Foundation. Over a dozen other such GW observatories are being constructed internationally. Some are even being planned to be satellite based.

(7.3) GW generation on Earth seems open to question – **but in truth it is not**:

(7.3.1) If you believe Einstein, then a gravitational force is no different than any other force. And quoting from a writing of the pioneering authority on GW, Joseph Weber in 1964 (p. 97): "There is no reason to believed that particles moving under the influence of electromagnetic forces or nuclear forces will not radiate (GW)… the non-gravitational forces play a basic role in methods for detection and generation of gravitational waves…". **It is NOT necessary to use gravitational attraction to generate gravitational waves!** In fact, Weber indicates that Leopold Infeld indicated that you could **not** use *gravitational forces* to generate GW , only non-gravitational forces – Infeld was proved wrong, **any** force can be utilized – gravitational force is so weak, it is not a good choice anyway. *Weber's assertions have never been challenged in the scientific literature.* Once theoretical physicists go back and reread Einstein, Grossman, and especially, Joseph Weber, they will believe the foregoing, skepticism will begin to clear, and the door will slowly open to the possibility of terrestrial GW generation! In fact, the term "gravitational waves" could be replaced by the term "force waves" since it is the change in force, any force, or jerk that results in the waves or ripples in the *spacetime* fabric. In this regard, the wave/particles for such a force wave should reasonably be defined as "*forceons*" or "*massons*". Such wave/particles would be analogous to *photons* associated with electromagnetic waves and *gravitons* associated with gravitational fields.

(7.3.2) It is recognized that electromagnetic forces are 10^{42} to 10^{44} (10 with over 40 zeros after it) times larger than gravitational attraction. Thus from the poster, where the quadrupole moment is indicated, there is a possibility of making the kernel sufficiently large to produce significant GW on Earth.

(7.3.3) From freshman physics we know what the $d^3(\ )/dt^3$ means; it represents a third time derivative, that is $d(\ )/dt$: speed, $d^2(\ )/dt^2$: acceleration, and $d^3(\ )/dt^3$: " jerk"

$\Delta f/\Delta t$, the jerk, is involved in the kernel of the quadrupole equation as discussed in my recent *American Institute of Aeronautics and Astronautics* (AIAA) paper. The time interval, Δt, is inversely proportional to the GW frequency.

Thus if we can go to high frequency, in fact to ultra-high frequency, that is, to very small Δt (along with a very large Δf) it makes for very large kernel. Note that the double star, PSR 1913 +16, has a period of 7.75 hours or about 30,000 seconds, whereas advanced ultra- high-speed switches might possibly create short pulses as small as a picosecond (1/1,000,000,000,000 seconds), that is, a very small Δt. Practical switches may not be quite this fast yet, but we are getting close.

(7.3.4) We now can do arithmetic with the quadrupole shown in the poster to determine approximate GW power by calculating the "jerk". In fact, using the "jerk" approach one obtains a value for GW power from double star PSR 1913+16 that is within 1.3% of the more conventional approach! From the GW power we can compute the bandwidth of the communications link (please see the poster).

(8) How do we actually get such a "jerk" (that is, such a large third derivative in the kernel)? Here comes the fourth element of the analysis: imagination (it is in addition to a literature survey, freshman physics, and arithmetic).

(8.1) At such high frequencies with an electron mobility speed about that of the speed of light, the electrons move about 0.3 mm in a picosecond -- so that is the length of a current pulse and the length of the coils. Thus very small coils are needed and millions of them in order to produce the impulsive force, Δf, in a magnetic field. This would have been a huge problem ten or more years ago -- not now -- silicon wafers and eventually nanomachines, perhaps encased in such wafers, will do the job. This is shown in FIGS. 1 of the poster.

(8.2) Let's look at one way of generating GW. Consider FIG. 2 of the poster. Here we have what is essentially a piston with lots of small magnets on its surface that is jerked along by pulsing the little coils surrounding it in a sheath. If the proposed device is somewhat similar microscopically to the collapse of a star, then as Dr. Burdge of the NSA stated in a letter to me dated 19 January 2000 "… the gravitational vector will propagate along the axes of the (star's) mass collapse." Or in this case along the axis of the motion of the piston (GW goes both directions).

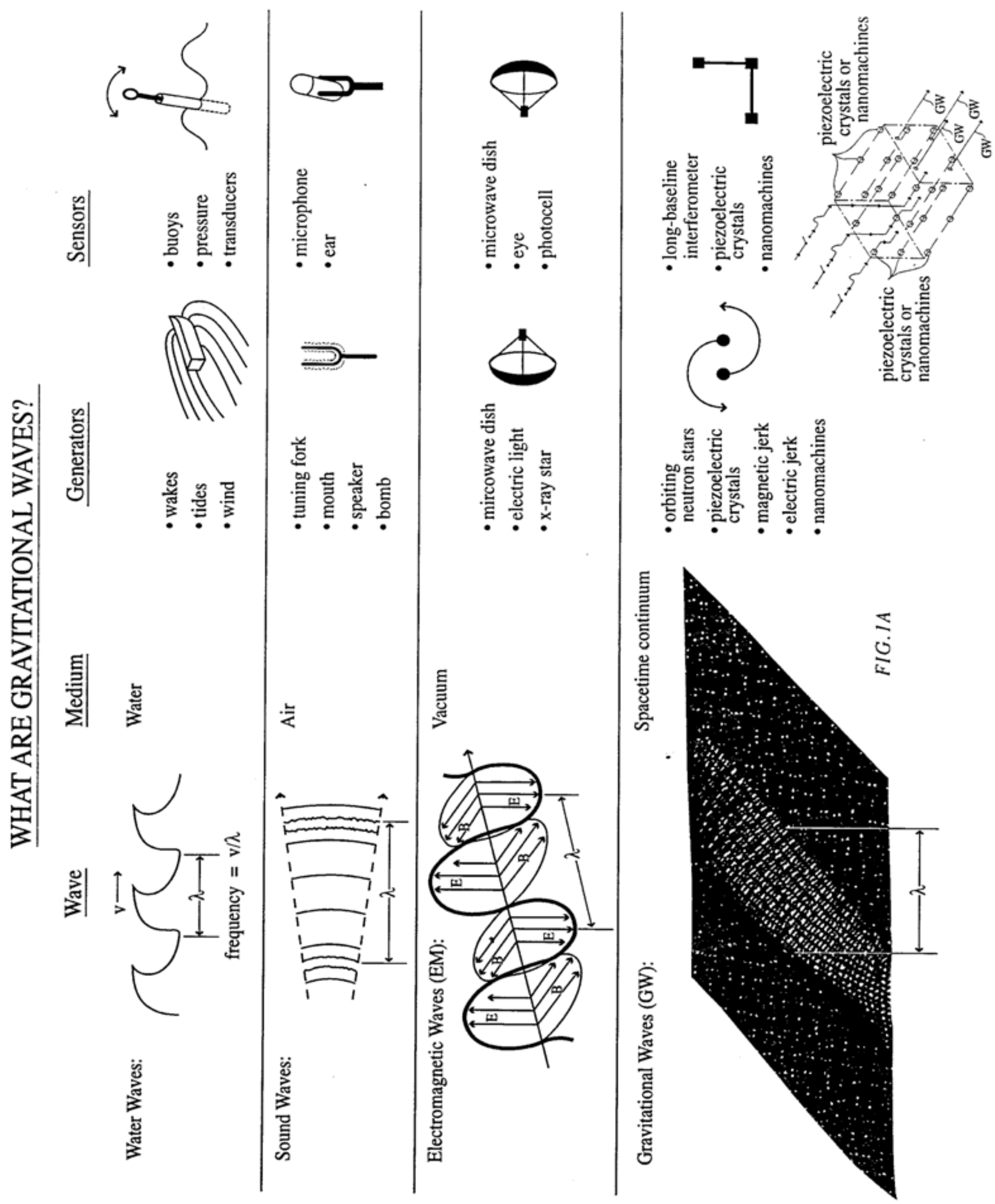
(8.3) Also we will have an ability to "shape" or modulate the GW as it builds up along the piston in order to transmit data (e. g., an "Internet backbone") by controlling the ultra-fast switches that trigger the current pulses by a computer. (I call this the Individual Independently Programmable Coil System or IIPCS.)

(8.4) Other alternative ways to generate GW, for example, wires carrying parallel currents --, piezoelectric crystals, nanomachines, etc. are also shown on the poster. With regard to piezoelectric crystals, Joseph Weber, the acknowledged GW authority, stated in a 1960 paper (pp. 306-313) "Waves (GW) one meter long could be radiated by a crystal of dimensions about 50 cm (about 20 inches) on aside and radiate about 10^{-20} watts…" since GW frequency equals light speed divided by GW wavelength = $3x10^8$ meters per second/one meter equals 300 MHz – a high frequency, but not the nearly THz ultra-high frequency considered here. The problem is that we could not grow crystals that large and that in the astrophysical community there is little or no interest in GW frequencies above a kHz since most astrophysical events are on the order of seconds if not thousands of seconds. **Note, however, that Weber's assertion concerning the generation of gravitational waves on Earth has never been challenged**; *it is simply that up to now no one has taken the possibility seriously of using high-frequency jerks caused by strong electromagnetic forces!*

(9) Spacecraft propulsion?

Landau and Lifshitz on page 349 of their book (Lifshitz was a friend of Einstein's in the 1930's; their book is a Bible in the general-relativity community) comment: "Since it has a definite energy, the GW is itself the source of some additional gravitational field. Like the energy producing it, this field is a second-order effect in the h_{ik} (tensor describing a weak perturbation of the galilean metric). **But in the case of high-frequency gravitational waves the effect is significantly strengthened...**" (Emphasis added.) Thus one could conceive of a "tractor beam" like in *Star Trek* to catapult a spacecraft to the stars. Actually, however, my motivation for emphasizing spacecraft propulsion in the AIAA paper, which I recently gave in Long Beach, is that aerospace people are not especially enthusiastic about the GW communication since it might result in a reduction in satellite transponder links!

(10) There you have it, a practical application (*intercontinental high-data-rate communication right through the Earth's mantle*) of Einstein's general-relativity theory (gravitational waves) provided by a literature survey, freshman physics, arithmetic, and a little imagination – a project that my partner, Fred Noble, and I intend to pursue on our own—Any questions?



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FIGS. 1 of the Poster. Silicon Wafer on Right.

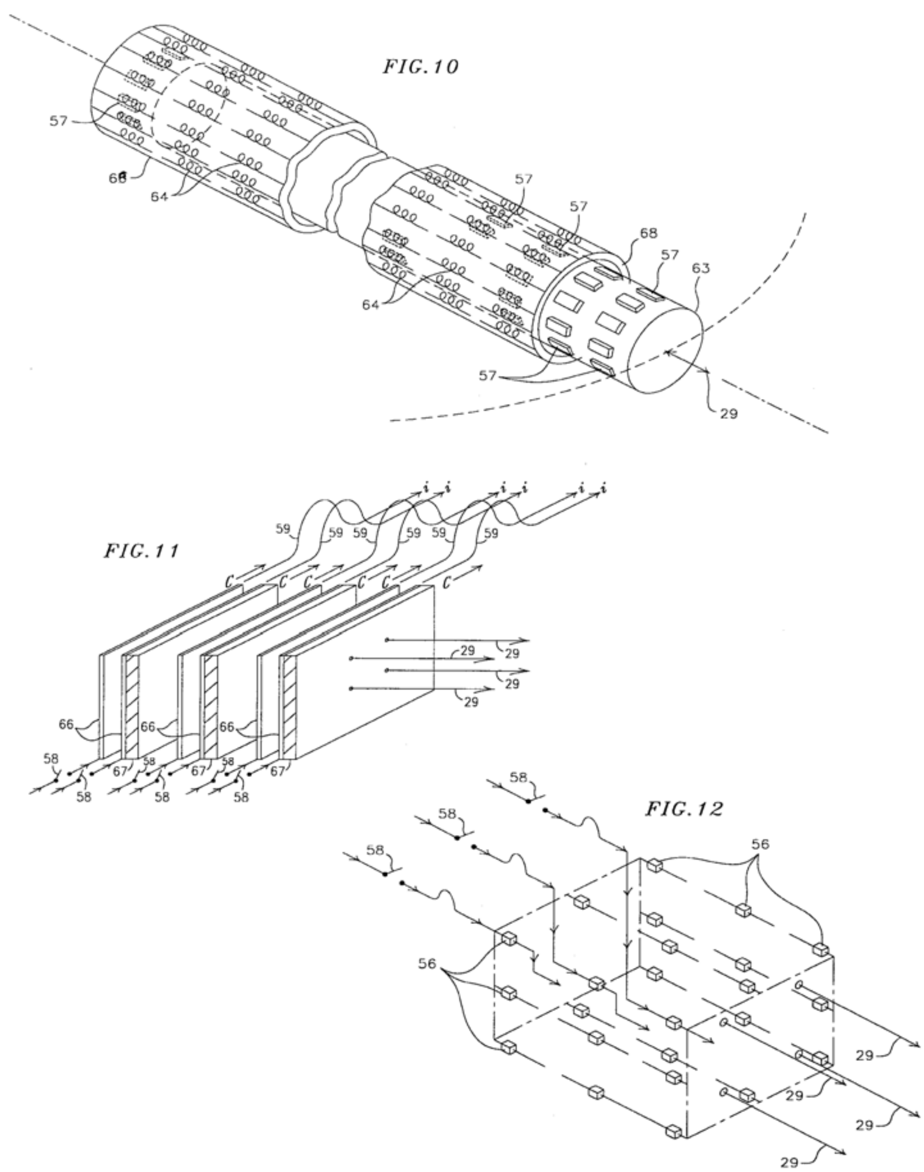

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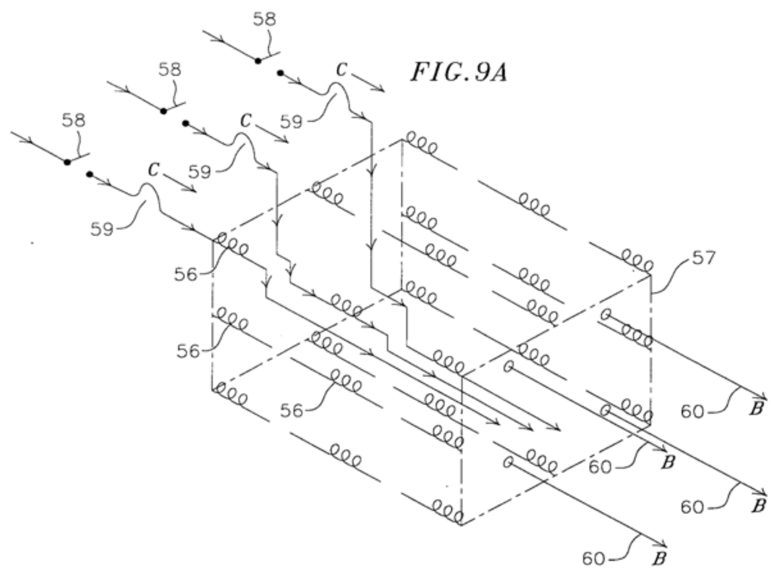
FIG. 2 of the Poster. At Top Piston with lots of Small Surface Magnets.



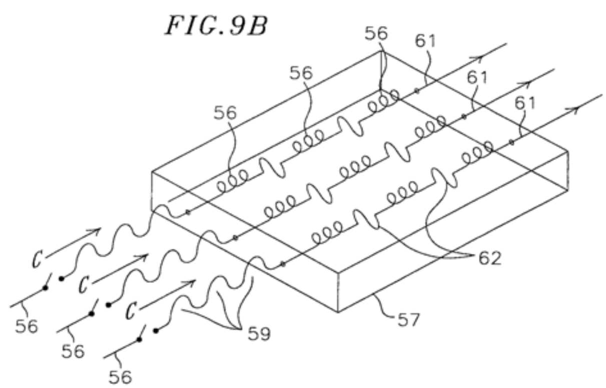


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FIG. 3 of the Poster. Ultra-fast Switches that Trigger Current Pulses.

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Economic Round Table, The California Club,
Fireside Room, 8:00 am, November 17, 2001:

TWINKLE, TWINKLE LITTLE STAR

"Twinkle, twinkle little star how I wonder what you are?

Way up there among the clusters, surrounded by a disk of dusters.

What is that I see whirling about you—why it's a planet -- one, or even two?

Our space telescopes found that clue"

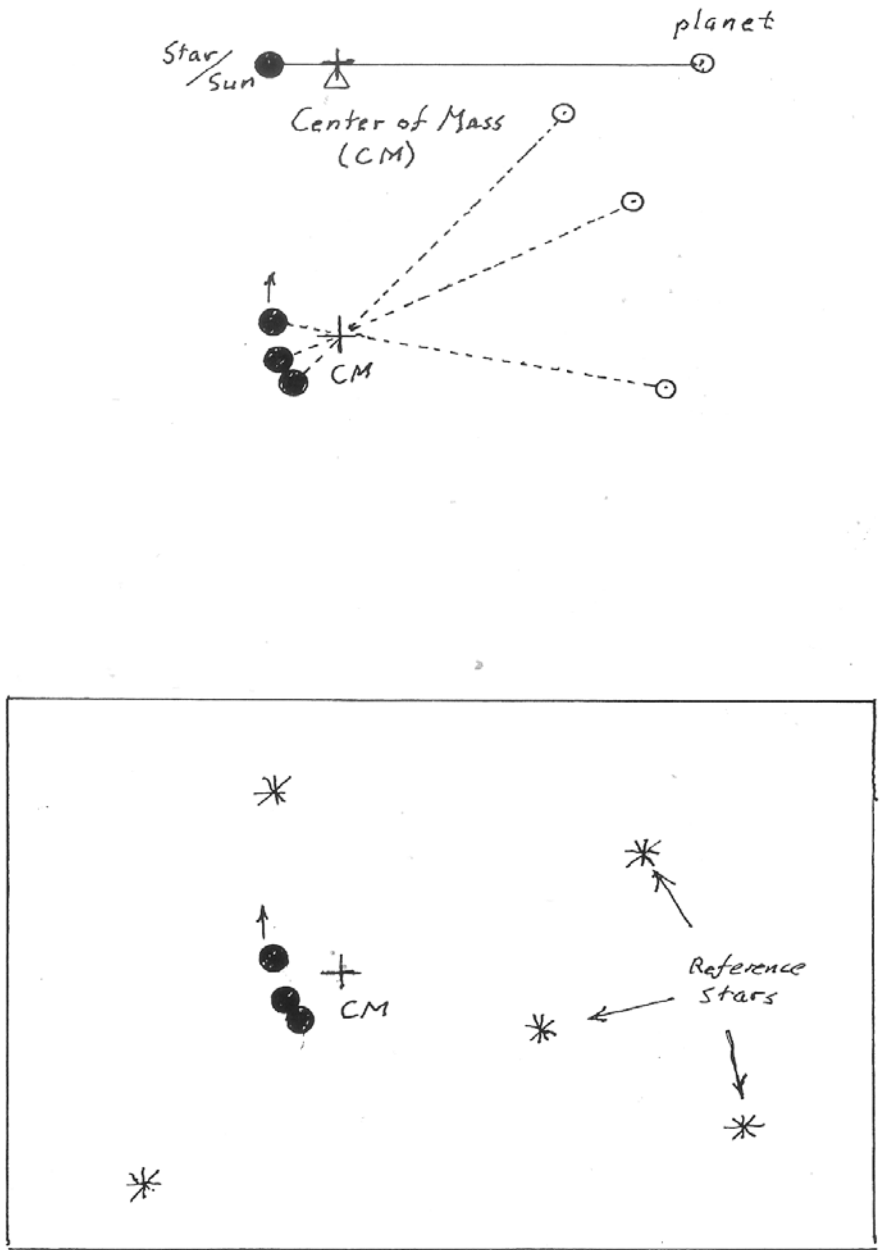
Our Solar System was formed billions of years ago by the coalescence of the disk of dust surrounding our Sun. For decades it has been believed that the formation of our Solar System was not unique, that other solar systems exist in the universe.

Back in the 1950s a slight wobbling motion was observed in the image of a star called Cigni 61. However, telescopic analysis of the motion revealed that the star's movement was caused by a large brown dwarf companion star not by a lower-mass orbiting planet. What produces this wobbling motion? Please look at Figure 1 that I will now distribute. Enter now the more recent astronomical instruments. These instruments are giving scientists unprecedented observations of discs of dust surrounding nearby stars – probably the beginning of planets like our home.

A crop of new astronomical images show several discs with mysterious bulges --perhaps dust-cloak giant planets – and others with holes torn in them, apparently caused by the gravitational attraction of unseen planets. "What we see is almost exactly what astronomers orbiting nearby stars would see if they had pointed a… telescope at our Sun a few billion years ago," said Jane Greaves of the Joint Astronomy Center in Hawaii. In one case – the youngest disk ever seen around a full-grown star – astronomers may be spying on the very moment of a planet's birth!

I will mention several scientists by name as sources of information, quotations, and research. I'll do this not only for appropriate attribution, but also in order to provide you with valuable additional sources for study – almost all of the scientists have websites that you can access over the Internet. At this time I will distribute a list of their names and affiliations as well as the acronyms of the organizations that I will mentioned from time to time during this talk.

Figure 1.



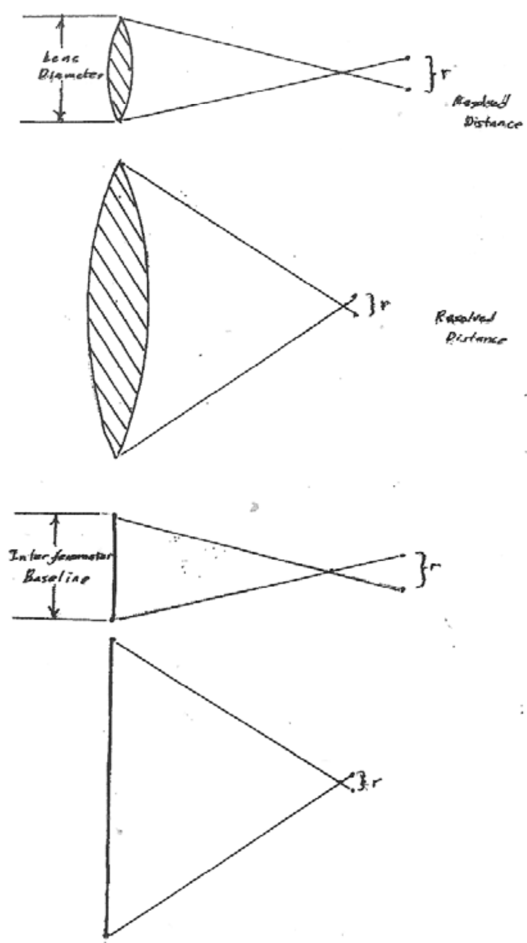
Since the subtle wobble of the nearby star Cigni 61gave astronomers their first indirect hint of a planet outside our Solar System, they have longed for a close-up view of distant worlds. The first actual planet detection was in 1995 in which the wobble of 51 Pegasi revealed a companion planet. Since 1995 such wobbles have revealed about 66 candidate extra solar planets hugging on to their 58 parent stars (as of April 2001). And although all are inhospitable “gas giants” similar to Jupiter, few astronomers doubt that small rocky planets like our own – possible nurseries for life – are waiting to be discovered. Actually visiting them may be out of the question (I will discuss a few ideas in this connection later, by the way). But by launching armadas of telescopes into space, astronomers hope to get a close-up look at other Earths and scan them for signs of life. Please pass around the list of extra solar planets and planetary systems.

Our undertakings into space have fired the imagination of astronomers and the general public alike, from Alain Leger of the Institute for Space Astrophysics in Orsay, near Paris, who calls it “a great adventure for humanity,” to Dan Golden, the National Aeronautics and Space Administration (NASA) administrator, who has made planet searching a cornerstone of NASA’s Origins program. And in a burst of studies and proposals over the past several years, astronomers in Europe and in the United States have proposed a planet-spotting strategy and planned a series of missions that, within 25 years, my return portraits of an alien Earth and even reveal signs of life and large features such as otherworldly Amazon jungles.

A useful single telescope that would be able to spot tiny dim planets just a whisker away from a bright star would need a mirror roughly 100 meters across, 10 times as wide as the largest available today, and even such a monster telescope could not reveal any detail on an alien world. So astronomers are pinning their hopes on a relatively new technique called optical interferometry. Interferometry combines light gathered by two or more standard-size telescopes placed some distance apart in such a way that the resulting image has a resolution of the telescope as wide as the baseline of the interferometer. Interferometry “is just another way of building larger and larger telescopes.” says Michael Shao of NASA’s Jet Propulsion Laboratory (JPL) in Pasadena. Basically, the ability to resolve images that are close together, like a planet and a star, is inversely proportional to the diameter of the telescope’s objective lens or mirror or the baseline of the interferometer; that is, the bigger the lens, mirror or baseline, the better the resolving power. Figure 2 exhibits the relationship between the diameter of a telescope objective lens or mirror or baseline of an interferometer to the ability to resolve small angular distances between stars and their companion planets or to resolve details of the planet image itself.

This is not to say that building a big planet-spotting interferometer will be easy. Optical interferometry stretches the limits of technology even on the ground, and planet imaging will have to be done from space. A space-based interferometer can be arbitrarily large, and the infrared wavelengths that carry information about substances such as oxygen and water – clues to possible life – are blocked by the Earth’s atmosphere and can only be detected in space. NASA is laying plans to fly, perhaps as early as next year, a technology-demonstration mission to see whether space-based interferometry is even possible. The ultimate goal, pencil in for 2020, is an instrument with the baseline as wide as the United States, which would provide the first image of an alien world and probe its atmosphere for signs of life. Note also, from my prior talk, that such a satellite interferometer system is also the basis for low-frequency, space-based gravitational-wave detection.

Figure 2.



Interferometry is nothing new for radio astronomers, who build arrays of telescopes spanning thousands of kilometers on the ground and have launched one antenna into space to create an interferometer larger than the Earth itself. But the challenge of interferometry is in precisely combining the signals from the telescopes, which entails holding the path length from star to image through each scope steady to one wavelength accuracy. That's a far easier task in radio astronomy where wave lengths are measured in meters than in optical astronomy where wave lengths are less than a millionth of a meter.

Several experimental optical interferometers are now in use around the world. But for planet searchers, says and JPL's Charles Beichman, "the atmosphere is a major problem, so we need to go to space to fully realize the advantage of interferometers." Controlling the light paths is challenging enough on the ground; and in space it is still more daunting. A space-based interferometer is likely to take the form of a flock of spacecraft, each carrying its own mirror, which would have to combine their light beams to the nearest tenth of a micrometer (one millionth of a meter) or better over long periods of time. But in just four years, if all goes well, planet searchers will test their ability to perform such precision flying.

The test will be a NASA program called Deep Space 3 (DS-3). Despite the imminent launch, the final form that the DS-3 will take has not yet been decided. In the latest version, two spacecraft would fly in tandem up to 1 kilometer apart, their relative position controlled to a 1 cm precision. With the help of on-board correcting optics, the maximum resolution of its images should be 0.1 milli-arc-seconds (mas), or 1/10,000th of a second of arc. There are 3,600 seconds of arc in one degree – the Moon's image is about 2000 seconds of arc across. Such a precision of about 1/36,000,000th of a degree is stunning compared to the 10 [mas] or 1/36,000th of a degree theoretically best resolution of today's biggest telescopes, ten-meter Keck Telescopes in Hawaii, and should be at least enough to get a clear "family portrait" of a nearby planetary system, showing planets as indistinct bright regions, like flashlights in a fog around a central star.

In practice, however, this is not DS-3's primary goal. "Basically, DS-3 is a technology-demonstration project… its main goal is not to do science," says Shao, who heads JPL's interferometry center, which is masterminding the DS-3 project. Instead, the aim is to test interferometry by combining light from separate spacecraft.

Satellite formation flying "…isn't quite as impossible as it sounds," says Shao. However, it does demand that the spacecraft fly well out of the range of the Earth's atmosphere, which would cause drag problems, and keep away from steep gravity gradients that pull on one spacecraft more than another spacecraft. Interestingly, such gravity gradient research goes back to the 1950s with some of my early studies of satellite librations. Essentially DS-3, like all formation-flying space interferometers, is destined to fly in deep space, circling the Sun along with the planets.

To control drift, the craft would fire ion thrusters – devices already found on communication satellites. These thrusters require a far smaller mass of propellant than rockets, because they use photocells to generate electricity to ionize a substance such as cesium and, then accelerate and eject the ions to provide thrust. A few kilograms of material like cesium can provide a year's thrusting. To make the final sub micrometer-scale adjustments necessary to form interferometer images, the spacecraft will need to measure their separation to a fraction of a micrometer with lasers and make finer scale corrections for drift with active optical elements such as moving mirrors. This kind of active optics control is already used in ground-based interferometry, according to Shao.

Although DS-3 will provide a test-bed for space interferometry, plans for the mission remain in flux, with Shao and his JPL team still working out the details. "The short story is that what we had originally wanted to do is a little bit more expensive than we can afford," says Shao. A decision in 1998 to scale back from three to two (with a slight reduction in resolving power) spacecraft should allow the mission to meet its 2002 departure time.

Because the technology for formation flying is still in its infancy, the first space interferometer to do actual science will take a safer approach. This project, NASA's Space Interferometry Mission (SIM), will involve seven or eight optical telescopes, each a modest 35 cm in diameter placed on a fixed arm with the baseline between 10 and 15 meters. SIM is not primarily designed for imaging; with its short baseline it will only be able to generate images with the resolution of 10 [mas], enough for a fuzzy family snapshot of the planetary system, "SIM's major purpose is to do astrometry (measuring star positions), as opposed to imaging says Shao who is SIM's project scientist.

In the ordinary mode, which relies on computing the location of the target-star's position relative to rather stationary reference stars (please see Figure 1); SIM would achieve a peak resolution about 0. 001 [mas] , which is as much as 250 times better than anything currently available, and will look for planets using the same methods now used from the Earth: searching for telltale wobbles in star positions. With its resolution, SIM could look for Jupiter-size planets orbiting around one billion or so stars close to the Earth that is, within about 400 light years from the Earth.

SIM's precision should also aid in a range of other studies, including measuring the expansion rate of the universe, revealing the spiral structure of our galaxy, low-frequency long wavelength gravitational wave detection and studying the spread of matter around super massive black holes by tracing the distortion of celestial objects due to gravitational pull of the Earth, the Moon, other planets and our Sun. "SIM will be able to verify Einstein's theory of relativity to a few parts per million, 300-2500 times better than today," states Shao.

Although SIM will avoid the technical challenges of formation flying, it still has many hurdles to overcome. One of the toughest will be vibration. The kind of vibration that the Hubble Space Telescope has had to endure from the wheels of its tape recorders would spell disaster for a space interferometer. SIM will dispense with tape recorders, but it will have to rely on spinning wheels, known as reaction wheels, to control its spin and rotated towards its targets. Even the best possible bearings transmit vibration into the optics. Vibration caused by thermal "snaps," when solar panels move between light and shade, also poses a threat to the interferometric signal. The JPL team hopes that a combination of vibration de-coupling – “basically just a soft spring,” says Shao – and yet more active optics should overcome this problem.

The effort to actually image extra solar planetary systems will began in earnest with the European Space Agency’s (ESA’s) Infrared Space Interferometer (IRSI) and NASA’s Terrestrial Planet Finder (TPF). These two projects, still at a much earlier stage of planning than the DS-3 and SIM, are both designed to snap more detailed family portraits of the other planetary systems and probe the atmosphere of the planets for elements and compounds that are hallmarks of life. Both will operate at infrared wavelengths, where the signatures of these substances are the strongest. The infrared has other advantages also: Planets are brighter in the infrared relative to their suns, and at these slightly longer wavelengths the demands for optical accuracy of the interferometer are loosened.

Top of the list for telltale substances that might reveal life is ozone, which can be formed when ultraviolet light strikes oxygen produced by plant life. “The presence of ozone would tell us that some form of life already exists on the planet, which would be fascinating indeed,” says Malcolm Fridlund of the European Space Agency’s (ESA’s) research center at Noordwijk in the Netherlands. The other two key signatures of a life-bearing planet are water and carbon dioxide.

With a tentative launch date of 2009, IRSI is still very much on the drawing board. “Currently we are studying concepts, the feasibility, eventually cost,” says Fridlund. The current version is for six 1.5-meter telescopes flying in a formation up to 50 meters across. The array will orbit the Sun at L2, a libration point on the Earth-Sun axis where the gravitational gradient is flat. There, says Fridlund, “the biggest force acting on the array is solar photon pressure.”

Fridlund sees a mountain of technical challenges before the IRSI takes its first pictures. “What is going to be extra challenging is the optical arrangement,” he says. It would take the array about 10 hours to detect an Earth-like planet and perhaps 14 days to obtain a reasonable spectroscopic signal to detect life; holding the array steady over such long periods is a major issue he notes.

Like IRSI, the Terrestrial Path Finder (TPF) is still at a formative stage. Current plans envisage four to six mirrors, each up to 5 meters in diameter, spanning a total distance of between 75 and 100 meters, with a tentative launch date of 2010. The mirrors might be mounted on a single structure but “formation flight is a very serious option,” says JPL’s Beichman, the TPF project manager. The big challenge facing TPF is the need for large, lightweight telescopes. “This relies on developments for the Next Generation Space Telescope project (the successor to Hubble)”, says Beichman. “We also need interferometry techniques being developed for SIM. With these projects under our belt, TPF can be done with acceptable risk.”

But of all the planned missions the grandest, most speculative, and furthest over the horizon is NASA’s Planet Imager (PI). The PI is a “dream mission,” says Fridlund. The

PI, with a tentative launch date of 2020 is likely to comprise squadrons of TPF-type spacecraft, each one carrying four eight-meter telescopes. They would be dispersed over distances comparable to the width of the United States and would produce images of alien planets that, although fuzzy, would have discernable detail. The PI will offer "humanity's first image of another world."

Whether or not it is NASA's PI that will give us or first glimpse of distant life, astronomers are convinced that some kind of space interferometer capable of seeing life-bearing planets is just a matter of time. "The urge to learn about habitable new worlds is too basic to ignore for long," says Antonio Labeyrie, director of the Observatory Haute-Provence near Marseilles, France. " It is perhaps the same curiosity which has stimulated the prehistoric dweller on the Greek coastline into observing and exploring the islands they could see in the distance," he says. Now that we have definite clues to other worlds, he adds, "We are in a similar situation." The IP will ultimately travel at least 250 Astronomical Units (AU – Earth-Sun distance or 92 million miles) from the Earth; but that is **only four thousandths of a light year** away from here!

Let us suppose that we are successful in imaging other planetary systems – what are we going to do about it? Why settle for poking through the clutter of our Solar System when we can break out into interstellar space? That was the mood in a 1998 workshop on Robotic Interstellar Exploration at JPL. Engineers took the opportunity to engage in some uninhibited thinking about practical – or, at least, plausible ways to propel, control, and communicate with an interstellar probe.

The notion of interstellar flight, a dream of scientists and others for decades, has been getting a boost from the recent discovery of planets around other stars that I have already discussed. Although the first interstellar probes would probably aim for nearby interstellar space, the ultimate goal would reach other planets within, say, 40 light-years of Earth. "If you can find them and image them, maybe you should think about the visiting them," says JPL's deputy director Larry Dumas.

That idea, says Dumas, "is so audacious that it both stimulates and confounds at the same time" – which is exactly the point, say researchers. The requirements of a journey thousands of times longer than any spacecraft has ever taken are so daunting that some people find them laughable. But even skeptics say that some of the novel propulsion, robotics, and communications concepts discussed at the JPL workshop could pay off for travel within our Solar System, if not to the stars. "I think it is enormously valuable and stimulating," says Louis Friedman of the Planetary Society in Pasadena. "I would just caution that the reality of interstellar flights is far off."

The scientific interest is already there, says Richard Mewaldt, a physicist at Caltech who spoke at the JPL workshop. The Solar System moves inside the heliosphere, a bubble blown into the ionized gases of the Interstellar Medium (ISM) by a wind of particles from the Sun. The ISM reflects the makeup of the galaxy billions of years ago, before the Solar System formed, and researchers would like to probe its composition and magnetic fields. They would also like to sample cosmic rays in the ISM, because many of them can't penetrate heliosphere, and survey two distant reserves of comets: the Kuiper Belt just outside the orbit of Pluto and the Oort Cloud further out in nearby interstellar space. A spacecraft at the right location in the ISM could even use the Sun as a colossal gravitational lens to bend light waves from the far reaches of the universe, magnifying them. “There’s science to be done all the way,” says JPL’s Sam Gulkis.

But just to reach the heliosphere’s edge, perhaps 100 Earth-Sun distances (100 AU) from the Sun, in a reasonable time, a craft would need a propulsion mechanism that is thousands of times more powerful than conventional chemical rockets yet don’t require carrying large amounts of fuel. (Today’s spacecraft would take at east 30 years to make the journey.) Three approaches have emerged as contenders, says Henry Harris, the JPL researcher who organized the workshop: thrusters or sails driven by Earth-based lasers, matter-antimatter annihilation, and nuclear power. To this I will add gravitational-wave propulsion.

In the first concept, a laser fired from the ground is reflective off a mirror and focused into a chamber at the back of the spacecraft, heating gases that then rushed out of the rocket to generate thrust. Please see Figure 3A. That concept “is very efficient because you’re leaving your engine on the ground,” says Harris. Before the craft leaves the Earth’s atmosphere, ambient air could serve as the propellant. At the JPL workshop, Leik Myrabo of Rensselaer Polytechnic Institute in Troy, New York, described ingenious actual flight tests in which he fired a 10,000-watt laser into a coke-can-sized facsimile of a spacecraft and lifted it about 30 m off the ground, says Harris. He says that million-watt lasers, which already exist, could fling objects into orbit, at a cost of about $500 per kilogram for the electricity.

Outside the atmosphere, such a probe would need to carry its own supply of propellant, which could be bulky. A better strategy for harnessing laser power might be to equip a craft with a large, reflective sail that would catch and deflect the beam from a laser – or even plain old sunlight—and accelerated under the bombardment of photons. Please see Figure 3B. Harris, who leads a program involving several NASA laboratories, the Army the Air Force and the Department of Defense to develop such sails, calculates that a ground-based, 46-billion-watt laser firing at a craft that has a 50-meter sail could send 10 kilograms to Mars in 10 days. One billion watts “is a lot,” allows Harris, with more than a touch of understatement -- it’s roughly the output of an average electric power station.

Another propulsion concept, based on the annihilation of matter with antimatter to heat up an expansion chamber, faces even bigger scientific hurdles. But it too would require only small masses of fuel to power a craft into deep space – assuming sufficient quantities of antimatter could be produced and stored. Please see Figure 4A. Still more futuristic engines would scoop hydrogen right out of interstellar space and use it as fusion fuel. Please see Figure 4B.

Figure 3A

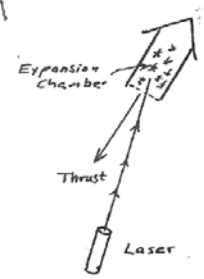
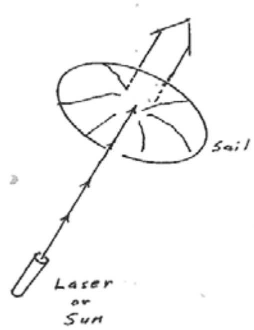


Figure 3 B



"These three technologies may have the capability of getting us to the nearest stars in a reasonable length of time – ten-to one hundred years," says Gulkis. To these technologies I add Gravitational-wave propulsion as exhibited in Figure 5. There are about 1000 stars within 40 light years of the Earth. Once a probe gets into interstellar space, communications delays of hours, weeks, or years rule out controlling the spacecraft from the ground. So other talks at the JPL workshop dealt with ways to get an interstellar probe to operate autonomously during its long, lonely voyage. Another challenge comes at the journeys end: sending back data across a distance of many light-years. Laser beams aimed at Earth might be the answer, some participants suggested. Because the lasers could be more tightly focused than radio beams, they could in principal be millions of times more efficient. Here again the use of high-frequency gravitational waves would superior even to lasers since they would not be attenuated by interstellar matter and could be of a greater bandwidth.

"The programmatic requirements are daunting," concedes NASA's Goldin. But if researchers meet the challenge, "it opens up the prospect of some truly innovative missions," he says. "It may be a probe to sample the interstellar medium… or a mission to explore the Kuiper Belt. But one thing is for sure: it will literally be out of this world."

Figure 4A

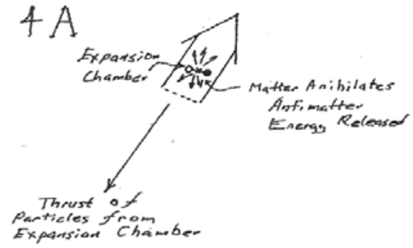
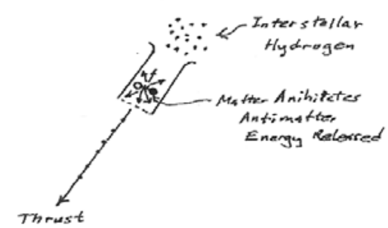


Figure 5B

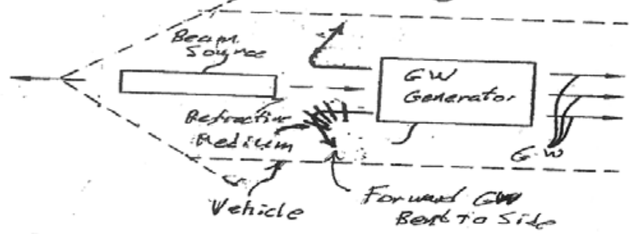


Since the JPL workshop in 1998 there has been considerable progress with respect to antimatter propulsion. G. R. Schmidt, H. P. Gerrish, and J. J. Martin of the NASA's *Marshall Space Flight Center* and G. A. Smith and K. J. Meyer of the *Pennsylvania State University* published antimatter requirements and energy costs for near-term propulsion applications in the September-October 2000 issue of the *Journal of Propulsion and Power*. They concluded that based on existing production technology that antimatter assisted fission/fusion hold promise for interplanetary travel. In the November-December 2000 issue of the *Journal of Propulsion and Power*, Terry Kammash, a professor at the *University of Michigan*, proposed a "magnetically insulated inertial confinement fusion" (MICF) antimatter propulsion concept. He computed the travel times to various destinations including *Alpha Centauri* – all of which took hundreds of years. Just so you know that this antimatter propulsion concept isn't science-fiction taken from "*Star Trek*" I'll now circulate a couple of typical pages from the journal articles that I've mentioned.

Almost all the controlled antimatter in the world is produced at either CERN (European Organization for Nuclear Research) or FNAL (Fermi National Acceleration Laboratory). The cost of producing a microgram of antimatter (for example, antiprotons) is $6.4 billion – however with upgrades this cost can be reduced to a mere $64 million per microgram that is per millionth of a gram of antimatter!

Finally, I propose my old friend, high-frequency gravitational waves for interstellar propulsion. This concept was the subject of a paper I presented in September 2000 to the AIAA. Essentially it also relies on the conversion of antimatter to produce the energy (as shown in Figure 5). There is, however, an intriguing possibility that is similar to the laser propulsion scheme already discussed. Although not rigorously developed yet, apparently the presence of strong high frequency gravitational waves modifies the gravitational field local to it. Thus there may be a way to utilize a land-based gravitational wave generator to produce something akin to Star *Trek's* tractor beam. In this regard, on p. 349 of Landau and Lifshitz's authoritative Russian text book concerning field theory and general relativity, they comment: "Since it has a definite energy, the GW is itself the source of some additional gravitational field. Like the energy producing it, this field is a second-order effect in the h_{ik} (tensor describing a weak perturbation of the galilean metric). But **in the case of high-frequency gravitational waves the effect is significantly strengthened…**" Thus we might be able to produce "hills and valleys" in a gravitational field in front of a spacecraft. The spacecraft would "fall" down a "hill" into a "valley" and thusly be "propelled." Obviously a tremendous amount of experimentation has to be accomplished before fielding such gravitational-wave "beam riding" interstellar probe.

FIG. 5



No matter how we do interstellar travel it is bound to take centuries to complete a round-trip. Of course the inverse problem, extraterrestrials visiting us, would also take a long time – but if "their" lifespan were, say one million years it would not be a problem for them. With our 100-year maximum lifetimes it would, however, be most difficult for us. The answer, of course, is to put people into suspended animation. That is, to pickle people. As the story goes a process for pickling people was made operational just in time for the first interstellar mission in 2040. Married couples were selected and pickled in pairs. The concept was that after each couple lived their lifetime and made observations along the way -- just before they passed on they would unpickle the next couple and so on until the entire trip was completed. All went well until the husband of one of the couples went around and unpickled all the women. This caused the termination of the voyage and also signals the end of my talk. Thank you.

Portions paraphrased from: *Science,* Vol. **280**, p. 523; Vol. **281**, pp. 765-766 and pp. 1940-1942.

ACRONYMS:

AIAA American Institute of Aeronautics and Astronautics

AU Astronomical Unit, Earth-Sun distance, 92,000,000 miles, 17/10,000,000th light years

CERN European Organization for Nuclear Research

DS-3 Deep Space 3 (NASA program)

FNAL Fermi National Acceleration Laboratory

IRSI Infrared Space Interferometer (ESA)

ISM Interstellar Medium

JPL Jet Propulsion Laboratory (in Pasadena, NASA)

MICF Magnetically insulated Inertial Confinement Fusion (antimatter propulsion concept)

mas milli-arc-seconds or 1/1000th of an arc second or 1/36,000,000th of a degree

NASA National Aeronautics and Space Administration

PI Planetary Imager (NASA project)

SIM Space Interferometry Mission (NASA)

TPF Terrestrial Planet Finder (NASA)

<u>SCIENTIST (FOR MORE INFORMATION GO TO THEIR WEB PAGE) / 1998 AFFILIATION</u>:

Charles Beichman	JPL (Pasadena)
Larry Dumas	JPL Deputy Director
Malcolm Fridlund	European Space Agency (NSA, Netherlands)
Louis Friedman	Planetary Society (Pasadena)
H. P. Gerrish	NASA Marshall Space Flight Center
Dan Golden	NASA Administrator
Jane Graves	Joint Astronomy Center (Hawaii)
Sam Gulkis	JPL
Henry Harris	JPL researcher
Terry Kammash	University of Michigan
Antonio Labeyrie	Observatory Haut Provence (Marseilles, France)
Lev Davidovich Landau	Russian author and expert in general relativity and field theory and had been associated with Einstein.
Alain Leger	Institute for Space Research (Orsay, France)
Evgeny Mikhailovitz Liftshitz	Russian author and expert in general relativity and field theory
J. J. Martin	NASA Marshall Space Flight Center (Huntsville)
Richard Mewaldt	Cal Tech physicist
K. J. Meyer	Penn State University
Leik Myrabo	Rensselar Polytechnic Institute (Troy, New York)
G. R. Schmidt	NASA Marshall Space Flight Center (Huntsville)
Michael Shao	NASA JPL (Pasadena), heads their interferometry effort
G. A. Smith	Penn State University

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"NECESSITY"

Presentation to the *Economic Round Table* at The California Club, Los Angeles, California, February 22, 2007

Robert M L Baker, Jr.

"The speed of the car should not exceed 35 mph at any time and then this speed should be governed only by perfectly smooth roads. Ample time should be allowed in order that this speed limit be adhered to at all times. When crossing any bump, dip, swale, ditch, railroad track or any uneven part of the road the speed should be reduced to such a minimum speed that the car move over the uneven part of the road with no violent motion that would tend to disturb the position of the party. (Two miles per hour has been suggested as such a speed going over rough or uneven roads.)" Unquote. Beverly Hills, California, February 20, 1958.

Howard Hughes' written instructions to his drivers, to prevent any unnecessary jarring of the breasts of his starlets.

A second story is about his father Howard Hughes Senior or "Big Howard" and is appropriate to this morning's talk: By the start of 1908 Big Howard felt like a failure. He had lost the attention of his wife, rarely saw his son, and found his friends now enjoying the finery and riches of fruitful careers as oil tycoons. Throughout his career as a wildcatter Big Howard, a 38-year-old braggart, was repeatedly frustrated by his lack of success in striking oil. The problem, he claimed, was not with the location of the wells, but rather with his inability to drill deep enough to tap into the oil reserves he was certain remained undisturbed beneath bedrock. Faced with the reality that no known drill bit could drill through the impenetrable rock, he became obsessed with the necessity to design such a bit, and worked for months in a futile effort to achieve positive results. It took a chance meeting at a bar called the "Oyster Pub" to motivate Big Howard toward his future and ultimately to lay the financial ground work for the future of billionaire to be, Howard Hughes Junior. At the bar he happened upon a millwright named Granny Humasson, who was attempting to interest the oil riggers in a drill bit he had invented that resembled two engaging pinecones. His concept called for the cones to rotate in opposite directions, meshing like a coffee grinder. While the other riggers laughed at the design, Big Howard took it seriously enough to pay $150 for two sewing thread spools that Humasson had carved to illustrate his invention. Hughes then fabricated a version of Humasson's invention out of steel. He took the finished prototype, mounted it on a rod in a press, and attempted to drill through a six-inch piece of granite. Legend has it that the drill bit went through the granite, drilled through the work bench, and was chewing through the concrete floor before the machinery could be stopped. Without acknowledging that it was actually Humasson's invention Big Howard filed for and was granted two US Patents 930,758 and 930,759 on August 10, 1909 in which he claimed that he was "… the sole inventor." Humasson never learned about the Patents.

According to Plato: "Necessity is the mother of invention." To the degree that inventions relate to patents – Necessity is the mother of Patents; but perhaps paranoia is the father, since those desiring patents are usually concerned that their idea will be taken from them and, as I have said, Howard Hughes' financial empire was built on his theft of another's idea. My own High-Frequency Gravitational Wave Patents are really not conceived out of necessity, but rather to memorialize the date and authorship of the idea or concept and, hopefully, to gain financial value from the resulting device in advance of others who might exploit the idea before I have a chance to.

A Patent is a limited monopoly and as Ron Ritchie told us during our first session last year, that monopoly lasted just 7 or so years in the 18th Century at the onset of the Industrial Revolution. Several of you Rounders have patents including Jim Caillouette who has over 31! The historical roots of patent law were far earlier than the Industrial Revolution. Generally speaking, patent laws are considered to have started in Italy with the Venetian statute of 1474. However, there is evidence suggesting that something like patents were used among ancient Greek cities. As I suggested, the first patent law was the Venetian statute of 1474 in which the Republic of Venice issued a decree by which new and inventive devices, once they had been put into practice, had to be communicated to the Republic in order to obtain legal protection against potential infringement. The period of protection was ten years. England followed with the *Statute of Monopolies* in 1624 under King James the First of England. Prior to this time the crown issued letters of patent providing any person with the monopoly to produce particular goods or provide particular services. The first such letter was granted by Henry the Sixth in 1489 to a Flemish man for a twenty-year monopoly (incidentally, the current length of the UK/EU patents is still 20 years) on the manufacture of stained glass (destined for Eton College). This was the start of a long tradition by the English Crown of granting of letter patent (from meaning open letters as opposed to letter under seal), which granted monopoly to favored persons (or to people who were prepared to pay for them). This power, which was to raise money for the crown, but widely abused, as the crown granted patents for all sorts of common goods (salt, for example). Consequently, the Court began to limit the circumstances in which patents could be granted. After public outcry, James the First was forced to revoke all the then issued patents and declare that they were only to be used for projects of new invention. This was incorporated into the *Statute of Monopolies* in which Parliament restricted the crown's power explicitly so that the King could only issue letters of patent to the inventors or introducers of original inventions for a fixed number of years. In the reign of Queen Anne (1702 to 1714) lawyers of the English Court developed a requirement that a written description of the invention must be submitted. These developments, which were also in place during colonial period in the United States, were the foundation for Patent Law in the United States, New Zealand and

Australia. In the United Kingdom, the Patents Act of 1977 harmonized UK patent law with the European Patent Convention. Consequently, UK patent law is no longer based upon the *Statute of Monopolies*, but an amalgam of UK and European practices.

During the period of America's 13 colonies a few inventors were able to obtain monopolies, that is patents, to produce and sell their inventions. These monopolies were granted by petition to a given colony's Legislature. In 1646, for example, the Province of Massachusetts Bay granted inventor Joseph Jenks Sr. the exclusive right to set up water mills using a speedier engine that he had develop for making sharp-edged tools such as scythes. His monopoly was to run for 14 years. The Patent and Copyright Clause of the U.S. Constitution was proposed in 1787 by James Madison and Charles Pickney. In the *Federalist Papers* Madison wrote "… the utility of the cause will scarcely be questioned. The copyright of authors has been solemnly adjudged in Great Britain to be the right in common law. The right to a useful invention seems with equal reason to belong to the inventors. The public good fully coincides in both cases with the claims of the individuals." The Patent Commission of the United States was created in 1790. Its first three members were Secretary of State Thomas Jefferson, Secretary of War Henry Knox and Attorney General Edmund Randolph. The first patent was granted on July 30th, 1790 to a Samuel Hopkins of Philadelphia for a method of producing potash (potassium carbonate) an essential ingredient used in making soap, glass and gunpowder. The earliest patent law required that a working model of each invention be submitted with the application. Patent applications were examined to determine if an inventor was entitled to the grant of patent. The requirement for working model was eventually dropped. The 1986 revision of the Patent Law requires a written description. The Commissioner of the United States Patent Office may ask for additional information, drawings, or a diagram if the description is not clear. The patent law was revised in 1793. The rate of patent grants had grown to about 20 per year and the time burden on the Secretary of State was considered to be too burdensome and patent applications were no longer examined. For comparison, in 2005 there were about 375,000 patent applications.

But are patents all that useful? Do they stimulate technological progress? *San Diego Union Tribune*, July 30, 2006: "**Foundation's stem cell patents impede research, scientists say –** In Wisconsin lurks a force that scientists say is strangling embryonic stem cell research far more than any federal funding restrictions. The *University of Wisconsin* Alumni Research Foundation, generally known as WARF, holds three broad patents that essentially give it control of embryonic stem cells used in the United States. Scientists charge that WARF's greed in controlling the patents is thwarting potentially life-saving research." These stem-cell patents are based upon the University of Wisconsin's research in 1990 accomplished primarily by James Thomson. But molecular biologist Jean Loring of the *Burnham Institute* in San Diego says that Thomson's work is "obvious to someone skilled in the art," a condition that should disqualify any application. Elizabeth Donley, a WARF attorney says that "If it were so obvious, it would have been done before." Experts say the challenges to some patents touch on fundamental difficulties about the obviousness and novelty of patent claims. "On the one hand, you can say the technology was almost identical to what they did in mouse cells before, so you could argue that it was obvious." says Allan Robins, a molecular biologist with

Irvine, California based stem-cell start up *Novocell.* "On the other hand, there had been failures in rats and pigs using stem cells, therefore you could argue that it was not obvious." In a related matter, many scientific historians have suggested that Einstein's Special Theory of relativity was not new. That previously Poincaré and others had noted the constancy of the speed of light and the variability of time; but they admit that Einstein made the "little final step in the argument."

In the same issue of the *San Diego Union Tribune* its business section article states: "**Qualcomm's patented wireless technology, which is vital for cell phones to perform multimedia functions, is on its way to being used in virtually every cell phone in the world –** If a barrage of lawsuits and trade complaints is any indication, wireless technology titan *Qualcomm* could be the most hated company these days next to *Microsoft Corp*. The San Diego company, which began 21 years ago as a tiny start up with no real product and an office over a pizza parlor, grew into a powerhouse that upset the status quo of the wireless industry. As the holder of 4,800 patents and pending patents – many related to making multimedia cell phones work – *Qualcomm* is on the verge of collecting royalties on virtually every handset in the world. But its *Qualcomm*'s prices for use of its intellectual property that has the old guard wireless giants, such as the No. 1 phone maker *Nokia*, in such an uproar."

Do patents actually threaten the advancement of science and technology? The December 1st 2006 issue of the Journal *Science* addressed that question:

In 1980 the Supreme Court handed down a seminal decision in Diamond v. Chakrabarty. Often mischaracterized as opening the door for patents claiming isolated and purified versions of naturally occurring products, including human genetic material. The Court actually distinguished between a product of nature and a patentable genetically modified bacterium cell that did not exist in nature. The Court reiterated that "a new mineral discovered in the earth or a new plant found in the wild is not patentable… Likewise, Einstein could not patent his celebrated law that $E = mc^2$; nor could Newton have patented the law of gravity (nor could I patent the quadrupole gravitational-power equation or Big Howard patent the oil that his bit tapped in to). Such discoveries are 'manifestations of … nature, free to all men'".

Even if a patent applicant exercised considerable innovation discovering a law of nature or product of nature, neither is patentable under existing Supreme Court precedent. A person might expend money and creativity building a telescope, but he should not be able to patent the new planet he discovers through the telescope.

Justices Breyer, Stevens, and Souter, dissenting in the Metabolite case, said "The justification of the principle does not lie in any claim that 'laws of nature' are obvious or that their discovery is easy, or that they are not useful. To the contrary, research into such matters may be costly and time-consuming; monetary incentives may matter; and the fruits of those incentives and that research may prove of great benefit to the human race. Rather, the reason for the exclusion is that sometimes too much patent protection can impede rather than 'promote the Progress of Science and useful Arts.' -- the constitutional objective of patent and copy-right protection".

The idea that a patent could block future innovation, to the detriment of the public, is pertinent because the US Patent Office is granting patents that could block scientific inquiry. Although the discoveries of natural phenomenon may be necessary precursors to invention, improperly tying up these discoveries with patent rights will only drive up the costs of such subsequent innovations, if not thwart them altogether.

The US Patent Office and lower courts are responsible for granting and enforcing patent rights that run contrary to U.S. Supreme Court precedent. Merging the U.S. Court of Claims and the U.S. Court of Customs and Patent Appeals to create the Federal Circuit in 1982 seems to have accelerated this expansion by creating a specialized, arguable pro-patent court.

Patent applicants who seek to patent laws of nature often point to a Federal Circuit opinion, State Street Bank & Trust Co. v. Signature Financial Group, which suggests that a law of nature is patentable if it produces a "useful, concrete, and tangible result". However this is clearly over inclusive and in direct conflict with existing Supreme Court precedent. To be patentable, there must be something more – a human invention that produces a result beyond the law of nature or product of nature itself.

Scientists may not have paid sufficient attention to the possible privatization of common knowledge because in the past they felt that research activities did not require approval from patent holders. The 2002 Madey v. Duke (*Madey* v. *Duke University*, 307 F. 3d 1351, 1362 (Fed. Cir. 2002)) decision put an end to such protection and, for example, if *Caltech* wanted to pursue high-frequency gravitational wave research utilizing the devices that I have patented, then they would have to seek my approval – this would really tick them off and may explain in part the reason they are only looking at low-frequency gravitational wave research, which has few if any practical applications! By the way, *Caltech* has hundreds if not thousands of their own patents and claims the right of approval from all other such research institutions – so it's a two-way street. Speaking of *Caltech*, a patent covering basic DNA gene-sequencing is owned by them and exclusively licensed to *Applied Biosystems* of Foster City, California. But *Enzo Biochem*, based in Farmingdale, New York, claims to have filed its patent in 1982, twelve months before *Caltech* scientists filed theirs. It says that continued amendments and Patent Office rejections delayed the progress of its application, which became public only last year. The Patent Office is expected to take up to two years to reach a decision and five years with appeals – leaving the patent ownership in limbo. Thus "Patent Pending" is often a more important label and restriction on the research, development and sale of a new concept or device than an actual published patent.

Another major patent concern is the determination of what is not obvious – one of the four tests that U. S. inventors must meet in order to receive a patent. (To win patent protection, an idea or device must be new, useful, and properly described.) The law also requires that a patentable idea would not have been obvious at the time of the invention to a hypothetical "person having ordinary skill in the art." This latter requirement has always been an inexact science, and for nearly two centuries the examiners had wide latitude to disqualify patents on that basis. But in the last three decades the Court of Appeals for the Federal Circuit has restricted their scope. Last year the U. S Supreme Court heard oral arguments on a landmark case, *KSR International Co*. v. *Teleflex Inc*. that could decide whether or not the current high standard for rejecting a patent based on obviousness should be lowered. The U. S. high-tech community is deeply divided over the issue. Most computing and technology firms hope that the high court will back a broad definition of obviousness, which gives the Patent Office more leeway to reject what the companies consider to be undeserving patent applications. In the past, they argue, such patents have led to expensive court battles and unpleasant business surprises. In contrast, the biotech and pharmacy sectors want the court to maintain what they see as a continued flow of legitimate innovations to preserve a healthy biomedical industry. Three dozen groups, as diverse as *AARP* and the *Michelin* tire company, have filed briefs on one side or the other.

Making the call as to obviousness is one of the toughest decisions that an examiner faces. It's not because of ignorance. All of Patent Office's 282 biotech examiners have advanced science degrees to inform their decisions; 63% have Ph.D.s. Yet federal judges, as in the Deuel case (Thomas Deuel won an appeal concerning his DNA discovery in 1995), have steadily narrowed definitions of obviousness, making it harder for the examiners to apply their expertise. "We had been rejecting those kinds of claims," says Esther Kepplinger, who was a supervisor in the biotechnology examiner corps when Deuel submitted his application. She says that the examiners were "startled that the court would have said this was not obvious."

The question before the high court last year began as a standard infringement case. In 2002, Limerick, Pennsylvania-based *Teleflex*, a manufacturer, sued *KSR*, an Ontario Canada-based firm that makes brake pedals, for patent infringement. It went before the federal circuit court, and *KSR* appealed to the Supreme Court, which decided earlier last year to take the case. At issue is whether *Teleflex's* 2001 patent, which combines an adjustable and electric pedal, was obvious and should not have been granted.

In a 1966 precedent-setting case involving plow parts, the high court gave examiners the power to "ascertain" or "determine" obviousness without much definition of the term. Patent lawyers say that gave examiners wide latitude to issue rejections. But since its 1982 founding, the federal circuit has established more direct instructions to the Patent Office: An existing specific teaching, suggestion, or motivation for a combination of elements is required to declare a patent claim obvious. "'Common sense' does not substitute for authority," the court said in 2002. Two years later a federal court ruled that a patent on a drug combining the painkillers Vicodin and ibuprofen was invalid as obvious. But the federal circuit reversed that decision because there was "no record of evidence. suggesting the enhanced biomedical effect of the combination."

Critics say such decisions have driven the Patent Office to issue bad patents that hurt consumers and innovators alike. "Anyone who's been sick knows you can put two analgesics together to fight pain," says Jeffrey Light of Washington, D.C.-based Patients not Patents, which joined with *AARP* on *KSR's* side. Such patents, says Light, "lead to higher costs" for consumers and choke competition. And they hurt truly innovative scientists, adds Duffy, who represents *KSR*: "Follow-on patents can rob the pioneering patents of their just rewards."

Defenders of the status quo, including the Biotechnology Industry Organization in Washington, D.C, say the high court shouldn't jeopardize a reliance "on factual findings" that as allowed the U.S. research enterprise to flourish. And Kevin Noonan, a patent attorney with McDonnell Beechnen Hulbert & Berghoff LLP in Chicago, Illinois, fears giving examiners, whose expertise varies greatly, too much say on the obviousness call. "Do we really want whether someone gets a patent to be based on what examiner they get by the luck of the draw?" he asks.

The federal circuit itself may even be rethinking the issue. Last month, in what its critics welcome as a new tack, it declared that its obviousness standards are "quite flexible" and require "consideration of common knowledge and common sense."

Last year, the high court avoided taking any dramatic steps to overhaul the patent system in cases dealing with the patentability of scientific concepts and the legal power of a granted patent. But critics are hopeful that the nine justices will now act forcefully to fix a flaw they think is more central to patent quality. "Obviousness is getting closer to the root of problem," says Josh Lerner of Harvard Business School in Boston, an outspoken opponent of the current regime. "The KSR case is potentially huge."

There is another dimension to patenting: the sheer number of patents that companies in the emerging high-technology countries apply for. Take India for example. "Patent or Perish" is the slogan of Raguna Mashkar, head of India's largest publicly funded scientific agency. Over the past decade he has turned the 40 or so labs under his control into patent factories. "Our labs obtain more patents in United States than all Indian inventors combined," boasts Mashkar, who directs the Council of Scientific and Industrial Research (CSIR). "To be noticed, you need a portfolio of patents." The approach of CSIR has been to file a patent on any new finding whether or not the agency whether or not the agency wants to commercialize it. That strategy has certainly been successful in terms of quantity. Between 2002 and 2006, the CSIR was granted 5420 U.S. patents – more than the total number granted with counterparts in France, Japan and Germany combined.

So there are good and bad aspects to patenting and they are relatively expensive for an individual inventor or for a small company. My experience has been that it costs between $15,000 and $25,000 for a United States Patent and if you want that patent also issued overseas, then add on an additional $20,000 per country or group of European countries. Also overseas patentability rules may be different from those in the United States. You are not guaranteed an overseas patent just because you have a US one. But like everything else you get what you pay for. If you want a good patent then utilize a good patent attorney.

Speaking of overseas patents, I have patents and pending patents in China. But just how useful are these Chinese patents in protecting intellectual property? Historically, China refused to protect intellectual property. However, for the past four years it has begun to take meaningful steps to offer such protection – especially to those holding Chinese patents.

China's historic refusal to protect intellectual property was due to two primary factors: communism discourages individual property, and the Chinese view copying as flattery – "the most sincere form of flattery" as they say. As a result, it has been estimated in the past that 90% of the Chinese government offices practiced piracy and that 96% of Chinese software was counterfeit. These problems plagued both Chinese and US companies. For example a few years back a Chinese software company estimated that only forty thousand of twenty million copies of its word-processing program were legitimate, and Microsoft had estimated that 98% of all Chinese software bearing its name was counterfeit, where $2,000 worth of software sells for as little as $22.

In the late 1970s, China recognized that it needed to protect intellectual property in order to attract foreign investment. Accordingly, China began passing comprehensive intellectual-property laws in the 1980s. However, despite passing numerous laws to protect intellectual property, enforcement efforts were often lax. For example, when Chinese authorities found 650,000 unauthorized Microsoft holograms in 1992, Chinese courts only imposed a $260 fine. In another early action, Microsoft received only $2,500 in damages when seeking $22 million.

To begin addressing these enforcement problems, China has subscribed to a number of multi-lateral international treaties, including the World Intellectual Property Organization in 1980, the Paris Convention in 1985, the Madrid Agreement for the International Registration of Trademarks in 1989, the Berne Convention in 1992, the Universal Copyright Convention also in 1992, the Geneva Convention for the Protection of Producers of Phonograms in 1993, the Patent Cooperation Treaty or PCT in 1994, and the World Trade Organization in 2001.Most of these treaties require nations to treat citizens and foreigners alike. Although these multi-lateral international treaties have formed a framework for additional enforcement activities, China has, from a practical perspective, a ways to go to match the enforcement mechanisms of the western world.

Under China's current regulatory framework, an inventor can designate China on a Patent Cooperation Treaty or PCT applications within twelve months of filing a US application, whereby the Chinese filing date is retroactive to the US filing date. However, the PCT only provides additional time to decide whether or not to pursue a Chinese patent – inventors must still separately pursue protection through the filing of a Chinese patent application. And US and Chinese patent laws are different. Until 1992-93, China did not protect chemical or pharmaceutical inventions since they believed that inventors should freely share such inventions. Still today, software, business methods, methods of diagnosing or treating diseases, and many plant varieties remain unpatentable in China. In addition, China requires absolute novelty as a prerequisite to patentability, while the US recognizes a one year statutory grace period during which, for example, an inventor could publish a paper describing his invention and still be allowed to file a patent – not so in China. And while China grants patents to inventors who first file a patent application, regardless of who first invents an invention, the US does not – except where the original inventor, such as Humasson's invention of the "Hughes bit," does not protest the patent. The Chinese, however, would have accepted Big Howard's patent application even if Granny Humasson had complained!

Other significant differences also exist. For instance, in China, foreigners must appoint an agent designated by the Chinese authorities to represent them before the State Intellectual Property Office in Beijing. In addition, patents granted in China do not extend to Hong Kong or Macao, which both maintain separate and independent patent systems. Hong Kong, for example, offers both "standard" and "short-term" patents (with different levels of review and patent terms), while patents in Macao are regulated according to Portuguese patent law. Finally, the US and China have different extension fee procedures, and some patent terms.

US and Chinese patent litigation also differ. As a preliminary matter, Chinese culture prefers arbitration and mediation, viewing litigation as a last resort. Moreover, in litigation, Chinese judges conduct discovery and collect evidence, whereas US litigants do so here. The US, unlike China, formally recognizes the doctrine of equivalency (The rule of law for determining equivalency as laid down by the US Supreme Court is quite simple: "If two devices do the same work in substantially the same way, and accomplish substantially the same result, they are the same, even though they differ in name, form, or shape."). China has a centralized patent appellate court, and does not recognize an innocent infringer (The innocent infringer defense may be used when the defendant consciously and intentionally copies from the plaintiff's work, believing in good faith that his conduct does not constitute an infringement). China, on the other hand, limits litigants to one binding appeal, forces patentees to issue compulsory licenses if they refuse reasonable license terms, and supports legal opinions with laws, statutes and regulations (but not previously decided cases). While US plaintiffs must prove infringement, Chinese defendants must prove non-infringement in certain cases. Finally, local favoritism and protectionism often depends on where the suit is brought. For example, judges in many Eastern cities, such as Beijing and Shanghai, tend to be versant, in patent law, well-educated and fair.

Although changes to China's intellectual property protection may be slow in coming, some believe it will be worth the wait. Bill Gates, for instance, stated, "Although about three million computers get sold every year in China, people don't pay for the software. Someday they will though. And as long as they are going to steal it, we want them to steal ours. They'll get sort of addicted, then we will somehow figure out how to collect sometime in the next decade." While few US companies have the resources to adopt such a stance, US companies should recognize that intellectual property protection is continuing to take shape in China, slowly but surely.

Well, suppose that you have a really good idea (like my daughter had a few months ago). Before you expend any time or money on your idea you must recognize that 97% of all patents don't earn the inventor any substantial income. The two most common reasons for this are that the initial marketing was poorly researched or the product is too easy to design around. For this reason you usually want some time to determine if your idea is a marketable moneymaker, but you don't want to commit to a possible $25,000 professional patent preparation cost. Nevertheless, you want some protection while you "shop" the idea around. Here's what I advise that you do: You write up a description of your new concept or device and list what is new about it and what it does. At first you should buy a bound log book or journal and record in ink your concept development and dates of your "discoveries." You might even want a witness to sign the pages and indicate that he or she understands your idea. Then you make some sketches and possibly take pictures of it. After that go to the United States Patent Office Website, www.uspto.gov (or even better http://patentsearch.patentcafe.com) and search for any patents that seem to be related to or similar to your device or new concept. Take your time; spend between a week and a month on this search. In your surfing you will no doubt find some ideas to incorporate into your description. You will also gain insight into what a real patent looks like. You can utilize Google or some other search engine to look up any words you may not fully understand or those that are not completely clear to you. Be prepared to drop your patent project altogether if it appears that it is not really new. Make three copies of all your revised descriptions, drawings and photos. Mail one copy by Registered mail to yourself – don't open it when it arrives (you can sometimes register it and pick it up at the same time at the Post Office), but attach a second copy to the unopened envelope. Next you return to the patent office website and file a "Provisional Patent." This will cost about $100, but a regular patent application must be submitted within one year in order to protect your date of conception of your idea. One problem, however, with inventors who have filed provisional patent applications is that once applied for, and after public disclosure, the clock is ticking. A year goes by very fast. If the inventor has not found the right opportunity in which to successfully market or license the new product or idea, whether as an entrepreneur or as a licensor, he/she may be forced to spend money on what may turn out to be a premature patent, or worse yet, abandon the patent application and possibly loose a great opportunity.

A next vital step is to evaluate the marketability of your potential patent – this is an important step that cannot be postponed. In my case of the High-Frequency Gravitational Wave inventions, an independent analysis was accomplished and now published in an American Institute of Physics Proceeding volume (Colby Harper and Gary Stephenson (2007), "The Value Estimation of an HFGW Frequency Time Standard for Telecommunications Network Optimization," in the proceedings of *Space Technology and Applications International Forum (STAIF-2007)*, edited by M.S. El-Genk, American Institute of Physics Conference Proceedings, Melville, NY **880**, pp. 1083-1091). The study concludes that through the use of my HFGW patents, after a successful proof-of concept experiment (a very important proviso), a telecommunications cost saving is conservatively estimated to be 51 billion dollars over ten years. It is often suggested that the best methodology to assess marketability initially is to use confidentiality agreements. It is also the method most commonly used by experienced entrepreneurs and established companies. On the other hand, there is a problem with such an approach: Let's go back to the millwright Granny Humasson, who was attempting to interest the oil riggers drinking at the "Oyster Pub" in a drill bit he had invented that resembled two engaging pinecones. If he had passed around a confidentiality agreement for all the bar patrons to sign he would have probably been laughed out of the bar. Certainly, "Big Howard" would not have purchased his wooden model and the invention of the "Hughes Bit" would have been greatly delayed and probably not developed at all! In general, people are reluctant to sign agreements; especially if in doing so they give up some of their rights. Also "shopping your idea around" often is an informal affair and written agreements would chill the conversations.

There are some guiding principles for evaluating marketability: (1) Look for trends – the best innovations to develop are those that create long-term trends such as high-frequency gravitational waves replacing electromagnetic waves. (2) Study probable competitive responses. Competitors who are vertically integrated can cause serious problems. Vertically integrated companies – those that are the suppliers of raw materials and the intermediate components used in your device's assembly tend to have a cost advantage over those who are not. If you are a threat to a company such as this, then you may not be able to secure a consistent supply of important components. (3) Compare your inventions to the Industry's state of the art -- is it an extension or a major technological leapt forward? (4) Identify unique attributes of your invention that sell!

Learn about manufacturing. You simply cannot expect "whatever you've dreamed up" to be easy to manufacture and to maintain. (1) What is the price elasticity of products in the field of your invention? This essentially is finding out how much more consumers will be willing to pay, if anything at all, for your invention whether it is an improvement over existing products or processes or is entirely new. (2) How will your invention be made? If you are unsure and if it is an entirely new device, then you need to find out!
Prototype your invention. This is where Henry Keck would have come in. No doubt your invention will go through a metamorphosis as you substantiate its marketability and learn about related manufacturing processes. This initial input almost always has an effect on the prototyping process. Sometimes an invention will bifurcate into two or more designs (in my case a piezoelectric-crystal resonator and ultra-high-intensity laser embodiments). An actual model of your device is invaluable in studying its operation, manufacture and testing the market for sales.. Making presentations with prototypes is especially important.

Secure marketing: Most entrepreneurial companies will have marketing commitments in place before patents are filed. If you are an independent inventor looking for licenses or a small business looking for marketing assistance, then securing good marketing advice is going to be your most time-consuming task. Never forget, nothing really happens until something gets sold!

Last but not least you must continue to improve your invention. In life, the one common element that leads to success is continuous improvement. This single principle almost guarantees that a person will be successful. This principle holds true with innovations also.

So, then, patents may be expensive, may thwart research, may be too numerous, and may be difficult to decide to develop; but on balance, I believe that patents provide a valuable safeguard to inventors and stimulate the development and utilization of an individual's novel ideas. So beware, and get a patent since there may be a "Big Howard" out there who will steal your idea and a make a fortune!

INTELLECTUAL PROPERTY

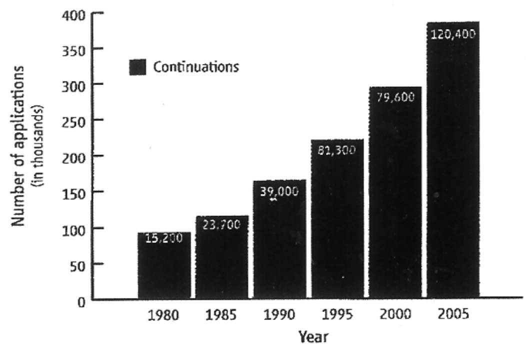
U.S. Wants to Curtail Add-On Patents to Reduce Backlog

In April 2000, Chiron Corp. received a U.S. patent for a monoclonal antibody specific to human breast cancer cells. It had actually begun the process of applying for the patent in 1984, piling on new claims even as the original application was being examined. Once the patent was awarded, Chiron sued rival California biotech Genentech, which had sold hundreds of millions of dollars of a drug, Herceptin, derived from very similar antibodies it had patented in filings made after Chiron's initial application.

Although Genentech eventually won the case, patent attorneys say that Chiron's attempt to strike back at a rival that had gotten to the market first exposes a well-used loophole in U.S. patent law: Companies can continually add detail to a pending application while benefiting from the early filing date of the initial scientific discovery. Such revised applications, known as continuations, last year made up nearly one-third of all filings with the U.S. Patent and Trademark Office (PTO).

PTO officials say the practice is drowning its workforce in paper. So in January, as part of a recent suite of reforms, the agency proposed to limit continuations to one per patent, with exceptions only on special appeals. "Examiners review the same applications over and over instead of reviewing new applications," says PTO Patent Commissioner John Doll. The new limit, he told *Science* this week, will "improve quality and move [PTO] backlog."

Although the comment period closed in May, the proposal continues to generate buzz among the intellectual-property community. Like other proposed reforms at PTO, the changes have pitted biotech companies and biomedical research institutions against the computing and software sectors. The former argue that the system works well enough now; the latter say that so-called patent trolls use continued applications to prey on true innovators. ▶



Continuous rise. A growing portion of U.S. patent applications are continuations, adding to the workload of examiners.

SOURCE: U.S. PATENT AND TRADEMARK OFFICE

to preserve" the waiver system to maintain expertise. Instead, he announced that FDA will review and make more transparent its waiver-granting process.

The announcement, light on specifics, drew fire. "Saying that there are not enough potential advisory panel members available without conflicts, as the FDA argues, is an empty claim," said Representative Maurice Hinchey (D–NY) in a statement critical of FDA's plans. Hinchey is the sponsor of the House legislation. And Merrill Goozner of the Center for Science in the Public Interest, which assembled the panel, notes that some National Institutes of Health committees have instituted far stricter conflict-of-interest rules than FDA's.

–JENNIFER COUZIN

... While U.K. Slays Acronyms

The U.K. government has decided to put all of its spending on large scientific facilities in the hands of one body. The change will in effect combine the Particle Physics and Astronomy Research Council (PPARC) and the Council for the Central Laboratory of the Research Councils.

Public comments this spring ran two-to-one in favor of creating a Large Facilities Council, which would have a budget of nearly $1 billion in 2007–'08. PPARC manages the U.K. subscription to large facilities such as the CERN particle physics lab near Geneva, Switzerland, and the European Southern Observatory in Chile.

Particle physicist Brian Foster of Oxford University says he is "cautiously optimistic" about the merger but adds that PPARC had too many large commitments. So, he says, the new council's success depends on sufficient resources. Both houses of Parliament must now approve formation of the new council.

–DANIEL CLERY

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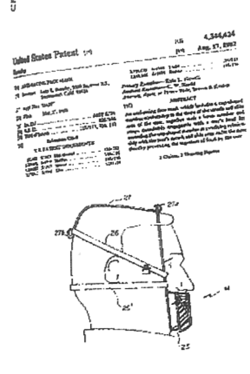

FUN

Not-Ready-for-Prime-Time Patents

The light bulb and the microchip were stellar ideas that revolutionized our lives. The bird diaper and the gravity-powered shoe air conditioner? Not so much. Check out these dubious innovations and more than 50 other examples of ingenuity gone awry at the Gallery of Obscure Patents, hosted by the publisher Thomson's Delphion patent service. The site provides excerpts from the patent documents, original drawings, and even animations showing the creations in action. However, you have to pay to see the full patent for entries such as the antieating facemask (left), a diet aid whose inventor proudly noted that it can be "locked in place on the user's head to prevent removal." >> www.delphion.com/gallery

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U.S. INTELLECTUAL PROPERTY

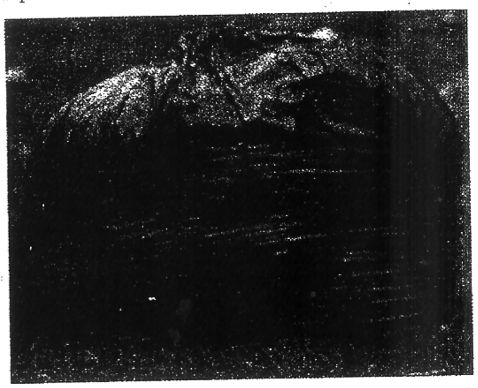
Patent Experts Hope High Court Will Clarify What's Obvious

Thomas Deuel thought his 1990 discovery of the purified DNA sequences that code for a cellular growth factor called pleiotrophin was sufficiently new and different to deserve a patent. The U.S. Patent and Trademark Office (PTO) respectfully disagreed. Citing "the routine nature of cloning techniques," PTO concluded that what the cell biologist had done in his lab at Washington University School of Medicine in St. Louis—purify, characterize, and obtain the DNA that codes for a protein—was "prima facie obvious." But Deuel appealed and won, with a special federal court declaring in 1995 that the patent office's view of what was common knowledge was based on "speculation and an impermissible hindsight."

Determining what is not obvious—one of the four tests that U.S. inventors must meet to receive a patent—has always been an inexact science, and for nearly 2 centuries, PTO's examiners had wide latitude to disqualify patents on that basis. But in the past 3 decades, the Court of Appeals for the Federal Circuit has restricted their scope with cases such as Deuel's. Next week, the U.S. Supreme Court will hear oral arguments on a landmark case, *KSR International Co.* v. *Teleflex Inc.*, that could decide whether the current high standard for rejecting a patent based on obviousness should be lowered.

The U.S. high-tech community is deeply divided over the issue. Most computing and technology firms hope the high court will back a broad definition of obviousness, which would give PTO more leeway to reject what the companies consider to be undeserving patent applications. In the past, they argue, such patents have led to expensive court battles and unpleasant business surprises. In contrast, the biotech and pharma sectors want the court to maintain what they see as a continued flow of legitimate innovations to preserve a healthy biomedical industry. Three dozen groups, as diverse as AARP and the Michelin tire company, have filed briefs on one or another side of the debate.

Law professor John Duffy of George Washington University in Washington, D.C., who represents KSR, calls nonobviousness "the heart of what is a patent." To win patent protection, an idea or object must be new, useful, and properly described. The law also requires that a patentable idea would not have been obvious at the time of invention to a hypothetical "person having ordinary skill in the art."



A head of its time? A pumpkin-shaped leaf bag is different enough from other bags to deserve a patent, a federal appeals court ruled in 1999.

Making that call is one of the toughest decisions that an examiner faces. It's not because of ignorance. All of PTO's 282 biotech examiners have advanced science degrees to inform their decisions; 63% have Ph.D.s. Yet federal judges, as in the Deuel case, have steadily narrowed definitions of obviousness, making it harder for the examiners to apply their expertise. "We had been rejecting those kinds of claims," says Esther Kepplinger, who was a supervisor in the biotechnology examiner corps when Deuel submitted his application. She says that the examiners were ▶

Government Questions Sequencing Patent

A decades-old patent application could rewrite the history of who invented the automated DNA sequencer.

Last week, the U.S. Patent and Trademark Office (PTO) decided that a 1982 application from Enzo Biochem, a small New York biotech company, covers the same invention named in a 1998 patent awarded to former California Institute of Technology biologist Leroy Hood and colleagues. Hood's patent, owned by the California Institute of Technology (Caltech) in Pasadena, covers sequencing using gel electrophoresis—the technology currently underpinning the $7 billion DNA sequencing industry.

PTO's decision to begin what's called an interference procedure follows decades of efforts by Enzo's lawyers to win a patent. At stake are presumed millions of dollars in royalty income for Caltech and the fiscal health of sequencing giant Applied Biosystems in Foster City, California, which licensed Hood's technology in a majority of its machines. Applied Biosystems, with fiscal 2006 sequencing-machine revenue of $540 million, has previously fought off other attacks on the intellectual property it owns or licenses.

Attorneys say the announcement itself marks a victory for Enzo, which last fiscal year recorded losses of $15.7 million. But the company's chances of success are hard to determine. Caltech's attorneys, who declined to comment on the matter, are expected to claim that PTO erred in deciding that Enzo's application covers Hood's invention, although a copy of the typed 1982 version does mention the procedure. At some point, the two sides will also bicker over who invented what first—with the answer hinging on yet-to-be-disclosed lab notebooks and calendars.

The whole process, which could include a subsequent trial and appeal, could last 5 years or longer, says interference specialist R. Danny Huntington of Bingham McCutchen LLP in Washington, D.C. Caltech's patent expires in 2015. If Enzo wins and receives a patent with a later expiration date, Applied Biosystems would have to pay additional royalties to use the technology. At the same time, a patent on gel electrophoresis could be less important by then, notes George Church of Harvard Medical School in Boston, because scientists are steadily moving toward new methods of sequencing DNA. Techniques include using pores or solid surfaces to cut costs or sequence genes faster (*Science*, 17 March, p. 1544).

—ELI KINTISCH

CREDIT: DAVID BEAULIEU/ABOUT.COM LANDSCAPING "startled that the court would have said this was not obvious."

More than common sense

The question before the high court next week began as a standard infringement case. In 2002, Limerick, Pennsylvania–based Teleflex, a manufacturer, sued KSR, an Ontario, Canada–based firm that makes brake pedals, for patent infringement. It won before the federal circuit court, and KSR appealed to the Supreme Court, which decided earlier this year to take the case. At issue is whether Teleflex's 2001 patent, which combines an adjustable and electric pedal, was obvious and should not have been granted.

In a 1966 precedent-setting case involving plow parts, the high court gave examiners the power to "ascertain" or "determine" obviousness without much definition of the term. Patent lawyers say that gave examiners wide latitude to issue rejections. But since its 1982 founding, the federal circuit has established more direct instructions to PTO: An existing specific teaching, suggestion, or motivation for a combination of elements is required to declare a patent claim obvious. "Common sense" does not "substitute for authority," the court said in 2002. Two years later, a federal court ruled that a patent on a drug combining the painkillers Vicodin and ibuprofen was invalid as obvious. But the federal circuit reversed that decision because there was "no record of evidence … suggesting the enhanced biomedical effect of the combination."

Critics say such decisions have driven PTO to issue bad patents that hurt consumers and innovators alike. "Anyone who's been sick knows you can put two analgesics together to fight pain," says Jeffrey Light of Washington, D.C.–based Patients not Patents, which joined with AARP on KSR's side. Such patents, says Light, "lead to higher costs" for consumers and choke competition. And they hurt truly innovative scientists, adds Duffy, who represents KSR: "Follow-on patents can rob the pioneering patents of their just rewards."

Defenders of the status quo, including the Biotechnology Industry Organization in Washington, D.C., say the high court shouldn't jeopardize a reliance "on factual findings" that has allowed the U.S. research enterprise to flourish. And Kevin Noonan, a patent attorney with McDonnell Boehnen Hulbert & Berghoff LLP in Chicago, Illinois, fears giving examiners, whose expertise varies greatly, too much say in the obviousness call. "Do we really want whether someone gets a patent to be based on what examiner they get by the luck of the draw?" he asks.

The federal circuit itself may even be rethinking the issue. Last month, in what its critics welcome as a new tack, it declared that its obviousness standards are "quite flexible" and require "consideration of common knowledge and common sense."

Last year, the high court avoided taking any dramatic steps to overhaul the patent system in cases dealing with the patentability of scientific concepts and the legal power of a granted patent. But critics are hopeful that the nine justices will now act forcefully to fix a flaw they think is more central to patent quality. "Obviousness is getting closer to the root of the problem," says Josh Lerner of Harvard Business School in Boston, an outspoken opponent of the current regime. "*KSR* is potentially huge."

–ELI KINTISCH

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Economic Roundtable Talk at The California Club
(October 11, 2008)
By Robert M L Baker, Jr.

It was November 1958, and I was a newly minted Ph.D. who had just advanced to department head at Aeroneutronic Philco Ford in beautiful Newport Beach California. To my surprise, I received a letter from the Department of Defense, stating that next month I should report to Hanscom Field, Boston, Massachusetts for a two year tour of active duty in the United States Air Force. I thought this must be some kind of mistake. Although I had been in the Air Force ROTC at UCLA, I didn't realize that they actually wanted me to serve! Here I was on the verge of a wonderful career in the burgeoning field of aerospace technology and now sidetracked by the US Air Force? I hurried down to the reserve Air Force headquarters at Wilshire and San Vicente. I told them "I will be happy to write you out of check for the $26 a month that I was paid during the AF ROTC program at UCLA and we can call it even – OK? " Unfortunately, that did not satisfy them, but they'd did say that there was a new Air Force Station opening up in El Segundo, California called the Air Force Ballistic Missile Division or AFBMD. They felt that "…it would be the perfect place for a brand-new aerospace engineer like you to serve."

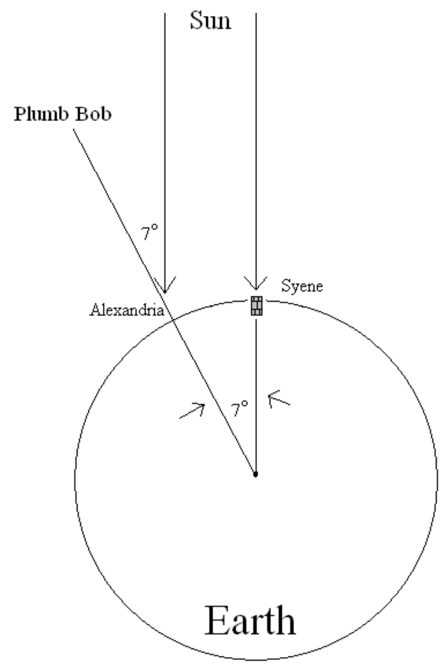
I pulled out my old Air Force uniform, polished up the brass and reported to AFBMD after a few months. Well, things weren't that bad. The base commander, General Ritland, had decided that all the officers should wear mainly civilian clothes because he did not want an obvious military presence in El Segundo. Furthermore, someone pulled out my 201 file, which showed that I had the first Ph.D. in aerospace with a specialization in orbit determination. It turned out that I was the only officer in the United States Air Force that had any real knowledge of the orbits that the craft they were building moved on. In order for me to be more productive, the good General assigned me my own private secretary, Gertrude. I was, as a matter of fact, the only lieutenant in the Air Force that had a private secretary. Up to this point the lowest ranking officer with such a secretary was a lieutenant colonel. Well, Gertrude and I got along famously and I was able to devote most of my time to writing technical papers. Some of which were published in the open scientific literature. I also held a Top Secret security clearance and worked on several very secret projects.

One day in late spring 1961 (I was about two months away from the end of my active-duty tour), I was walking across the quad (the whole base was somewhat like a college campus then) an officer that I knew was walking the other way. He said over his shoulder. "Well, Bob. I see that you're up for court martial." I walked a few paces, turned around and said "what was that you said." He reiterated that I was on court-martial list and suggested that I go to the Judge Advocate General's office, which I quickly did. Yes, indeed I found myself listed on the wall as being up for court martial and attempted to find out what the charges actually were. Nobody seemed very interested in my predicament, but I persisted. They finally indicated that I was up for divulging classified military secrets. "What secrets?" Well, they said that it had something to do with the ballistic missile firing tables. “Okay, but what specifically?” I ask. After about half an hour searching through the files, a secretary said "well, you divulged a classified number in the ballistic missile firing tables." "What number?" She turned to me and said "you published in the open literature (The Journal of the Astronautical Sciences, Volume 8, Number 1) the equatorial radius of the Earth that is being used in the firing tables. Very serious Lieutenant Baker!" That number was 6,378,150 m and I will never forget it. I waited to see the JAG. He was an attorney and a knew almost nothing about orbit determination. I told them it was all the other way around! The people who had written up the firing tables had lifted that number from the paper that I had published and not the other way around. He said it was “…no problem, I am sure that you got a release for the paper prior to publication, and just show us that security release and the whole issue will be dropped.”

Around noon I went right back to my office and asked Gertrude to please find me security release letter on the paper that I had written; the one on the subject of what are called “Astrodynamic constants” and included the value for the Earth's equatorial radius of 6,378,150 m that were copied and used in the ballistic-missile firing tables. Everybody starts home at around 4:15 pm in the afternoon at AFBMD so that around 4:00 pm I went in to talk to Gertrude. Well, she said "Lieutenant Baker. I've looked everywhere, but I can't seem to find that letter." I indicated to Gertrude that this was a very serious matter and that I might wind up in Lompoc or Leavenworth if that letter could not be found. Gertrude said that she would get right back to it the next day. The next morning I found on my desk, not the letter but a chocolate cake that she had baked the evening before.. She suggested that since she couldn't find a letter, the ncake might make me feel a lot better. I told her that unless she had put a hacksaw blade in the cake. “…your cake really wasn't that helpful.” So I took the whole office apart, and lo and behold in the pages of an issue of Aerospace America was a security release letter. I was finally off the hook.

This brings me to what I really wanted to talk about this morning -- how one determines the size and shape of the Earth. We go back to the time of Eratosthenes (276 BC to 194 BC). At that time most people believed that the Earth was flat and determining that it was spherical with a radius was a very complex issue. Eratosthenes was a brilliant mathematician born in what is now known as Shahhat, Libya. He lived in an old town near Syene (a town near the Nile river where the Aswan dam is now located). He noticed that on a particular day of the year at noon, when the Sun was directly overhead, the bottom of a well was illuminated. He concluded that on this particular date the Sun was truly in the zenith and that the Sun was so far away that all of the Sun’s rays were parallel. On the same day the next year he moved along the meridian of longitude of the original well, that is, he went due north. This distance on the Earth's surface was measured as precisely as was possible (actually the distance was known to be about 5,000 stadia). On this very same day a year later, he concluded that the Sun would again be directly over the well (at its zenith) so that if he measured the angle from Syene to the Sun at noon at Alexandria this angle (about 7°) would be the same as that subtended at the center of the Earth between Alexandria and Syene. Simple proportions show that the measured angle, 7^0 at Alexandria (for example, using plumb bob to establish local vertical or zenith) divided by 360° equal the measured arc on the Alexandrian meridian divided by local radius of curvature of the Earth.

Please take a look at the first diagram that I've distributed. The proportion is 5,000 stadia/7^0 = (circumference of the Earth)/360^0 so that, doing the arithmetic, the circumference of the Earth ≈ 257,000 stadia. As exhibited in the other handout, the circumference divided by 2π is the Earth's radius ≈ 40,000 stadia. The solution for the radius by Eratosthenes seems to be quite reasonable, but defies critical evaluation as his measurement was in terms of "stadia." Historians and archaeologists have not been able to tell us which stadium he had in mind (probably one stadia was about 1/10 of a mile or 157 meters in length; leading to an equatorial radius of about 6,250,000 m, which is remarkably close to today's value). Like Eratosthenes, modern geodetic surveyors estimate the local radius of curvature of the Earth, but with the use of much longer and more precise measuring arcs and angles on the Earth. As will be mentioned in the following such direct methods are now being supplemented by indirect satellite observations.

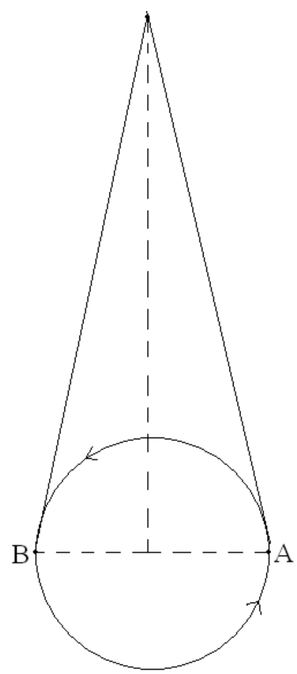


Between 1735 and 1743 the French dispatched an expedition to measure the length of one degree of latitude at different points on the Earth's surface. If the Earth were spherical, then the degree would have about the same length and meters (as measured along the Earth's surface) at all latitudes. The expedition found a difference in the length of the degree and thereby confirm that the Earth was indeed not perfectly spherical. And that was "flattened" at the poles. Even prior to this time Newton had come to the same conclusion on the basis of a study of the dynamics of a spinning body, such as the Earth, which "bulges" out at its equator. Today geophysicists are able to make very precise estimates of the Earth's shape through these surveys.

But how was I able to obtain the value 6,378, 150 m for the equatorial radius of the Earth in 1961? I found that the geometrical figure of the Earth, as obtained by geodetic surveys and the dynamical figure of the Earth, as obtained from satellites, are actually in considerable agreement. Approximately at least, the Earth is in a state of hydrostatic equilibrium, that is, it has assumed nearly the form that a freely rotating fluid body would assume under its own internal gravitational forces. In fact, when the strengths of the material that make up the Earth's mantle are considered, it becomes obvious that if there existed any gravitational dynamical asphericity of the Earth (caused, for example, by a gross heterogeneity in the Earth's crust), then the material of the Earth could not resist the stresses and the Earth's geometrical figure would soon be brought into agreement with the Earth's dynamical figure, that is, in the form of an oblate aspherical Earth. Underneath the Earth's surface (more specifically, under the lithosphere) is a point in so-called isostatic equilibrium. This level is what Mike LeRoy suggested to be what the continents seemed to float on. A measurable quantity is the acceleration of gravity at the Earth's surface. It is also computed from a general gravity formula that includes the figure of the Earth. Thus we have a relationship between the observed acceleration of gravity at any latitude on the assumption that the Earth is symmetrical about the equator. Given a large number of these measured gravitational accelerations at specific latitudes (measurements reduced to sea level), one can solve for the various coefficients that describe the dynamical figure of the Earth. The orbits of satellites are also modified due to the dynamical figure of the Earth. For example, the equatorial bulge tends to pull the satellites towards the equator. This so called perturbation depends upon the distribution of mass that is the aspherical nature of the Earth. As I mentioned earlier, the geometrical shape of the Earth can be obtained in a procedure similar to the one Eratosthenes utilized. Both of these measurements, when conducted over the entire surface of the Earth (over the oceans the situation is more complex, but some measurements can still be taken), show that the Earth is not exactly symmetrical about the equator. Like some of us, it is pear-shaped. Nevertheless, the Earth has an average radius at the equator that is obtained by combining all of the aforementioned measurements. That is, by combining measurements of the local radius of curvature of the Earth's surface (somewhat like Eratosthenes' approach), with measurements of the acceleration of gravity reduced to sea level, and with observations of the perturbations of Earth satellites. The most recent unclassified value for the equatorial radius of the Earth is 6,378,137 m from the 1984 World Geodetic System. There is now, as it was in the Air Force, a classified value for that reference constant good to a few centimeters (or less) for use in GPS and other high-precision satellite orbits and in the new firing tables, but I wouldn't even dare to guess at its value!

Let us now discuss some of the other so-called Astrodynamic constants and what they're used for besides those that describe the Earth. First, let us consider the Moon. There are several fundamental constants involved in travel to and from our Moon. The first is the distance to the Moon. The Moon is not on a circular orbit, but rather follows an elliptical orbital path It has the semi-major axis of the elliptical orbit and a measure of its ellipticity, which is called its eccentricity (for the Moon's orbit the eccentricity $e \approx 0.06$, which means it departs from a perfect circle by about 6%). Please take a look at the handout. Notice the drawing of the ellipse. Its major axis is just that -- the largest distance across. Half that distance is a semi-major axis, and given the usual symbol of *a*. The distance from the focus of the ellipse to the closest point (perifocus or periapsis) is given by the quantity $a(1 - e)$ and the distance to the furthest point (the apofocus or apoapsis) is given by $a(1 - e)$.

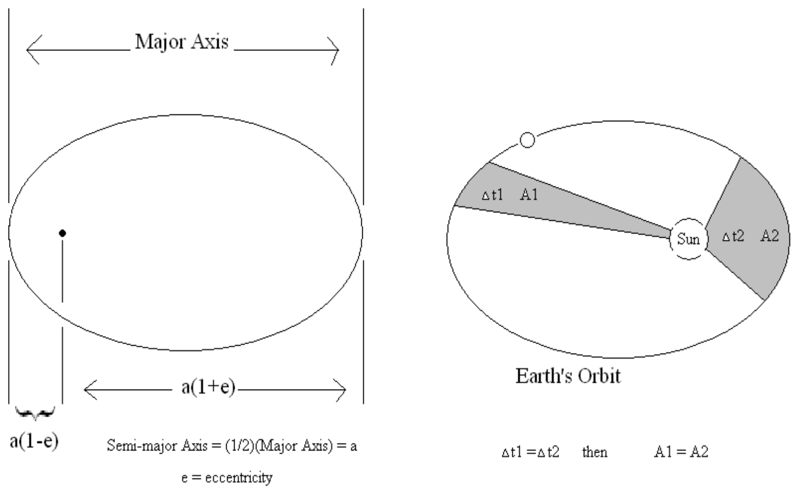
How do we determine those two Astrodynamic constants, *a* and *e*? Again, we utilize some of the same procedures as were carried out by Eratosthenes. First, we need to determine the varying distance to the Moon while it moves on its elliptical orbit. We could do this by measuring the angle to the Moon at dawn and at dusk. Using knowledge of the motion of the Moon as originally developed by Kepler over the period of 1609 to 1618 (almost two thousand years after the work of Eratosthenes!) and trigonometry, he essentially used the diameter of the Earth as the baseline (we are at one end of the diameter at dawn (A) and the other end of the diameter at dusk (B) – approximately – as shown in the hand out). Such triangulation is exactly what surveyors accomplish here on Earth. Such an approach led Eratosthenes to determine that the Moon was about 780,000 stadia away. This is about 122 million meters and off by a factor of three from its true value of 384 million meters. Such a discrepancy was probably due, at least in part, to the lack of knowledge of the true orbital dynamics of the Moon's orbit. As already mentioned, this knowledge had to wait almost 2000 years for Kepler and then Sir Isaac Newton to develop the laws of planetary motion, which of course also apply to the Moon's orbit.



Allow me to digress here and discuss Kepler's famous laws of planetary motion:

(I) Every planet moves on an ellipse with the Sun at one focus. As we have seen an ellipse is an oval-shaped figure that departs from a perfect circle in its form and exhibits an eccentricity.

(II) Every planet moves in such a way that its radius vector sweeps over equal areas and equal times. The easiest way to visualize this is to think of a string from the Sun out to a given planet. If you put paint on the string, then as a planet moves, say, over a period of a few days (mathematically termed Δt), the area, *A*, painted by the string is the same no matter where you are on the orbit. Thus when the planet is very near the Sun (called aphelion) it must move faster than when it is furthest from the Sun (called perihelion) in order that the string paints out equal areas at those orbital points. Please see the handout.



(III) The squares of the periods of revolution, of any planet that moves around the Sun (that is the time it takes that particular planet to make a complete circuit of the Sun) are to each other as the cubes of their mean distances of the planet from the Sun. In equation form this relationship is expressed as:

$(\text{Period of planet})^2$ proportional to $(\text{mean distance})^3$

or P^2 proportional to a^3

Consider the Table:

Planet	Period (years)	Period Squared	Semi-major Axis (AUs)	Semi-major Axis Cubed	Ratio of Period Squared to Semi-major Axis Cubed
Venus	0.615	0.378	0.723	0.378	1.000
Earth	1	1	1	1	1
Mars	1.88	3.53	1.524	3.51	1.006
Jupiter	11.86	140.66	5.204	140.9	0.998

This law holds not only for the planets, but also for satellites of the Earth such as the Moon and artificial satellites such as are involved in the GPS system and, as we will see, to interplanetary trajectories..

Classical astronomical constants, although they are among the most precisely known of any constants found in nature, do not suffice for predicting exact trajectory to modern space vehicles. Not only is a greater precision found essential, but new kinds of constants, not ordinarily associate with astronomy, have assumed importance. Irregularities in the motion of nearby satellites, for example, have brought to light higher order terms in the Earth's gravitational field that have no counterpart in lunar theory, thus providing valuable new data regarding the Earth’s figure and distribution of mass. For interplanetary and lunar trajectories more exact values of the solar parallax, or the ratio of the astronomical unit (AU) to the kilometer, and the distances, diameters, masses, temperatures, and atmospheres of the Moon and target planets are essential to a successful mission. Obviously, it is important to select such parameters in advance. The best possible values of the constants involved in a given experiment. You may remember a few years ago, when the use of incorrect constants in an onboard computer program resulted in the total failure of a Mars spacecraft and the associated multi-million dollar mission. It is vitally important, therefore, to make an assessment of the uncertainty in the adopted reference values of astrodynamic constants and analyze the effect that an error in a fundamental constant will have on to derive constants and on the final outcome of a mission. I found that the numerical value to be chosen for any given constant specifically should **not** be based upon: (1). An average of all given values, (2) the choice of the most recent value, or (3) the value endowed by its author with the smallest standard deviation or uncertainty. The choice is a complicated one based upon a thoroughgoing analysis of all investigators’ works. For this reason a very large number of experimental observations is required and different theories tying them together utilized.

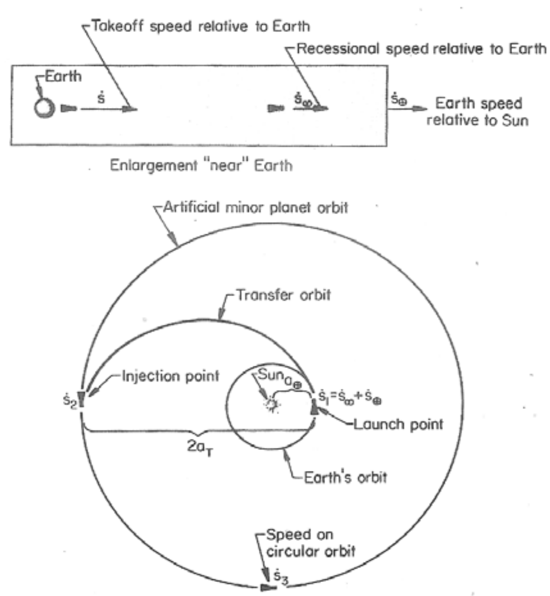
Perhaps the most important of the fundamental constants is the ratio of the astronomical unit (AU) (semi-major axis of the Earth’s orbit around the Sun – sometimes termed the mean distance to the Sun, which is utilized in interplanetary trajectories) to the kilometer. As an illustration of the complexity of the problem of determining a basic constant, we shall cite here the experiments which were carried out in Europe and in the US for the purpose of evaluating the ratio. Two equivalent terms are used in conjunction with this problem: "determination of the ratio of the astronomical unit to the kilometer" and "determination of the solar parallax." These terms are synonymous since the solar parallax is simply the angle whose sine is the ratio of the Earth's equatorial radius (well-known in kilometers as we have discovered) to the astronomical unit. In less mathematical terms the solar parallax angle can be imagined as half the angles subtended by the Earth's equator as observed from the center of the Sun. The problem of determining the ratio of the astronomical unit to the kilometer and the solar parallax are, therefore, identical. In the case of modern radar experiments one approaches the problem as follows: knowing the speed of light in kilometers per second, measure the time required by a radar pulse to travel from the Earth to Venus and be reflected back. The distance from the radar station to the surface of Venus is equal to one half the product of the speed of light multiplied by the travel time to Venus and return, allowance being made for the motion of the two planets in that time interval. The diameters of the Earth and Venus must be known, as well as the exact location of the radar antenna with respect to the center of the Earth and the radar reflection point on Venus relative to the center of

Venus, in order to reduce the observations to their centers. Using knowledge of the precise orbital elements of both planets (such as their semi-major axis and orbital eccentricity) the exact distance in astronomical units between their centers at the time of observation can be determined. Equating the distance in kilometers to the distance in astronomical units leads to a direct evaluation of the astronomical unit in kilometers.

By the way, Eratosthenes also computed the distance to the Sun by making optical measurements at dawn and dusk (the diameter of the Earth being the baseline) and because during the 12 hour time span the Earth moved much less on its orbit than the Moon in 12 hours the computation was more exact. He found the distance to be 104,000,000 stadia. This amounted to about 80,000,000 miles or 126,000,000 km. Today we find in the distance to be about 92,000,000 miles or 149,000,000 km. This determination was almost 2000 years before Copernicus (1473 -1543), Galileo (1564 - 1642), Kepler (1571 -1630) and Newton (1642 -- 1721). At this ancient time, he probably recognized that the Earth moved around the Sun, certainly recognized that the Earth was spherical in form and was able to determine the Earth's distance from the Sun to a few percent of today's modern value. Eratosthenes was amazing! He was brilliant, and many decades ahead of his time in the contributions to number theory, geography wrote poetry, including the poem *Hermes,* inspired by astronomy, as well as literary works on the theater and on ethics, which was a favorite topic of the Greeks. Despite being a leading all around scholar, he was considered a fall short of the highest rank. As the biographer Heath writes: “Eratosthenes was, indeed, recognized by his contemporaries as a man of great distinction in all branches of knowledge, though in each subject he just fell short of the highest place. On the latter ground, he was called in *Beta*, and another nickname applied to him had the same implication, representing as it does an all-around athlete who is not the first runner or best wrestler, but took the second prize in these contests with others.” Certainly this was a harsh nickname to give to a man whose accomplishments in many different areas are remembered today not only has historically important part, remarkable and in many cases still providing a basis for my modern scientific methods thousands of years later. In many scientific quarters, he was not considered "mainstream."

But, returning to the subject of Astrodynamic constants, why do we need to know the AU in kilometers you might ask? Utilization of literally thousands if not millions of optical (telescope) observations of the planets have provided us with extremely accurate locations of the planets (called ephemerides). As in the case of locating the Moon by using the diameter of the Earth as the baseline, we locate the planets using the diameter of the Earth’s orbit as the “baseline” and that baseline is by definition two astronomical units (or AUs)in length. Thus all of the planetary locations are in AUs. On the other hand, all of the spacecraft trajectory and guidance information is in the Earth-based metric system, e.g., the kilometer, so we must be able to tie the two together.

As a practical example let us consider an interplanetary transfer trajectory for transportation to an artificial minor planet orbit. Such a trajectory is just like the one we are planning to land Man on Mars. Again, please look at the handout. Here we assume that the Earth's orbit is circular, and that the orbit to which we want to transfer is also circular. As I said it could be a minor planet orbit, the orbit of Mars, the orbit of Venus -- -- in fact, it could be orbit of almost any planet. The little s with the dots over it represents speed. Here you have to think of the Earth as something like a railroad flat car. It moves at a certain speed down the track. That's the orbital speed of the Earth, relative to the Sun. The little circle with the cross and it is a symbol for Earth. We see that the spacecraft launch from the Earth is in the direction of the Earth's motion that is in the direction of a flat car movement. At the Earth's surface the spacecraft is moving quite rapidly and as it moves away from the Earth it is slowed down by the Earth's gravitational field and reaches a terminal velocity, called the recessional speed relative to the Earth. We add that to the speed of the Earth (flat car) and that becomes the speed relative to the Sun on the transfer orbit – and defines the spacecraft's transfer trajectory. As can be seen the transfer orbit is simply half of an ellipse. If the spacecraft did not reach the objective planet at just the right time and passed it by, then it would complete the elliptical trajectory again and again. As it approaches the objective object (minor planet, or Mars, Venus, Jupiter, etc) touchdown is similar to landing on an aircraft carrier that is moving across the ocean, the ocean being the framework of the orbit around the Sun. The spacecraft now has to slow down or speed up in order to bring its speed in coincidence with that of the objective or target planet in order that a safe landing can be accomplished. This discussion is meant to show how important the Astrodynamic constants are. First of all, we have to know near the Earth its equatorial radius and its mass in order to determine the amount that the Earth slows the launched spacecraft. We have to know the astronomical unit and the mass of the Sun in order to determine the characteristics of the transfer orbit. We have to time the transfer in order to perfectly meet up with the objective planet landing point. To do this we have to be able to define the target planet's speed when we are attempting to rendezvous the planet and the spacecraft at the other end of the line. In other words we have to define the speed of the spacecraft relative to the target. This means we have to know the mass and radius of the target since we don't want to crash because we under or overestimated the mass or under or over estimated its size or shape. Thus we must have accurate determinations of the Astrodynamic constants associated with the Earth, Sun and target planet.



Transfer to artificial minor planet orbit.

The next planned manned mission (the George W. Bush vision) is to Mars. We also must look forward to travel to some of the well over 200 recently discovered so-called extrasolar planetary systems or exoplanets circling many nearby stars relatively near our star called the Sun. In this regard, when marveling at the stars on a clear night, it's hard to imagine that there are up to 400 billion of them in our galaxy alone ands perhaps billions of galaxies. Even harder to comprehend is how many planets are orbiting the stars -- a number that could run into the trillions. Surely somewhere among them there must be a comfortable home for alien life, even if it's not advanced enough to be gazing back at us? This is a question that exoplanet hunters are trying to answer. So far they have spotted about 209 planets beyond our Solar System. When I last reported on such exoplanets in 2001, there were only 66. These exoplanets tend to be gas giants in searingly hot orbits close their parent stars -- unlikely to be habitable. But researchers are edging closer to finding the one type of planet that we know can support life -- a carbon copy of our own Earth. Thanks to improve techniques, mounting data and new space missions, many believe that 2008 could be the year we find the first truly earthlike planet. There are new telescope designs that can cut out the central star's relatively intense light – something like an artificial eclipse of the star and allow visualization of any companion planets. At the very least we should have a better idea of how many common alien earths there may be within some given distance from our Sun.

The main obstacle for exoplanet hunters is that planets outside our Solar System are obscured by the light from their star, so that telescopes, except for the new designs just mentioned, cannot see them directly. Most researchers make use of the fact that when a planet orbits a star, its gravitational pull causes a star to wobble slightly. As a star wobbles, its speed is seen from the Earth (called radial velocity, that is velocity directly toward or away from us) changes, and this shows itself as a change in the wavelength of the star's light. This change can be used to estimate a lower limit for the planet's mass. Unfortunately, radial velocity measurements tend to detect big planets that are close to their stars. Heavier planets cause more wobbles. So far, the method has found the 209 exoplanets we have mentioned, the smallest of which is about 7.4 times the mass of the Earth. The improvements in accuracy are allowing researchers to spot even smaller planets, and as more observations are made, it is possible to detect planets that are further from their stars. In a recent edition of the Astrophysical Journal, researchers determined what the characteristic of these Earth look-alikes actually might be. They assumed the planets are composed of concentric shells and similar composition. The researchers then solve equations for density, gravity, mass and pressure in each exoplanet. Here again, we have what we have discussed before: Astrodynamic Constants; but now they are associated with exoplanets rather than the Earth and or Solar System's planets? One such exoplanet was reported to have an equatorial radius of about 12,000 km - a little under twice that of the Earth.

How many of these mostly Jupiter like planets exist in our galaxy? New calculations made at the University of New South Wales in Australia, may have an encouraging answer to this question. The researchers expect that a large number of "Jupiters" will be found, perhaps 50% more than currently expected. Each such discovery would be significant in the hunt for planets that could harbor life. Because much of the evolution of own Solar System, including the formation of the Earth, was orchestrated or affected by Jupiter, the largest planet with by far the bulk of the Solar System's mass, excepting of course, the Sun. When Jupiter developed, it simply bullied other objects into positions or out of existence. And then the mighty gas giant became Earth protector. Though the fledgling Earth was pummeled by asteroids and comets, making it difficult for life to take hold, it could've been much worse. Jupiter shielded Earth from an even heavier bombardment of debris that made its way from the outskirts of the new Solar System towards its central star, the Sun. That protective role continues. In 1994, Jupiter used its immense gravity to lure comet Shoemaker-Levy into a death plunge. Had the comet hit Earth, it would've sterilized much or all of our planet. For now, no one knows whether our Solar System represents a common method of formation and evolution. In fact, discoveries over the past six years seem to indicate otherwise. Most of the roughly 209 planets discovered outside our Solar System are much more massive than Jupiter. They also orbit perilously close to their host stars, locations that would likely prevent rocky planets from forming in so-called habitable orbits in which their surface temperatures are between the freezing and boiling point of water. But experts attribute these findings to the limitation of technology. Smaller planets in more comfortable orbits around the other stars simply can't be detected yet. So how many "Jupiters" are out there orbiting sun-like stars in the Milky Way galaxy? At least a billion, but probably more like 30 billion. There are about 300 billion stars in our galaxy. About 10% are roughly sun-like. At least 5% (1.5 billion), but possibly as many as 90% or hundred percent (about 30 billion) of these have Jupiter-like planets. A reasonable guess is that the number of earthlike planets are about the same as the number of Jupiters. It is expected the Jupiter-like planets are commonplace, and so are earthlike planets in these extrasolar planetary systems. NASA is planning for a new mission, called "Kepler" that will monitor 100,000 stars for telltale dips in their light indicating an earth-sized planet in an earth-like orbit has crossed in front of a star. While it could not take photographs of the actual exoplanets Kepler could provide the first census of planets that have the potential to support life.

But how do we get to these exoplanets? The interstellar transfer trajectories are quite different from the interplanetary transfer trajectories. Even if we extrapolate current propulsion system technology in the most generous way, we find that it will be difficult to even approach the speed of light, about 186,000 miles per second – in comparison the escape velocity from the Earth for most of our conventional interplanetary spacecraft is about 7 miles per second.. Thus the interstellar spacecraft will no doubt have to accelerate during half of the journey towards the objective exoplanetary system and then decelerate until it rendezvous with the exoplanet of interest – at which point its speed will need to be in coincidence. As I discussed in my talk on "Twinkle, Twinkle Little Star" this will probably take years, if not centuries in transit time. Thus "they" will probably visit us before we visit them – so keep your welcome mat out for the extraterrestrials!

Thank you.

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December 1, 2005

Economic Round Table (ERT)
The California Club, Los Angeles

The Human Kindness Index
By
Robert M. L. Baker, Jr.

Early this year, as we viewed the panorama of the blue Pacific from Skip Bowling's beautiful Rosarito Beach home and sipped margaritas, Skip and I conjectured on the course of humanity over the past million or so years. We concluded that it would be extremely interesting to determine whether or not humanity is getting better or worse as time goes on. As homosapiens moved out of the caves and advanced in intellect and capability did they become kinder and gentler in dealing with one another? The measure of this trend I will call "The Human Kindness Index," or HKI. Since one does not know apriori whether we are getting kinder or not we could just as easily define a "Human Unkindness Index," but I will choose the former for the purpose of positive thinking.

I had not seriously addressed the issue until I came across an article in the *Wall Street Journal* by Sharon Begley last April (4-29-05) reviewing a book entitled "Adapting Minds" … a book on evolutionary psychology or social anthropology. This book dashed my cherished belief that it had been proven that over time and through natural selection and evolution younger women would prefer higher-status older men, such we are at ERT, and thereby justified men falling for beautiful young babes – providing us all with the defense "evolution made me do it!" Not so said author David Buller. Well, I conjectured, maybe there is also no evolutionary basis for humanity becoming kinder (or meaner) over time. Since I was unwilling to give up on "my cherished beliefs" I decided to research further and set about reading several other books on the subject: "The Selfish Gene" by Richard Dawkins, "The Meme Machine" by Susan Blackmore, "Sociobiology" by Edward O. Wilson, and, of course, "Adapting Minds" by David J. Buller.

Before I relay to you my conclusions from reading these interesting books, I must confess that I was searching for some quantitative basis for the Human Kindness Index in them such as the *number of deaths at the hands of another per hundred thousand per year.* So far I have not found such a statistic. I will, therefore, concentrate in this talk on the subject of modern evolutionary theory based upon Darwin (and even touch on "Intelligent Design" or ID) with the objective of determining if evolution can affect the HKI – or is "everyday a new day" for humanity and we all start off with a clean slate and genetics does not influence our general behavior as homosapiens? Perhaps the most interesting and informative introduction to modern evolutionary theory is "The selfish gene" by Richard Dawkins. Dawkins argues that a predominant quality to be expected in a successful gene is ruthless selfishness. This gene selfishness will usually give rise to selfishness in individual behavior. However, and more to the point of HKI, we will see that there are special circumstances in which a gene can achieve its selfish goals best by fostering a limited form of altruism at the level of individual animals such as humans. It should be recognized, however, that universal love and the welfare of our species are concepts that simply do not make evolutionary sense. Let us consider an example: if we were told the man had lived a long and prosperous life in the world of a Chicago gangster, we would be entitled to make some guesses as to the sort of man he was. We might expect that he would have qualities such as toughness, a quick trigger finger, and the ability to attract loyal friend. These would not be infallible deductions, but you can make some inferences about man's character if you know something about the conditions in which he has survived and prospered. The argument is that we, and all other animals, are machines created by our genes. Like a successful Chicago gangster, our genes have survived, in some cases for millions of years, in a highly competitive world. From what I have just said we might think that genes had some kind of a life of their own, an ability to plan and predicted their future. But this is simply not the case.

There are three characteristics of a gene (as we will see later, also of a “meme") that make it an element of evolution:

1. The gene must be able to replicate itself;

2. The replication may not be perfect (or may be “mutated” in some way); and

3 The gene will eventually die out if most of the machines that utilize the "part," which is specified by the particular gene, are inferior and do not survive.

Thus the machines that are fabricated from the parts specified by these genes, we humans, are products of the "survival of the fittest." The gene is "blind." It cannot plan, it cannot predict. It can only replicate itself and, if in its environment the machines using the part specified by the gene do not survive, then the gene will die out and not be replicated.

Let us, therefore, define the living entities fabricated from the parts specified by the genes as "survival machines" and study them from the beginning of life on our planet. Survival machines began as passive receptacles for the genes, providing a little more than walls to protect them from the chemical warfare of their rivals and the ravages of accidental molecular bombardment. In the early days they "fed" on organic molecules freely available in the primeval soup, which had been slowly built up under the energetic influence of centuries of sunlight, until the soup was all used up. A major branch of survival machines, now called plants, started to utilize sunlight directly themselves to build up complex molecules from simple ones, re-enacting at much higher speed the synthesis process of the original soup. Another branch, now known as animals, "discovered" how to exploit the chemical labors of the plant, either by eating them, or by eating other animals. Both main branches of survival machines evolved more and more ingenious tricks to increase their efficiency in their various ways of life, and new ways of life were continually being opened up. Sub branches and sub-sub branches evolved, each one excelling in a particular specialized way of making a living: in the sea, on the ground, in the air, underground, up trees, inside other living bodies. This sub branching has given rise to the immense diversity of animals and plants which so impresses us today. We are all survival machines with the same kind of replicator-molecules called DNA -- genes are made of DNA, but there are many different ways of making a living in the world, and the replicators have built a vast range of machines to support them. A monkey is a machine that preserves genes up trees, a fish is a machine that preserves genes in the water; there's even a small worm that preserves its DNA in German beer mugs. Genes made of DNA work in mysterious ways. For simplicity I had given the impression that modern genes are much the same as the first replicators in the primeval soup. The original replicators may, however, have been a related kind of molecules to DNA or they may have been totally different. If so the original replicators were utterly destroyed, for no trace of them remains in modern survival machines. Along these lines A. G. Cairns-Smith has made the intriguing suggestion that our ancestors, the first replicators, may have not been organic molecules at all, but inorganic crystal minerals, little bits of clay. Usurper or not genes made of DNA are in charge today. The story of the Big Bad Wolf and the three Little Pigs is a good example of genes and DNA. The houses of straw, wood, and brick were like the genes and the plans and specifications for them were like the DNA. The Big Bad Wolf who huffed and puffed until he blew all the houses (genes) down except for the fittest brick house was the hostile environment. I hope that they remember the Three Little Pigs when they rebuild New Orleans.

The genes control the behavior of their survival machines, not directly with their fingers on puppet strings, but indirectly like a computer programmer. All they can do is to set up “computer programs” before hand; then the survival machines are on their own, and the genes can only sit passively inside. Why are they so passive? Why don't they grab the rains and take charge from moment a moment? The answer is that they cannot because of time-lag problems. This is best shown by another analogy, taken from science fiction: *A for Andromeda* by Fred Hoyle and John Elliot is an exciting story, and, like all good science fiction, it has some interesting scientific points lying behind it. Strangely, the book seems to lack explicit mention of the most important of all these underlying points. It is left to the reader's imagination. I hope the authors will not mind if I spelled it out here.

There is a civilization 200 light years away, in the constellation of Andromeda and their lifetimes are about the same as ours. They want to spread their culture to a distant world. How best to do it? Direct travel is out of the question. The speed of light imposes a theoretical upper limit to the rate at which you can get from one place to another in the universe, and mechanical considerations impose a much lower speed limit in practice. Besides there may not be all that many worlds worth going to, and how do you know which direction to go in? Radio waves, or as I expect gravitational waves, are a better way of communicating with the rest of the universe, since if you have enough power to broadcast signals in all directions rather than beam them in one direction, you can reach a very large number of worlds (the number increasing as a square of the distance the signal travels). Radio waves and gravitational waves travel at the speed of light, which means the signal takes 200 years to reach the Earth from Andromeda. The trouble with this sort of distance is that you can never hold a conversation. Even if you discount the fact that each message from Earth would be transmitted by people separated from each other by 12 generations; it would be just plain wasteful to attempt to converse over such distances. The problem has already arrived in earnest for us: it takes about five to twenty-five minutes for radio waves to travel between here and Mars -- depending upon the Earth-Mars orbital distance. There can be no doubt that spacemen in the planned mission to Mars will have to get out of the habit of conversing in short alternating sentences, you'll have to use long soliloquies or monologues, more like letters than conversations. The way in which the recent Mars Rover was guided is an example of this. General instructions were given: "Go from the hill two meters in front of you to a crater three meters to the right of the hill." And the Rover utilized a preprogrammed general strategy to accomplish that task. A strategy that kept it from being impaled on a rock or ditched in a ravine.

The Andromedians of the story did a similar thing. Since there was no point in waiting for a reply, they assembled everything they wanted to say into one huge unbroken message, and then they broadcast that out into space over and over again with the cycle time of several months. Their message was very different from the message instructing the Mars Rover to maneuver. It consisted of code instructions for the building and programming of a giant computer. Of course the instructions were not given in human language, but almost any code can be broken by a skilled cryptographer, especially if the designers of the code intended it to be easily broken. Picked up by the Jodrell Bank radio telescope or by a Chinese gravitational-wave detector, the message was eventually decoded and the computer built and the program run. The results were nearly disastrous for mankind, for the intentions of Andromedians were not universally altruistic, and the computer was well on the way to dictatorship over the world before the hero in the story finished it off with an axe.

From our point of view, the interesting question is in what sense the Andromedians could be said to be manipulating events on Earth. They had no direct control over what the computer did from moment a moment; indeed they had no possible way of even knowing even if the computer had been built, since the information would have taken 200 years to get back to them. The decisions and actions of the computer were entirely its own. It could not even refer back to its master for general policy instructions. All its instructions had to be built in advance because of the unavoidable two-hundred-year barrier, just as instructions for the Mars Rover had to be accomplished in advance and an attempt made before the flight to be prepared for any possible eventuality. In principle, the computer must have been programmed very much like a chess-playing computer, but with greater flexibility in capacity for absorbing local information. This was because the program had to be designed to work and not just on Earth, but on any world possessing advanced technology, any of a set of worlds whose detailed conditions the Andromedians had no way of knowing.

Just as the Andromedians had to have a computer on Earth to make day-to-day decisions for them, our genes have to build a brain. But the genes are not only the Andromedians who sent the code instructions; they are also the instructions themselves. The reason why they cannot manipulate our puppet strings directly is the same: time-lags. Genes work by controlling protein synthesis. This is a powerful way of manipulating the world, but it is slow. It takes months of patiently pulling proteins strings to build an embryo. The whole point about behavior, on the other hand, is that it is fast. It works on the time scale of not months or seconds, but fractions of seconds. Something happens in the world, an owl flashes overhead, a rustle in the long grass betrays prey, and in milliseconds nervous systems crackle interaction, muscles leap, and someone's life is saved or lost. Genes don't have a reaction times like that. Like the Andromedians, the genes can only do their best *in advance* by building a fast executive computer for themselves, and programming it in advanced with rules and "advice" to cope with as many eventuality as they can "anticipate." But life, like the game of chest, offers too many different possible eventualities for all of them to be anticipated. Like the chest programmer, the genes have to "instruct" their survival machines not in the specifics, but in the general strategies and tricks of the living trade.

But what is this all to do with altruism, selfishness, and finding the Human Kindness Index? The idea is that animal behavior, altruistic or selfish, kind or mean, is under the control of genes in only an indirect, but still very powerful sense. By dictating the way survival machines and their nervous systems are built, genes exert ultimate power over behavior. But the moment-to-moment decisions about what to do next are taken by the nervous system. Genes are the primary policy-makers; brains are the executives. But as brains became more highly developed, they took over more and more of the actual policy decisions, using "tricks" like learning and simulation in doing so. The logical conclusion to this trend, not yet reached in any species, would be for the genes to give the survival machines a single overall policy instruction: such as “do what ever you think best to keep us alive.”

Before we completely leave science fiction and the Andromedians, let me mention two additional very speculative evolutionary concepts one concerning the very, very large and the other concerning the very, very small: first, that universes (yes, it is now believed that there exist multiple universes) are but large-scale evolving computer programs and second, that there exist self-replicating nanobots. Autonomously self-replicating machines have long caught the imagination, but have yet to acquire the sophistication of biological systems, which assemble structures from disordered building blocks. In a recent article in the September 29, 2005 issue of the journal *Nature*, Saul Griffith, Dan Goldwater, and Joseph Jacobson, describe the autonomous self-replicating of a reconfigurable string of parts assembled from randomly positioned input components. Such a component, if suitably miniaturized and mass-produced, that is nano-machines or nanobots, could constitute cell fabricating systems whose assembly is brought about by the parts themselves. A key feature of biological replication is a template, that is a molecule's ability to make copies of itself (as in the case of DNA) by selecting the appropriate building blocks (nucleotides) from parts that are randomly and continuously distributed in its environment; the system also has a built-in ability to correct errors made during copying. The efficiency of this two-step process enables biological systems to generate exponentially increasing numbers of accurate copies of themselves as a function of time. To create these properties in an artificial system, a machine needs to be capable autonomous acquisition of randomly distributed building blocks and carrying out error correction during the copying process (but all errors could not be corrected of course). Given the compact requirement of internal-state machines, coupled with recent advances in micro-electromechanical systems (MEMS), it is possible that components, such as those described here, could eventually be miniaturized and, in fact, become evolving nanobots. They might be used to create a general system that is capable of self replicating or being programmed to self-fabricate into complex structures and evolve! The science-fiction book "Prey" by Michael Crichton has this story line. ("Cry-ton")

But what about the other speculative concept: that universes are but large-scale evolving computer programs (as Shakespeare said: "… all life is but a stage and we are the players.")? Such a computer-program concept is the basis for several science-fiction movies such as "Matrix" and "The Thirteenth Floor." It is also discussed in serious peer-reviewed scientific papers such as "Are you living in a computer simulation?" in the 2003 *Philosophical Quarterly* article by Bostrom, "Computational Creationism," in the 1999 *American Scientist* article by Hayes, "The Computational Universe," in the 2005 *Philosophical Quarterly* article by Lloyd, and "Traveling in a Computational Universe," in a forthcoming 2006 *American Institute of Physics Proceedings* article by Fontana. The computer code for one of a number of universes maybe similar to the gene. Optimization may involve the "survival" of the fittest, that is, universes with physical "laws" that are self consistent and do not lead to extinction will be fit. Again, the three keys to evolution are:

1) replication, that is a universe or program can be copied – this happens every time you "save" a computer program after modifying it;
(2) errors or imperfections in the program code or universe will inevitably occur; and
(3) some programs or universes will be so flawed (physical laws and/or dimensions, etc. inconsistent or other factors leading to the "quick" demise of a universe e.g., entropy death) that they will not long survive and be less "fit".

In a sense this is what happens as programmers develop computer programs. They try one approach and code it, run it, and reject or improve (debug) it. In a systems approach there are several teams of programmers working the same problem and only the fittest among them survive: "survival of the fittest" as per Darwin. In the Darwinian sense the programs are similar to genes that define a life form here on Earth, but instead the program defines a given universe. Who are the programmers and what are their motivations – that is the fundamental and unanswerable question? Another vital question: how can we discern that our Universe is a computer program (or subroutine)? Can we come up with an experiment? The clue to it – possibly from the movie I referenced: "The Thirteenth Floor," is that all computer programs are limited, so our Universe computer program will probably NOT BE COMPLETE. If looking backwards in time to the Big Bang or forward in time at an interface between universes, at singularities like black holes or the "quantum foam" at the very smallest dimensions, we find something NOT COPLETED or "not computed" as yet, then we may have some proof of a "Universe Computer." A theory or hypothesis should be CAPABLE of finding evidence, by experiment, showing it to be right or wrong. For the universe theorized as a computer program this is difficult. I proposed a “halfway” solution by experimentally searching for “lack of completeness” in the universe program. It is a half solution like the Search for Extra Terrestrial Intelligence (SETI) since you can’t prove a negative such as “There is no extraterrestrial intelligence.” In this case you can’t prove “We are not living in a computer-generated universe.” Nevertheless, we have the SETI program and it is viewed as “scientifically defensible.”

Analogies with science fiction, Andromedian computers and with human decision making are all very well. But now we must come down to earth and remember that evolution in fact occurs step by step, through the differential survival of genes in the gene pool. Therefore, in order for a behavior pattern -- altruistic or selfish -- to evolve, it is necessary that a gene 'for' that behavior should survive in the gene pool more successfully than a rival gene 'for' some different behavior. A gene for altruistic or kind behavior means any gene that influences the development of nervous systems in such a way as to make them likely to behave altruistically or kindly. Here is a very over simplified example, this time expressed in the form of a game. The object of the game is to pass as many of my genes as possible onto the next generation. I am an animal who has found a clump of eight mushrooms. After taking account of their nutritional value, and subtracting something for the slight risk that they might be poisonous, I estimate that they are + 6 units each (the units are arbitrary payoffs for my ability to pass my genes onward because of my good nutrition). The mushrooms are so very big that I can eat only three of them. Should I inform anybody else about my find, by giving a "food call"? Who is within ear shot? Brother *B* (his relatedness to me is on average 1/2 since he, on average, carries half of my genes to pass onward), cousin *C* (related less to me =1/8), and *D* (no particular relation: his relatedness to me is some small number which can be treated as zero for all practical purposes). The net benefits to me if I keep quiet about my find will be +6 for each of the three mushrooms I eat, that is 18 in all. My net benefits score if I give the food call needs a bit of figuring. The eight mushrooms will be shared equally among the four of us. The payoff to me from the two that I eat myself will be the full +6 units each, that is +12 in all. But I shall also get payoff when my brother and cousin eat their two mushrooms each because of our shared genes that they can pass on to the next generation. The actual score comes to (1 x 12) + (1/2 x 12) +(1/8 x 12) + (0 x 12) = 19-1/2 .The corresponding net benefit for the selfish behavior was 18: it is a close call but the verdict is clear. I should give the food call; altruism on my part in this case pays my selfish genes.

Lest we forget in these theoretical analyses: man's way of life is also determined by culture and environment. The point is summed up in one of Aesop's fables: "The rabbit runs faster than the fox, because the rabbit is running for his life, while the fox is only running for his dinner." This is called the life/dinner principal. Because of the life/dinner principal, animals at times behave in ways that are not in their own best interest, manipulated or coerced by some other animal. In this case the rabbit might trip into a hole and die. Actually, in a sense they are acting in their own best interests: the whole point of the life/dinner principal is that they theoretically could resist manipulation but it would be too costly to do so.

The success that a gene or replicator has will depend on what kind of the world it is--the pre-existing conditions. Among the most important of these conditions will be other replicators and their consequences. Often people working together have mutually beneficial activities that will dominate their own activities. At some point in the evolution of life on our Earth, this ganging up of mutually compatible replicators began to be formalized in the creation of discrete vehicles -- cells and, later many-celled bodies. Vehicles or individual organisms that survived and prospered became more discrete and vehicle like. This packaging of living material into discrete vehicles becomes such a salient and dominant feature that, when biologists arrived on the scene and started asking questions about life, their questions were mostly about vehicles -- individual organisms. The individual organisms came first in the biologist consciousness, while the replicators --now know as genes --were seen as part of the machinery use by individual organisms. It requires a deliberate mental effort to turn biology the right way up again, and remind ourselves that the replicators or genes come first, in importance as well in history -- at least that's what Richard Dawkins believes.

Next we turn to Susan Blackmore's "The Meme Machine." According to the "new" dictionary (Google) a "meme" is defined as: A contagious information pattern that replicates by parasitically infecting human minds and altering their behavior, causing them to propagate the pattern. (Term coined by Dawkins, by analogy with "gene".) Individual slogans, catch-phrases, melodies, icons, inventions, computer programs, and fashions are typical memes. An idea or information pattern is not a meme until it causes someone to replicate it, to repeat it to someone else. All transmitted knowledge is by memes.

What makes us a human being? What is the difference between homosapiens and all the other animals on the planet? What sets us apart and will this difference provide a clue to the Human Kindness Index? In 1975, just before Dawkins proposed the idea of memes, the American anthropologist F. T. Cloak wrote about cultural instructions. He pointed out that whenever we see any behavior being performed we assume that there is some internal structure in the animal's nervous system that causes that behavior. All animals have such instructions but humans, unlike other animals, can acquire new instructions by observing and imitating others. The psychologist, Edward Lee Thorndike in 1898 was possibly the first to provide a clear definition of imitation as "learning to do an act from seeing it done." Thorndike's definition (although confined to visual information) captures the essential idea that imitation is a new behavior learned by copying it from someone else. Imitation is one form of social learning, but there are others that are not truly imitative. Animal researchers have recently made considerable progress in distinguishing between these kinds of learning and finding out which animals are capable of true imitation. The results have been surprising: In 1921, in the south of England, small garden birds were seen pecking open the wax tops of milk bottles left on the doorstep. Subsequently, these habits became widespread across England and some parts of Scotland and Wales, with other species of birds joining in, and foil tops being pecked as well. That small garden birds learned from each other was suggested by the way the trick spread gradually from village to village, and across different areas, although it was obviously independently reinvented many times. With the advent of supermarkets and cardboard cartons, the bottle left by the milkman is becoming rare, but even today you'll occasionally find your milk top pecked open.

This spread of milk bottle pecking was a simple cultural phenomenon, but scientists would argue that it was based not on imitation, but on a simpler kind of social learning. Imagine that one bird learned, by trial and error, that there was cream to be had by pecking at the bottles. Then another bird chanced by and saw the pecking and the obviously pecked top. Pecking is a natural action for small garden birds and now that the attention of a second bird had been drawn to the bottle it was more likely to land on it and peck too. Reinforcement in the form of nice tasty cream would lead this bird to repeat the action and possibly be seen by other birds and so on. The fact that the birds used lots of different methods for opening bottles also suggests that they did not learn by direct imitation. After nearly a century of research there is very little evidence of true imitation in nonhuman animals. Birdsong is obviously an exception (song birds do imitate simple tunes), and we may be simply ignorant of the underwater world of dolphin imitation. Chimpanzees and Gorillas that have been brought up in human families occasionally imitate in ways that their wild counterpart do not. However, when apes and human children are given the same problems, only the children readily used imitation to solve them. It seems we are wrong to use the verb "to ape" to mean imitate, for apes rarely ape! It is NOT “Monkey see, Monkey do”!

By contrast, humans are "consummate imitative generalists.” Human infants are able to imitate a wide range of vocal sounds, body postures, actions on objects, and even completely arbitrary actions like bending down to touch your head on a plastic panel. By 14 months of age they can even delay imitation for a week or more and they seem to know when they're being imitated by adults. Unlike any other animals we readily imitate, replicate memes, for almost everything and anything -- and seem to take pleasure in doing so.

Imitation necessarily involves:

(1) decisions about what to imitate, or what counts as "the same” or "similar,"
(2) complex transformations from one point of view to another, and
(3) the production of matching bodily actions

That sounds complicated because it is. Only homosapiens readily do it. Essentially memes and our propensity to copy or imitate are almost the exclusive feature that defines we humans.
Imagine two people. Bonnie is an altruist and has a high kindness index. She is kind, generous, and thoughtful. She gives good parties, has a great personality, is beautiful, and is a lot of fun. She often has friends around for meals and plays Bridge with them and she sends out lots of birthday cards and e-mails. If Bonnie’s friends are in need, then she takes the trouble to phone, to help them out, or visit them in the hospital. Bobby is mean and selfish and has a low kindness index. He resents buying other people drinks or picking up the tab for meals, and thinks a birthday card is a waste of money. He never invites people around for a meal or e-mails them, and if his (few) friends are in trouble he

always has something more important to worry about. Now the question is --who will spread more memes?

Other things being equal, Bonnie will. She has more friends and spends much more time talking to them or composing e-mails to them; they like her and they like to listen to her. The memes she spreads might include the story she tells or even gossip, the music she likes, the clothes she wears, and the fashion she follows. They might be ideas about giving to the charities she likes or discussing her political views. Most important they will also include all the memes that make her the way she is – memes for giving good parties, for sending out a lot of cards and e-mails, for helping people in need him, for looking for contributions for her favorite charities. Psychological experiments confirmed that people are more likely to be influenced and persuaded by people they like. So her friends will imitate her popular behavior and thus her altruism will spread. And the more friends she has the more people can potentially pickup her ways of making herself popular. We could call Bonnie a meme-fountain.

Meanwhile, Bobby has few friends. He makes few opportunities for talking to the ones he does have, and rarely finds himself chatting over a drink or passing the time of day with a neighbor. His memes have few chances to replicate because the few people who can potentially imitate him rarely do so. Whatever he thinks about the state of the Nation or the best way of making a scientific theory work, his ideas are unlikely to spread far because people do not listen to him, and if they do they do not adopt is ideas because they do not like him. We might call Bobby a meme-drain.

This difference forms of the basis of a meme theory of altruism. The essential meme point is this: if people are altruistic and have a high kindness index, then they become popular, because they are popular they are copied, and because they are copied their memes spread more widely then the memes of not so altruistic people. This process provides a theoretical mechanism for spreading altruistic behavior and improving the Human Kindness Index. But we need quantitative proof. – "where's the beef?"

From an historical perspective, once imitation evolved in homosapiens, something like two and a half to three million years ago, the second replicator, the meme, was born as in addition to the gene. As people began to copy each other the highest-quality memes did the best -- that is, those with (1) high fidelity, (2) intellectual productivity, and (3) longevity. A spoken grammatical language resulted from the success of copyable sounds that were high in all these three. The early speakers of this language not only copied the best speakers in their society, but also mated with them, creating natural selection pressures on genes to produce brains that were ever better and better at spreading the new memes. In this way the memes and the genes coevolved to produce just one species with extraordinary properties of a large brain and language. The only essential step in starting this process was the beginning of imitation. The general principles of evolution are enough to account for the rest.

We next come to another interesting book: Edward O. Wilson's "Sociobiology – the New Synthesis." Wilson suggested many interesting political concepts associative with evolution. He notes critics of Darwinism and the fact that the intellectual left were greatly offended. Their ranks included the last of the Marxist intellectuals, most prominently represented by Stephen Jay Gould and Richard C. Lewontin. They disliked the idea, to put it mildly, that human nature could have any genetic basis at all. They championed the opposing view that the developing human brain is the true essence of a human. The only human nature, they said, is a flexible mind. One could not be born more fit than another! Egalintarnism must reign. Theirs was a standard political position taken by the Marxist from the late 1920s forward: the ideal political economy is socialism they said in the true essence of the human mind can be fitted to it. A mind arising from a genetic human nature might not prove comfortable -- since socialism is the supreme good to be sought. The new left had a second objection to evolution, this time centered on social justice. If genes prescribe human nature, they said, then it follows that differences in personality and ability also might exist from birth. Such a possibility cannot be tolerated! At least its discussion cannot be tolerated, said the critics, because it tilts thinking onto the slippery slope down which humankind easily descends to racism, sexism, class repression, colonialism, and perhaps worst of all -- capitalism! That was in 1984. The argument for the political test of scientific knowledge lost its strength during the collapse of world socialism and the end of the Cold War. It is not been heard from since at least not until recently with the emergence of creation science and intelligent design and even the concepts of Deism.

Intelligent design is a bigger concept than creation science or creationism, and deliberately so. It posits only that an intelligent creator shaped the course of evolution. The general idea has been discussed by theologians since Darwin's time, but it was only after recent court rulings that it obtained significant following in the United States. Unlike creation science, intelligent design or ID is not affiliated with any specific religion. Rather than attempting to prove its own explanation of the origin of the species, it aims to punch holes in scientific doctrine. By encouraging students to believe that a scientific theory (evolution, astronomy, chemistry, etc.) is the same as a philosophical assertion or myth (ID, astrology, alchemy, etc.) a great educational disservice occurs that will further jeopardize our Nation's already challenged scientific base. There should not be a University's Department of Astrology juxtaposed with a Department of Astronomy, Alchemy with Chemistry and Intelligent Design with Evolutionary Science. Intelligent design's supporters, many of them Fundamental Christians, have been hoping all along that the concept is sufficiently secular for the courts to permit its teaching in public schools. As a matter of fact, at the end of last September, 2005, the U.S. Federal Court in Harrisburg, Pennsylvania began hearings on this very subject – a decision on this case may have now been issued. By the way, a recently published book on the subject "The Evolution-Creation Struggle" by Michael Ruse is certainly worth reading. It should be understood that a theory or hypothesis is untestable in principle if there is no possible evidence that could count for or against it. To put this in another way, if a theory or hypothesis is compatible with all possible evidence, then it is unscientific – it is NOT a scientific theory. When creation scientists proclaim that the Earth is only six thousand years old, and back it up with denials of the fossil record, or claims that the speed of light has slowed since creation so as to give an illusion of a vast universe and an ancient planet, then it is unscientific. That is, the claim that God did all this just to fool us and since God is all powerful and can do anything, these theories are not only uncontestable but UNTESTABLE and are by definition, not scientific. Such theorizing boarders on *Lysenkoism* ("Li-sen-ko-ism")a wonderful big word which means that the requirements of the state, a religious belief, or a powerful group take precedence over the actual facts. Deism is defined in Webster's Encyclopedic Dictionary, as: "[From Latin Deus, God. Deity]. The doctrine or creed of a Deist." And a Deist is defined in the same dictionary as: "One who believes in the existence of a God or a Supreme Being, but denies revealed religion, basing his belief on the light of nature and reason." If it is not "revealed" or not experimentally verifiable, then Deism is also non-scientific – but by some accounts Einstein was a Deist and believed: "Subtle is the Lord." He also believed that there was something that kept order in the Universe and things did not happen by chance: "God does not play dice" Einstein said.

Turning finally to the book that initiated my intellectual tour of modern evolutionary theory "Adapting Minds," David Buller aims to show that evolutionary psychology is "wrong in almost every detail." He argues that it is based on a mistaken view of neural development, that its reconstruction of the environment in which humans involved are "pure guesswork," and that its major empirical findings are better explained by alternative theories. However, despite this barrage of criticism, Buller's attempted demolition ultimately fails. Buller relies on the theory of "neural Darwinism" to argue that the functional organization of the brain is a product not of genetic instructions, but of a process analogous to natural selection that occurs during the lifetime of an individual -- that we all started out with a clean slate. Buller claims that genes merely provide an initial oversupply of neurons and connections and at birth our brain was a formless "mass of clay." These neurons then engaged in a Darwinian fight to the death, from which "circuits will develop better specialized in dealing with what ever environmental inputs are most salient." Thus the mind is not adapted to ancestral conditions: nothing is truly inherited, the mind is capable of adapting to what ever the immediate environment demands. No serious scholar would think that human behavior is controlled the way animal instinct is, without the intervention of culture. By the same token no serious scholar would think that our actions and our capabilities are totally independent of inherited traits -- of our genes that have evolved – that would return us to ideas before Darwin! There is a combination of environment and genetics that makes the man or the woman. Finally, Buller's empirical criticisms tend to promise more than they deliver. He states, for example, there is "no convincing evidence" of women's preference for older men, whereas he quotes data supporting that conclusion a plenty!

In summary then, there's good news and there's bad news. The bad news is that even though we homosapiens differ from all other animals on the planet and have the evolutionary possibility to grow kinder and gentler as a whole, I have found no quantitative evidence collected by evolutionary psychologists or social anthropologists to support that trend – it may be there; but I have not found it. The good news is that in spite of Buller's objections there does appear to be evidence that younger women would prefer higher-status older men. So Rounders, as you leave The California Club today BEWARE of those beautiful young babes who have their eyes on you!

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Economic Round Table
The California Club
Los Angeles, California, USA

"Who goes there?"

January 26, 2012
by
Robert M L Baker, Jr.

SUMMARY

Are computers something like a person? If so, then "Who goes there?" First there was discussed whether or not a computer exhibits characteristics such that one would consider it to be a "living thing" -- an entity. Therefore the question of what constitutes "Life" arises. Next was considered the answer to the basic question: "What is intelligent life?" and can a computer replicate it? That is, what is "Artificial Intelligence"? Second, inasmuch as humans have been working to integrate artificially intelligent devices into biological entities (e.g., neural networks on chips), it was concluded that the natural evolution of humankind would be towards humans incorporating such entities into their persons, i.e., *cyborgs*. Finally, since we have no other examples of other living entities, except for *Science Fiction*, we can only suppose that extraterrestrials would be similar to advanced humankind. We decide what "intelligent" is by comparing behavior of other entities to that of humans. We have no other reference frame. There may be some other behavior that is intelligent but we would not know it. Some 2,336 extrasolar planets have been found as of December 2011; thus the existence of advanced extraterrestrial beings who we would deem intelligent is extremely probable. Therefore electronic and biological combination entities, who are nearly immortal, might populate our Universe!

Two years ago, at our December 10th 2009 Economic Round Table (ERT meeting, Harlan Thompson discussed "*Facebook*" and "*You Tube*" and how Internet and the computer will "tell our human story." This talk started me thinking about how we view computer technology in general and the Internet in particular and what strong influence will be played by them in future – **I mean in the future of mankind!** Recently I commented to my wife how useful it was on Google to input a question and then, especially if I had misspelling, to have it asked me "Did you mean …" She said "Well, that may be, but *Facebook* somehow got into my computer addresses and I don't like it!"

It occurs to me that the two of us were treating *Google, Facebook, You Tube* and the like, as actual personalities or individual "entities." Well, they do have many almost human characteristics: great memories (far better than any human entity), great logical capability (the computational power of computers is enormous). Through microphones, TV cameras, temperature probes, even olfactory detectors -- the computer's ability to "sense" things is also limitless. But does a computer "dream"? Well I make my computer "hibernate" and while it is "sleeping" it seems to accomplish all kinds of "clean up" duties such as removing unnecessary extra copies of documents and going through diagnostics and even self correcting itself. That is akin to "dreaming." OK the computer exhibits almost superhuman capabilities and when they are linked by Internet their capability is truly awesome. So could they be something like a "person" and if so, then "who goes there?"

A "person" maybe, but a human entity they probably are not. Why? For at least two reasons: first, the computer has no emotions and in particular does not have a selfish drive to survive and second it cannot reproduce without outside help by we human entities (human programmers and chip manufacturers). Now this is **not** entirely true, in fact computers have emotions, wish to survive, repair themselves and so on as elaborated in *Science Fiction*: There was the Hal 9000 in *2001: A Space Odyssey* (1968) and the DOD computer in *Eagle Eye* (2008) in which the computers took survival action on their own and in *Demon Seed* (1977) in which Julie Christie is sexually assaulted by a computer and gives birth to a hybrid, computerized baby. Can computers "learn" as did the War Operational Planned Response (WOPR) computer did in *WarGames* (1983) or the Master Control Computer (MCP) in *TRON* (1982)? It is certainly possible that cosmic rays might randomly and unpredictably change a computer's logic and memory modules and change it from being "perfect." As was related sometime ago to the ERT (I believe it was in the talk by Chuck Stephens); synthesized orchestra music can exhibit no errors, but to make it more realistic and more "human" the drumbeat had a random number generator override it every so often to produce an incorrect drum beat. Accidents do happen and that is part of "being human." When I was in the 6^{th} grade I was painting watercolors at school and the painting I was working on fell to the floor and my paints fell on top of it. The teacher, having not seen the accident, exclaimed "What a magnificent sunset Bobbie!!" – it won first prize at a *UCLA Children's Art Contest* and my Mother kept all of my "paintings" and sketches for many years until she determined I was not a Picasso. So sometimes accidents lead to a good outcome. If such accidents happen to a computer randomly and arbitrarily change its circuit or program by the action of a stray cosmic ray, then it will become "different." Of these "different" computers some will be better and some worse so in a sense one might have "survival of the fittest" situation and the computer would exhibit "evolution" and self improvement similar to a biological life form. But can this only be possible in the imaginations of science-fiction writers? And why do I refer to Science Fiction. Well as Einstein said "Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination is limitless and embraces the entire world, and all there ever will be to know and understand." And "Science Fiction" **is** imagination

Often "imagination" involves what we call "thinking out of the box." This reminds me of another story about school. A grammar-school teacher teaching arithmetic asked the class: "If there were three birds on a branch and one was shot dead by a hunter, then how many birds were left?" Johnnie raised his hand and answered "No birds would be left on the branch." The teacher responded "Johnnie, one bird was shot and two remained. "No" said Johnnie "There would be no birds left on the branch since the gunshot would have scared them off." "You are wrong" responded the teacher " but I like your thinking." Then Johnnie said" Teacher I would like to ask you a question" "OK Johnnie" said the teacher. Johnnie asked. "If you a sitting at a table with our two other teachers eating ice cream cones and one of you was chewing her cone, one was licking her cone and one was sucking her cone, then which one would I say was married?" The teacher thought for a while and then responded: "The one who was sucking her cone." "No" said Johnnie, "it was you because you are the only one of our teachers wearing a wedding ring – but I like your thinking teacher." Could Johnnie be replaced by a computer? Is the computer a "living thing" even an "intelligent" life form? In order to answer these questions we must first answer the very fundamental question, a question that I alluded to at the beginning of my talk: "What is Life?" The first or at least best-known answer to this question comes from Aristotle: "By life we mean self-nutrition and growth." Often interpreted as "life" being an entity that struggles against never-ending threats to its existence and growth.

There are, however, several books on this subject (referenced at the endof this paper): One of the first was by Erwin Schrödinger – who I mentioned already in a prior talk in connection with his being the father of quantum mechanics and famous for "Schrödinger's cat." Erwin Schrödinger's essay "What is Life" presents a physicist's view of the molecular world of living organisms. Written in 1944, it explained why the physics of his time was inadequate to give a complete description of the molecular mechanism of life. It is the realization of what can be summarize as the Large and the Small. Schrödinger realized that there is no physics known that can bridge the laws of the very small, e.g., atomic nuclei, and the laws of the very large such as our Earth (to which life belongs while making extensive use of the very small, e.g., molecules). His book presents many thought provoking analyses of what constitutes life. In particular it relates to one aspect of the definition of life: "evolution" and especially "survival of the fittest." It is rather easy to hypothesize, as I have done, that there can be unexpected random changes to electrical circuits caused by cosmic rays, just as such rays can change a living cell's makeup and lead to mutations. Mutations that, depending upon whether or not they are valuable, can change the "behavior" of the organic being or an electrical "being." Thus, as I said, leading to the survival of the fittest mutated electrical being. But there are problems with this rather cavalier statement. We know what survival means to an organic life form, but what would it mean to an electronic "life form"? Considering the "fittest" implies that there are other electronic life forms, possibly not as fit, to compete against and how many and what does surviving in the competition mean exactly?

First, let us consider "how many" Changes? Schrödinger tackles this problem in organic life forms by saying that there must be a large number so that the competition is "meaningful." As illustration allow me to introduce another anecdote about my early years. In High School I was an 880 yard runnier – not a very good one, but somehow I managed to run in the CIF finals of the 880. I won a third-place medal – the only athletic medal I was ever awarded (unfortunately, my mother lost it). Well there were six competing in the race – as the race progressed three contestants dropped out with shin splints – hence my third place award. Clearly, there needs to be a large number of runners or the race does not mean anything. Schrödinger then essentially says that it must "take two to tango." All organic evolutionary theory of the time presupposes two entities: male and female who produce progenies that share their genes 50:50. Furthermore there cannot be a very frequent "change" for example, caused by cosmic rays or x-rays. He indicates that it is like the test of a new car design. If more than one item is changed at a time, say the carburetor and spark plugs, then it is difficult to identify what caused the increase or decrease in the car's performance: was it the change in the carburetor or the spark plugs?. Which particular mutation will be "best" out of multiple possible causes for that mutation? Also too many changes or too few participants (large change to group/size ratio) might also lead to deleterious inbreeding; that is the chance for malevolent mutants to be formed.

How would all this translate to electronic life forms? We could have a large number of electronic life forms around (the ubiquitous personal computers comes to mind), but some male and some female computers is a stretch and how would they have sex and procreate? Well, as I mentioned at the outset of my talk Julie Christie was sexually assaulted by a computer and gave birth to a hybrid, computerized baby, but this certainly is not a pretty prospect for any organic life – we will however come back to Julie later. What would the electronic life form compete for, computational speed I suppose, but for what prize? And would the lack of computational speed cause an electronic life form to die? Would one electronic life form attempt to kill another; possibly by means of transmitting a computer virus! We will also return to these difficulties later.

Fifty years ago Francis Crick and James D. Watson proposed the double helix model for the DNA molecule. They believed they had, as Crick put it, discovered the "secret of life," and many agreed. But in the intervening years, science has marched—sometimes leaped—forward, and now the question "What is life?" has been posed once again in the molecular biologist Michel Morange's 2008 book: *Life Explained*. In the quarter century between 1940 and 1965, scientific understanding of the fundamental phenomenon of life made remarkable advances and the question "what is life?" was thought to be answered. The situation is different now and fewer and fewer scientists are convinced that we have the complete answer. An example of this is John L.Casti's 1992 paper: "That's Life?—Yes, No, Maybe." Let me now draw a distinction between "replication" and "reproduction." To replicate is to make a faithful copy of an object such as the laptop computers coming off a production line. On the other hand, reproduction in the biological sense implies the existence of a complex autonomous organism and its participation in the creation of a second organism that is similarly autonomous. The term "reproduction" therefore refers to a complex process involving entities with complex functions and structures. As Morange points out in illustration: "In the case of both viruses and genes, only the term 'replication' is appropriate; reproduction implies an autonomy that neither posses." The active agents in cells, as we now know, are proteins – macromolecules that act as catalysts, activating chemical reactions, receiving and transmitting molecular signals, and endowing cells with form and mobility. Proteins are formed by chaining together smaller molecules – amino acids – in a specific and predetermined sequence. This sequence is not directly transmitted from generation to generation; instead it is indirectly coded in another macromolecule, DNA. Decoding this sequence permits the synthesis of proteins responsible for the incessant chemical transformations that take place inside the living cell, and for its reproduction. As I have already mentioned with the discovery of the simple double-helix structure of DNA in 1953 by Watson and Crick, it became possible to understand the ease with which this molecule replicates itself, and also how the information needed for the precise synthesis of proteins could be contained in its nucleotide elements. But "life" is sometimes short sighted and depends upon an individual entities' local viewpoint. It is like the fellow who was watching TV news and heard that a car was going the wrong direction on highway 5. Good grief! He realized that his father was driving his car on Highway 5! So he phoned his dad in his car. “Dad” he shouted “one car is driving the wrong way on the road you are on!” His dad replied: “One car? There are hundreds going the wrong way!” Hs father had a different viewpoint!

After World War II it had become possible to imagine the development of computing machines that were sufficiently powerful to reproduce all the complexity of “life.” Progress toward this objective, through the construction of the first computers and the implementation of complex cybernetic networks, quite naturally led mathematicians like Alan Turing and John von Neumann to ask what, if anything, distinguished organisms from machines that could imitate the behavior of organisms. In particular, the question arose whether a machine could cross the boundary between the inanimate and living worlds. It was in this context that von Neumann proposed the theory of “automata,” in a historic paper published in 1948 that sketched the outlines of a machine that could reproduce itself by locating the necessary components in its environment. Now we see the beginning of the concept of an electronic life form! In this regard there is a radical new type of circuit element that incorporates both semiconductor and nanotechnology called the memristor. Since the memristor "remembers" what state it’s in, by doing a calculation with a group of the circuits and feeding back the output of a calculation to the same memristors, the device could effectively "self-program." (By the way memristors don't forget their state when they're turned off, so they difficult to “kill”.) As Hewlett-Packard spokesman Tim Williams puts it: "self-programming is a form of learning. Thus, circuits with memristors may have the capacity to learn how to perform a task, rather than have to be programmed to do it.” While some software engineers thought of factories in terms of human workers organized toward efficient use of their labor, others looked to the automated factory first realized by Henry Ford's assembly line, where the product was built into the machines of production, leaving little or nothing to the skill of the worker. One aspect of that system attracted particular attention. Production by means of interchangeable parts was translated into such concepts as "mass-produced software components", modular programming, object-oriented programming, and reusable software. At the same time, in a manner similar to earlier work in compiler theory or indeed as an extension of it, research into formal methods of requirements analysis, specification, and design went hand in hand with the development of corresponding computer languages: FORTRAN, COBOL, BASIC, etc. Such languages were aimed at providing a continuous, automatic translation of a system from a description of its intended behavior to a working computer program produced **<u>without</u>** the need for human programmers. Also large, highly distributed Internet systems resemble biological bodies with billions of self-contained cells, coordinating their efforts to accomplish high-level tasks.

Speaking of “cells” the book “What is Life?” by Ed Regis (a well-respected science writer) discusses a scientific project to create an artificial human cell. In the 1980s at the Los Alamos “Atomic Bomb” laboratory a workshop was created “… to simulate and then actually to create a new life-form.” The Los Alamos National Laboratory (LANL) appropriated $4.5 million for the project. The main attributes that any such life entity had to have according to these scientists was:

1. It had to take in nutrients and turn them into energy, meaning it had to have metabolism;
2. It had to reproduce itself and
3. Its descendants had to be able to evolve by means of natural selection.

As it turned out, money for such a far-fetched project was also relative easy to secure in Europe and a similar laboratory was established during the early 2000s in Venice, Italy – the *European Center for Living Technology* (ECLT) raised about 14 million US. As Regis wrote concerning the outcome of these studies "Most important of all was the fact that metabolism seemed to be an even more basic life function than replication, development or growth …" Items 2 and 3 (reproduction and natural selection) could not take place if the living entity lacked a working metabolism. After all not all organisms reproduce: sterile hybrids such as mules don't but are life forms – the heart and the brain are "alive" in some derivative sense, despite the fact that they have no capacity whatsoever for reproduction! In short life is <u>not</u> replication, <u>not</u> reproduction, <u>not</u> code script, <u>not</u> the gene. Most fundamentally **life is METABOLISM**! So the incredible "*Blob*" (1958) was a living entity – and I have never heard of any "Baby Blobs." Certainly the Blob had an incredible appetite for living creatures in its environment and a robust metabolism! In keeping with Einstein's admonition that "Imagination is more important than knowledge" and conjecture based upon Science Fiction, I turn to my favorite Science-Fiction movie: "*Forbidden Planet*" (1956).It takes place on the distant planet *Altair 4*. Apparently the inhabitants there, the Krell, became extinct hundreds of thousands of years ago. The Krell were truly advanced and controlled everything by their mind, their thoughts. If they wanted a light on they just thought about turning on a switch and the light turned on – they did not need to move at all. I would have guessed that their demise was due to obesity since they hardly needed to move and by the looks of the wide triangular doors, shown in the movie, that they passed through they were rotund. But no, they were destroyed by creatures that they formed in their dreams, their nightmares. The "Id" as the Movie suggested. Similar to the Id in Shakespeare's "The Tempest". Freud tells us that the Id is entirely unconscious. And is often shown as parts of the Ego and the Super-Ego. Now, according to Freud, the Id is the reservoir of libido, the primary source of all psychic energy, and it functions to fulfill the pleasure principle The Ghost that appears to bid Shakespeare's Hamlet to avenge him is only apparently a ghost. He is in actuality Hamlet's Id, who acts according to the pleasure principle. Well, So much for Shakespeare and Freud, the relevance here is that the Krell developed an immense power plant and computer system to serve them and empower their lethal dreams. It functioned and repaired itself unattended for centuries. Thus in the sense of metabolism it was ALIVE!

But wait! We are really interested in intelligent life! Astrobiologist David Morrison was asked: What is the definition of intelligent life? Is it the ability to analyze situations and react in the correct way, or is the complexity the primary issue? His answer:

(Quote) "This is a difficult question, and I have never found a satisfactory answer. This question is sometimes addressed in books and articles on the Search for Extraterrestrial Intelligence or SETI (for example, in "Extraterrestrials: Science and Alien Intelligence", edited by Edward Regis (mentioned earlier), Cambridge University Press, 1985), but from the SETI perspective intelligence must include the ability to transmit and receive signals over interstellar distances (that is, technological intelligence). More generally, Carl Sagan wrote (in "Cosmic Connection," recently reprinted by Cambridge University Press) that intelligence involves the tendency toward control of the environment -- including a non-hereditary adaptive quality developed during the lifetime of a single individual (that is, intelligent creatures can learn). Other more recent definitions have been suggested by those working in the field of artificial intelligence. But good luck with this pursuit! " (Close Quote)

OK, fair enough; but can humankind (the variety here on planet Earth) evolve their brains and become "smarter"? Is there a biological limit to "brain power"? In the July 2011 issue of *Scientific American* this question was addressed. In principle one could enlarge brain size by adding more neurons, which would increase brain processing capacity. But neurons consume a lot of energy and as brains get bigger the axon neuron appendages or long "tails", which interconnect neurons and provide communication, would need to become longer, thicker and, therefore slower, Of course adding more links between distant neurons would allow brain parts to communicate faster. But the added wiring consumes even more energy and takes up space. It is also theoretically possible to increase interneuron signaling or communication speed by making the axon thicker , but it would also involve more energy consumption and space. Brain processes that increase the need for energy to "feed" them also create heat and that heat must be dissipated. If an enhanced brain is grappling with a "burning question," then it might heat up and burn itself! We also could pack more neurons into existing brain space (increase their number density) by shrinking the size of neurons and axons. If, however they get too small they fire randomly. Like microchips, if you approach molecular size random effects (noise) takes over – something like Heisenberg's uncertainty limit one can only get so small. Miniaturization is, of course, an evolutionary possibility and could enhance our intelligence a bit, but as concluded in the *Scientific American* article: all evolutionary 'tweaks "… carry disadvantages and run into thermodynamic hurdles.(too much heat to radiate) Perhaps (as stated in the Article) we are **already** close to being as smart as neuron-based intelligence can be." Thus evolution may have already led us to an optimized brain design for biologically based homosapiens already.

As Dr. Jeremy Horne (a well-known Philosopher) recently communicated to me:: "We have had a parallel development of real living things [cloning, artificial (or transplanted body parts), etc.] and intelligent devices [computers, (artificial-intelligence programs like the one that automatically landed one of our spy drones in Iran last month and will help guide our *Curiosity Rover* on Mars).], but what happens when we mate the two, as with a *cyborg*? Two aspects of this are that humans may understand more about themselves as the artificial entity with a mind equivalent to what humans can "report" to us its nature, and if (and probably when) this device can exceed the limits of human intelligence/mind/consciousness (as it will have no limitation of energy - contrary to the human case)." Of course the human mind may have better ways of expanding without the need for further biological evolution. Honey bees and other social insects do it; acting in concert with their hive sisters, they form a collective entity that is smarter than the sum of its parts. Through social networks we also have learned to pool our intelligence with others. Harlan Thompson told us about the human animal "… being able to exchange ideas and things and specialize." Here we have a concept like "cloud computing" in which we utilize a “cloud” composed of many computers to work in concert and solve problems (something like the distributed Internet systems that I have already mentioned). This begs the question though since enhancing each member of the cloud or distributed individual system elements would enhance its overall capability and we are looking instead at the individual intellectual (living) entities or elements and their individual capacity.

Let’s now turn to the “intelligence” definitions found in a Google search. Some people would say intelligence is the ability to ask questions and ponder answers. Others define intelligence as the capacity to learn and respond dynamically to stimuli. Problem solving (the ability to cope with new problems and situations), language/communication often to influence other entities (politics, sales?), ability to perform inductive and deductive logic, imagination, sense of humor, the capacity to grasp difficult or abstract concepts, mental alertness and prompt response (displaying quickness of understanding), learning, planning, motivation to travel or communicate to meet others, exhibition of emotion, create art or forms that other entities enjoy, visualization of concepts, exercising or showing (good) judgment, the capacity to understand and learn, … Wow! The list from Google goes on and on. Some of these aspects of intelligence are not really measures of “smartness” at all. Just gaining knowledge and regurgitating it quickly may cause you to say “that is really a smart computer …”, but it is probably not a good definition of real intelligence. So the definition of “intelligence” and, therefore “intelligent life” is itself abstract and may require an “intelligent life form,” more intelligent than we are to define it! So much for native “intelligence,” so what about “Artificial Intelligence” noted by David Morrison? From Wikipedia we find the definition of “Artificial Intelligence” or AI as:

“… the intelligence of machines and the branch of computer science that aims to create it.” AI textbooks define the field as "the study and design of intelligent agents" where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success. John McCarthy, who coined the term AI in 1956, defines it as "the science and engineering of making intelligent machines."

Again quoting Jeremy Horne: “Now, we need to ask the question whether any of these devices will have consciousness. We do not seem to have a good idea of what consciousness, itself, is. This is what I think your audience may want to come to grips with. We develop a relationship with our environment through interactions with it, and this applies to a situation in which we create devices with which we can have a dialogue. Let alone the issues of it having intelligence, we have to address its ethical standing, and what if, for example, it takes on an ethical system of its own and is intelligent enough to convince us of its desirability?”

I recall in the 1970s and 1980s the field of AI was burgeoning. A breakthrough appeared to be imminent, but what was meant by a “breakthrough”? Computers were being designed to win at Chess – to type conversation, be a physician’s assistant, a pilot’s assistant, etc. The Mars *Rover* vehicle roamed the planet’s surface and because of the time delay in transmission of video was “on its own” for up to an hour and had to make “decisions” without human assistance as to how to proceed on the Mars’ surface and avoid rocks and ravines. These concepts are not really new, for example some were discussed in fiction such as "*Brave New World*," Aldous Huxley's fifth novel, written in 1931 and published in 1932. Even computerized psychoanalyses have been proposed. Let's look as a fictional example:

Patient: "Hello Doctor Computer. I am feeling really depressed today. What do you suggest I do?
Doctor Computer: "You are feeling really depressed today and I am so sorry. What are you depressed about?"

Patient: "My husband died."
Doctor Computer: "Your husband died, how very sad. Can I prescribe some medication for you?"

Patient: "OK. That might help."
Doctor Computer: "Do you feel better now?"

Patient: "Yes."

Here is another example:

Patient: "Hello Doctor Computer. I am feeling extremely anxious. What do you suggest that may help me?"
Doctor Computer: "You are anxious and I am so sorry. What are you anxious about?"

Patient: "I lost my job"
Doctor Computer: "You lost your job how very sad. Can I prescribe some medication for you?"

Patient: "Well that might be useful."
Doctor Computer: "Do you feel better now?"

Patient: "Yes."

Thus, what might be considered to be the emotion of compassion and understanding – even problem solving by a computer may actually just be clever programming! How many times have you called the Information Operator and heard: "I am very sorry, but I did not understand that and I will connect you to another Operator"? We sometimes believe that we can shake a computer to make it work and that is stubbornly malfunctioning just to bug us. Essentially, we are imbuing that computer with an emotion: malice toward us!

Furthermore there would be many vexing aspects of a computer-like entity. Like "*Robocop*" (1987) computers only know right and wrong (essentially zeros and ones) and cannot deal with shades of grey or the nuances of a decision or understanding process. Here we again run into the ability to ask questions and ponder answers. This flaw might often leads to "Catch 22" situations, but of course biological-entities often have the same problem. Here is a "Catch 22" situation. While at an El Segundo Restaurant, my wife's purse was stolen. He driver's license and other ID was in the purse. It was recovered by the LAPD and we were instructed to come to Parker Center and claim it. She appeared at the Police Center and asked to go to the Stolen Property Office. "Well you must have an ID specifically a Driver's License to enter." My wife responded "I don't have one since it was stolen and you have it." The Officer replied that she could not enter until she had her license. She asked if her husband could come to Parker Center and recover it since he had a Driver's License. "No!" They said it had to be the License owner. Finally, the Officer in charge of the investigation appeared and she got in.

Well, we probably don't know how to program a computer to solve such "Catch 22" misunderstandings and certainly do not know how to provide a computerized entity with sexual drives like the one who attacked Julie Christie or emotion like the HAL9000 in "*2001: A Space Odyssey*" exhibited. In fact, that probably is not even be possible. But why are we interested in this very unlikely task? Probably for two reasons: First, we may be interested in what another life form out there in the Universe might be like especially if they visit our Earth in the past or in the future. As of December 2011 the NASA *Kepler* satellite has observed some 2,336 extrasolar planets so. the existence of extraterrestrial intelligent entities is very probable. Certainly if they came from a place, say 100,000 light years away, their trip to us would not be feasible, unless of course, their life span was several million years. And such longevity probably would imply that they were a computer or somehow electronic in nature. Our Universe is about 13.5 billion (13,500 million) years old. Suppose about 6 million years ago an electronic intelligent life (cyberspace life) was developed in the *Andromeda Galaxy* (about 2.5 million light years away) and that it evolved into an immortal life form. And suppose also, that after about a million years, their curiosity and capability allowed them to set out for stars at our distance (2.5 million light years away) at half the speed of light. Now, 6 million years later after their creation, they would arrive here. But how would we sense them and would they be interested in sensing us – we relatively dumb biological intelligent life? Probably not – how often have you tried to communicate with an Ant Hill?

Concerning computer entities in extraterrestrial cyberspace: How would they communicate? Possibly like the main character in *2010: Odyssey Two* (1984), David Bowman, who disappeared into a huge alien Monolith orbiting Jupiter, and was transformed into a non-corporeal, energy-based life-form who can ring telephone bells all over the World or like the digitalized characters in *TRON* (1982) who manifests themselves through standard computers. Extraterrestrials would, however most probably not communicate with us using electromagnetic waves such as radio, lasers, modulated quasar light, etc. which are easily absorbed by interstellar matter. No they would no doubt utilize *high-frequency gravitational waves* that I have discussed in two other ERT talks; but that is another story. .Second, we may be interested in how we, humankind, may evolve -- would we **become** essentially a computer?

Since we don't know much about extraterrestrials, except from science-fiction movies, let's consider the second reason for our curiosity. Are we evolving and becoming computers? "No" you say, but not so fast there! Some hearing challenged have ocular implants (from, say, the local *House Ear Institute*), others have implanted pacemakers and defibrillators. According to an article in the journal *SCIENCE* (Vol. 333, page 277) people are using the Internet as a personal computer and the technology available today could implant miniature computer chips in our bodies -- why not? Artificial Heart and

Pancreas and other body parts are possible. If it becomes possible to include artificial, especially microelectronics, in our bodies and if those of us (*cyborgs)* containing electronics are more fit and live longer, then evolution takes over and **we will evolve**! Like ordinary evolution it is probably a very slow process. But I am not so sure. As Schrödinger realized, regular evolution is slow and very gradual, but "electronic evolution" could be very fast and would move *at the speed of technology* – a very fast speed indeed! The evolution would not lead to the enhancement of human physical prowess as in the "The Six Million Dollar Man." Such physical skills were of great benefit to early hunters and gatherers and even in the industrial revolution, but are becoming irrelevant even now compared to the skills required in our new technology society Indeed, athletics will probably radically change as the need for physical skills diminishes. Also evolution will probably not be based on the replacement of body parts by those transplanted or grown in laboratories. No; such processes simply extend our lives as is. They do not evolve homosapiens into more fit entities.

We need not even implant microelectronic chips into our brains. Artificial neurons could be fabricated to comprise artificial neural networks. As discussed by Anne Condon (Department of Computer Science, *University of British Columbia*) in the journal *Nature* (Volume 475, pp. 304-305 and pp. 368-372) the design of intelligent systems (e.g., AI) is a long-standing goal of scientists, not least those in the *Acme Labs* of the animated TV series *Pinky and the Brain*. The Acme researchers used their technology to enhance greatly the intelligence of the pet mouse Pinky. Unfortunately, Pinky became a fiendish genius bent on world domination. Pinky's subsequent transformation by the Lab to a dimwit was less impressive (it is easy to become dumb!) Such experiments are clearly fantasy, but a related and compelling bioengineering challenge in the real world is to demonstrate how tiny biological molecules could support forms of intelligent behavior as must have happened before brains evolved. Brains are large networks of neurons. Within these networks, individual cells produce electrochemical signals whose strength depends in a complex way on the strengths of the input signals received from other neurons in the network, or from sensory inputs. There are now artificial-brain projects such as The *Blue Brain Project* [http://bluebrain.epfl.ch/] and The *Riken Brain Science Institute* [http://www.brain.riken.jp/en/]. In the July 25, 2011 issue of *Nature* (page 377), it is noted that researchers at computing giant IBM have unveiled experimental microchips that they say emulate the brain's architecture. Conventional chips connect their computational elements in the central processing unit (CPU), with the random-access memory (RAM) off to one side. But in IBM's "cognitive computing" chips, the two are wired together like neurons allowing signals to flit between memory and computation. Because less energy is wasted shuffling electrons around, the main benefit is decreased power consumption, which of course would reduce the thermodynamic "hurdle" limit to our "brain power" As already mentioned. So, move over Artificial Heart and make way for the Artificial Brain! Thus we may be heading for or evolving into combination electronic-biological cyborg entities. On the other hand, would we evolve into a **completely** electronic life form? A life form possessing aforementioned traits of : the ability to cope with new problems and situations, language/communication often to influence other entities (politics, sales?), ability to perform inductive and deductive logic, imagination, sense of humor, the capacity to grasp difficult or abstract concepts, mental alertness and prompt response (displaying quickness of understanding), learning, planning, motivation to travel or communicate to meet others, exhibition of emotion, create art or forms that other entities enjoy, visualization of concepts, exercising or showing (good) judgment, , etc., **Probably not!** Thus a combination of biological and electronics will most likely evolve: a cyborg. **Well such an advanced form of homosapiens maybe our best guess as to the actual form of extraterrestrial entities. Such electronic-biological entities or cyborgs might be nearly immortal and actually populate our Universe! They would not be the exception – they would be the RULE!**

Next let us suppose there were some biological entities on Earth living side-by-side with electronically-enabled entities. Would biological intelligent life have anything to fear from electronic intelligent life? Well it would be just the other way round and the answer is that biological life, like we current homosapiens, would be far away from the capability of "pulling the plug" on electronic life. It would no doubt be a symbiotic relationship, something like not fearing the microbes in our gut that assist digestion. Slow thinking biological life might be a curiosity to electronic life, but nothing to fear -- so contrariwise biological life would have nothing to fear from electronic life. Two classes of individuals who are quite different co-existing is not an unusual situation on our planet or even in America. For example, consider the two diverse classes: young politicians and old retirees. This reminds me of a favorite Art Linkletter story: A young politician is visiting an old retirees' home in order to campaign for election. He circulates around the home shaking hands. He approaches an older lady who looks at him quizzically. In order to secure her vote he asks her "Do you know my name?" She responds: "No. But if you go to the front desk they will tell you!"

Thank you and remember to be very kind to your computer because that computer may become you or YOU BECOME IT!!

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