We have seen that a falling body produces an area of compressed mass which in turn causes the body to spin/rotate. We've seen that to compress mass the space the atom normally possesses is reduced, and that this extracted energy (gravity/space) then detects the lesser gravitational potential at the axle - at which time it moves toward this void and re-enters the body. It has likewise been shown that this extracted energy, in its travels around the body, "pushes" all things existing within the gravitational field toward the surface of the body. This is gravity A - the "attractive" portion of gravity.

With all of this reasonably clear we may now continue on and examine the inertial force which allows the Faraday generator to function, and in so doing we can readily show why a falling body produces a magnetic field.

That which generates the "power" to produce a flow of electric (ie., mass) is <u>motion</u>. Motion is the result of gravity, and without gravity there can be no motion. The value of electrical flow is directly proportional to the <u>velocity</u> of the motion. Once again we turn to the Faraday generator (figure 57).

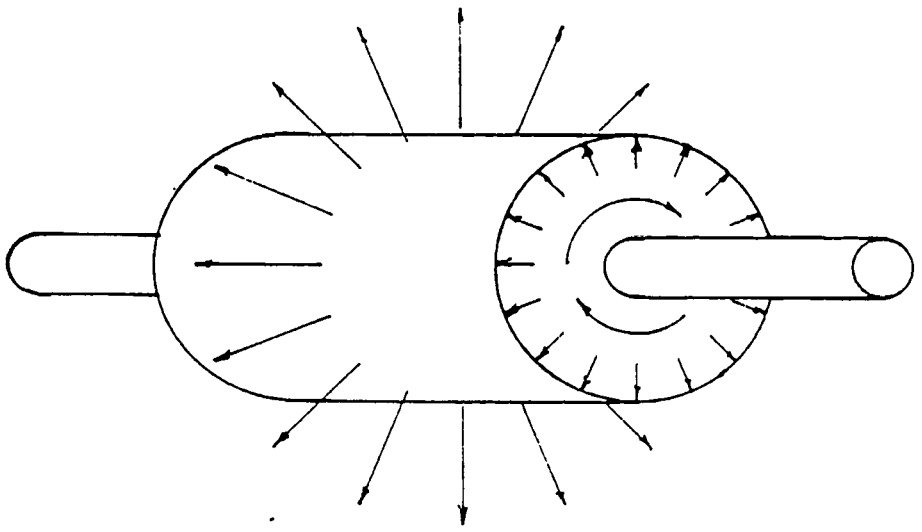


figure 57

Due to centrifugal force, <u>mass</u> is forced from the axle area toward the surface of the spinning/rotating disc, and the movement of mass from the axle area to the circumference (surface) is very rapid. This rapid movement of the mass results in the moving mass obtaining an <u>inertia</u> force. The inertia force experienced by the atoms and particles is so great that this mass is thrown out, or <u>leaves</u> the rotating disc. This forced out mass results in the area around the disc (or body) being filled with high velocity particles and atoms of mass. This area is then said to be filled with electric.

The axle area of the rotating/spinning disc or body now presents a condition where mass is "missing". The axle area of "missing mass" is now seen as a positively charged area (or female factor). The escaped mass (ie., electrical field) around the spinning/rotating disc or body becomes the male factor and can be seen as or measured by instruments as a negative charge. At this point then, the disc is in an unbalanced state, with an abundance of mass around the circumference, and a severe absence of mass along the axle. The mass ejected due to inertia forces will continue to move out away from the disc <u>until</u> it detects the difference in potential between it and the axle, at which time it will move toward the axle and re-enter the disc in order to re-estab sh balance between the male and female areas.

It is commonly known that electric will follow the path of least resistance. Should a brush be placed on the axle and on the circumference of a spinning disc with a conductor between the brushes, a current (or electric) flow will exist in the conductor. In the case of the Faraday generator, should brushes and conductor <u>not</u> be used, an electrical flow is detected from the circumference of the rotating body <u>to</u> the axle areas <u>through the air</u> (figure 58).

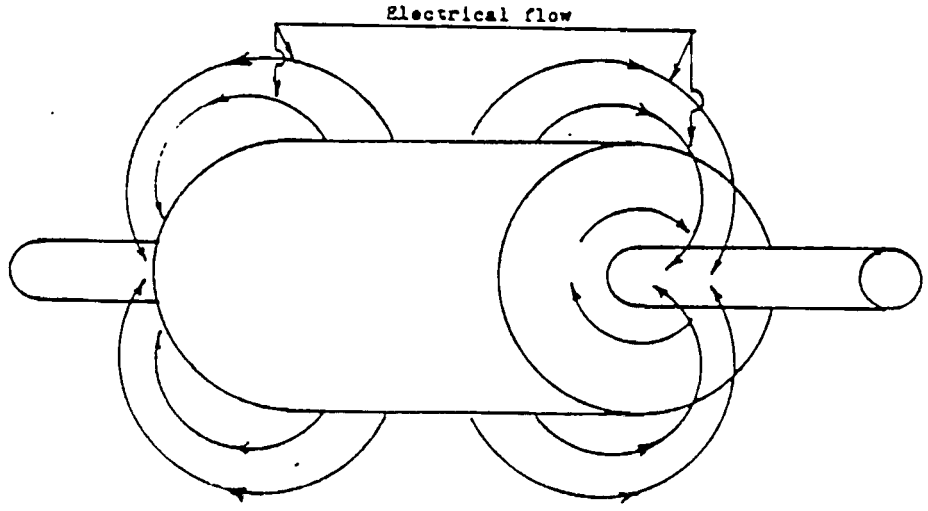


figure 58

This flow of electricity has been proven through careful testing by the Project Stardust team and by researchers globally. Now, by applying what has been said to a falling body, the "secret" of the repulsive force can be seen, and a primary consideration in this discussion is <u>direction</u> of motion - and the direction of an electrical flow can be predetermined.

If the Faraday generator were placed in a concise east-west direction before being rotated, and if the generator were to be constructed of a material with a low permeability value, the flow of electric would be as shown previously in figure 58. However, should the same generator be placed in a precise magnetic north-south direction, the electrical flow will be as shown in figure 59.

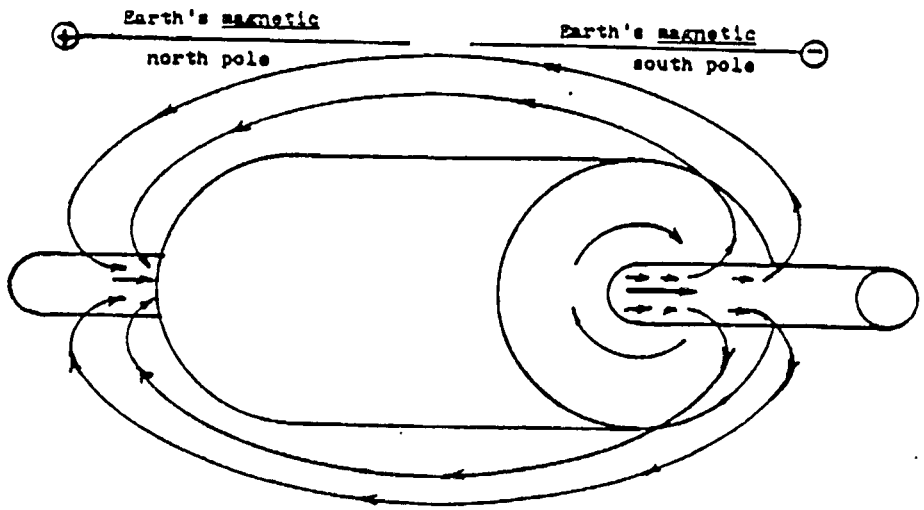


figure 59

This flow of electric to the north (+) magnetic pole of this planet is due to a very common fact - electric (ie., mass) follows the path of least resistance. So that there is no confusion as to why this is the path of least resistance we will pause momentarily and speak of terrestrial electricity. That which is called atmospheric electricity flows from the south magnetic pole of planet earth to the north magnetic pole. Although this south (-) to north (+) flow of atmospheric electricity is grossly distorted (sometimes so much so that it flows west to east), the main flow is nevertheless from pole to pole. To follow the path of least resistance the electric (mass) produced by the Faraday generator must flow with the electric flow of planet earth. To flow against the earth's atmospheric electric flow would create resistance to the flow of the generator, and so it will not take this path. The law applies - electric follows the path of least resistance.

Having clarified that point we may now apply what we know of the Faraday generator to a falling body in general, and so move a bit closer to understanding the elusive repulsive force.

To quickly review : a falling body rotates due to centrifugal force, creating an area of compressed mass. When a falling body rotates/spins, centrifugal force is applied at the equator, or leading edge of the fall. This in turn causes the atoms and particles within the body to be affected by the law of inertia and to be ejected from the falling body (see figure 60).

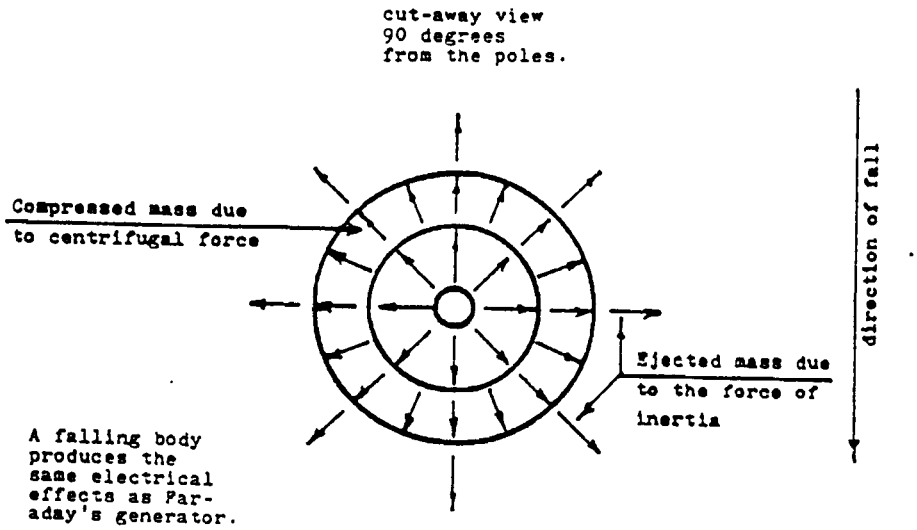


figure 60

It is now time to show some of the finer details of what was happening to those test balls by applying what we know of gravity and magnetism. Figure 61 illustrates the rotation and electrical flow of one of our test bodies (see paper titled Tests and Results, test 6, page 8, figure 9) in respect to the planet earth.

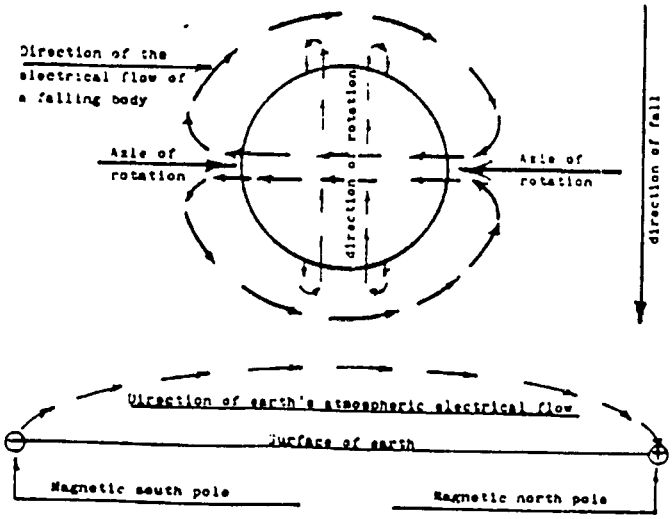


figure 61

By studying figure 61 it can be seen that, as with the Faraday generator, the electric flow through our test body follows the path of least resistance, and so aligns with the pre-existing electric flow of planet earth. Electric is simply mass in motion, and mass has magnetic properties. That which determines pole values is the direction of electric flow. The electric flow of our test body is moving in the same direction as the electric flow of planet earth, and so the mass which comprises the electric flows of the test body and planet earth are polarized in the same direction. A common and often demonstrated law of physics states that unlike magnetic poles attract and like magnetic poles repell. Pole values are established based on the direction of electric flow, and so there will be a repulsion between two flows of electric which are moving in the same direction. This can be seen by reproducing the classic test where two inductors are placed side by side and a flow of electric is passed through the wires in the same direction. The inductors (wires) will be pushed away from each other. By studying figure 61 it should be clear that the same law is in effect, and that the initial but minor repulsive force felt by a falling body is due to magnetic repulsion, simply because like poles (directions) repell.

Our test body had only a short distance (2000 feet) in which to fall. Had it been able to continue its fall it would have continued to increase its velocity until balanced gravitational and electric (mass) cycles were established. A falling body which is allowed to continue its fall will continue to expell mass at increasing rates until reaching a balanced threshold. Not all of the mass thus expelled travels the same route back into the axle area of the body, but rather tends to "spread out" as the body continues to accelerate. As with the Faraday generator, this ejected mass will continue to spread out until it detects the lesser potential of the axle, at which time it will then move toward and re-enter the body at the axle area. (figure 62).

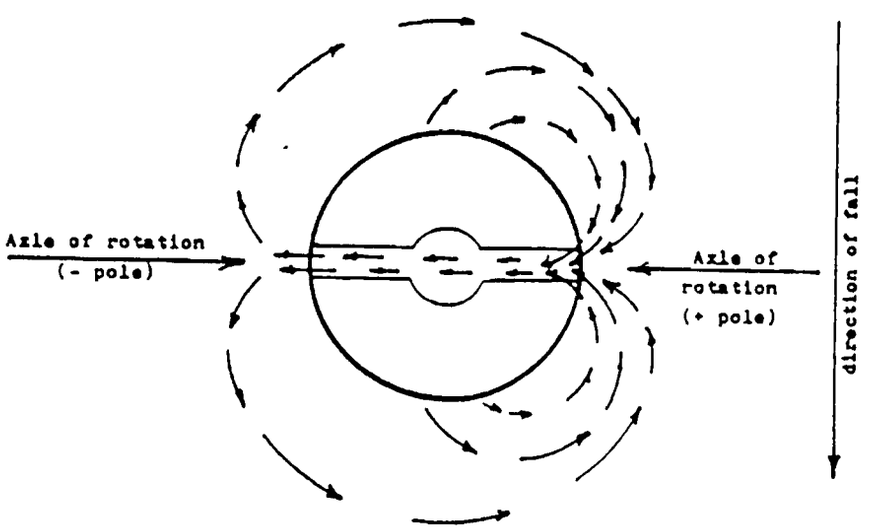


figure 62

As these different flows of mass establish themselves, they quite clearly are moving in the same direction, and so are of like polarities. This means that there will be a repulsion between these different flows of mass, resulting in these flows establishing shells or "lines" of moving mass which are separate from one another.

It must be apparent that a so called magnetic field is not merely the "effects of" a flow of electric, as pseudoscience teaches, but rather <u>is</u> a flow of electric (ie., mass). There is nothing mystical about it - a magnetic field is simply mass in motion in a given direction. If this can be comprehended, we may now proceed to consider the inertia forces applied to these shells of mass, and in so doing we can at last rescue gravity from the "effects of" pseudoscience.

As the magnetic field around a falling body expands, the outermost shells <u>must</u> obtain a greater velocity than the inner shells in order to keep up with the rotational rate of the body below. This need for greater velocity within the outer shells is due to the simple fact that mass within these shells have a greater distance to traverse than the inner shells, yet must travel this distance in the same amount of time as mass in the inner shells. The principle is clearly seen by observing the velocities involved in a wheel, ie., a point near the axle moves with the axle, but travels a much shorter distance than a point on the edge of the wheel, which also must keep up with the movement of the axle. The point on the edge of the wheel must move faster than the point near the axle.

Due to the inertial force applied to the mass in the outer shells (lines) of the magnetic field, there is a point where the outer shells can no longer keep up with the surface of the falling body. When this happens, the outer shells begin to <u>slip</u>, which then allows slower moving (ie., more inner) shells of the magnetic field to "pass" the outer shells (lines). This slippage is of the greatest value on the equatorial plane (the leading edge of the falling body) where the inertial forces are greatest.

The mass within these shells are en route to the axle area, to balance the "need" for mass there. These shells are rotating with the body, and are of varying velocities depending upon how far from the surface of the body they are. The axle areas, on the other hand, rotate very slowly compared to the rotation rate of the magnetic shells. Now, this means that as the mass from the shells enter an axle area they will "back up" to some extent, forming great vortexes above and leading into (or out of in the case of the opposite axle) the pole (or axle) area. As was the case in the gravitational cycle, one polar vortex will move clockwise while the other moves counterclockwise.

Between the stresses placed on outer shells by this "twisting" at the poles, and the aforementioned slippage along the equatorial plane, great pressures are felt by these outer shells, causing them to <u>stretch</u>. When these shells reach the point where they can no longer keep up and can stretch no further they will shear (break). A common and oft demonstrated law of physics states that a magnetic line of force releases the energy it contains at the point of breakage. What they call the "energy" within a magnetic line is <u>mass</u>, and once released, this mass must <u>go</u> somewhere, and so will instantly join with a nearby line of force which is still intact.

Many velocities are involved with the mass released from a broken line of force, but in this paper we will consider only the two primary velocities. First, the velocity of the mass within an unbroken line of force has been demonstrated to be the velocity of light (c). This velocity is obtained as mass exits one pole and moves toward the other - on the exterior of the body. The second velocity to consider is the added velocity applied to the line itself as it attempts to "keep up with" the rotational motion of the surface of the body. (This precise velocity is variable, and depends largely on the value of the magnetic field itself and on the spin/rotational value of the body as a whole). When a magnetic line of force is sheared, the mass within that line experiences the additive effect of these various velocities, and therefore is released from the broken shell at a velocity slightly greater than that of light ($>c$), and immediately joins an existing line.

Mass thus released from a magnetic shell leaves in its former position a "hole" which has a velocity greater than that of light. This hole may be visualized as a bubble of nothing, or an absolute vacuum which is moving too fast for any mass to catch up with and fill it. This bubble of nothing (space) is repelled by the mass which produced it and vice versa. If not restricted, this bubble will move away from the body and continue to accelerate, with a top velocity in the area of c^2. This is gravity B - the major repulsive force.

Gravity B offers the greatest value of repulsion at the point where the velocity of c^2 is attained. From that point on, due to ever decreasing concentrations of gravity B (as it spreads out from the body) it will begin to lose its repulsive value at an inverse rate of its distance squared.

The primary factor determining the specific value of both the major and minor repulsive forces is the permeability of the body, and this fact was clearly demonstrated through our actual, non-apocryphal tests with falling bodies. Note for example, test 2, figure 2, on page three of the paper Tests and Results. The iron ball used in this test had been manufactured for us by a local foundry, and weighed ten pounds. Without question it was cast iron, most likely from auto engine blocks. This ball fell 2000 feet in 10.5 seconds. In comparision, the balls used in test 3 (fig. 3) and test 5 (figs. 6,7,8,) were ball bearings salvaged from the Great Northern Railway. They were 1½ inches in diameter and were composed of a high valued hardened nickel and steel. Though these balls weighed much, much less than the iron balls we used, and their densities were comparable to iron, the ball bearings fell 2000 feet in 13.7 seconds.

After further testing and experimentation our theory began to take shape. Based on results of variations of tests 7 and 8 (pages 9 - 11), and through ongoing follow-up tests with permanent and electro-magnets, alternating currents and direct currents, we discovered how to produce an abundant, uncontrollable flow of gravity A and B. We thereby concluded that the repulsive force is directly proportional to the permeability value of the falling body times the total mass value, so that $Fr = um$, where Fr = force repulsive, u = permeability, and m = mass. This of course is stated in the simplest of terms, for as we take into consideration the many integral functions such as velocities, rotation rates, gravitational fields involved, and the specific magnetic fields the falling body is passing through, the mathematical functions take on levels of complexities which cannot be properly addressed in this short paper. Even so, it should now be apparent why a falling body with a high permeability value accelerates at a much lower rate than a body of identical size and weight but composed of an element with a low permeability value.

After countless failures, our team in 1980 built and tested a gravity generator to check the validity of our application of the theory of falling bodies to solar structure and solar power generation. It worked beautifully, producing great quantities of gravity B - the repulsive force. This theory is correct, and further research has revealed methods of controlling the output and direction of gravity B.

Project Stardust is now nearly thirty years old, and though we have repeatedly been crucified by the scientific community each and every time we've made one of our periodic disclosures, reverence for the truth demands we say again : Galileo was incorrect ; Newton was incorrect ; and Einstein was incorrect. Clearly, the electron theory is wrong, and nuclear theory is very, very wrong. We have <u>proven</u> them invalid.

In the time of Galileo and Newton the church decided questions of nature's laws in the following manner : we believe this or that, therefore it is true. During the days of Maxwell and Faraday this mystical base had been temporarily replaced with a true scientific doctrine : it is true, therefore we believe it. One has only to examine quantum physics to understand which doctrine is currently prevailing, and if this isn't corrected, and <u>quickly</u>, the planet earth and all her inhabitants will pay the price for man's transgressions against the laws of nature. We have warned of the results to expect as nature seeks to balance cycles disrupted by the applications of the electron and nuclear theories, but the warnings for the most part have fallen on deaf ears. The prevailing attitude is : we <u>believe</u> everything is alright, and therefore there is no problem. To this we say - blind faith is <u>blind</u>. It's time to open your eyes and <u>act</u>, for time is short.

Zirbes Enterprises

Supplement

Beyond the Ionosphere

Existing around earth (and all planets) is a neutral belt of radiation. Measuring from the equator of earth outward, the outer edge of earth's belt is approximately 40,000 miles high, and under <u>normal</u> conditions would be roughly 100 miles thick. The "layers" of this belt are "locked" into existing shells of the earth's magnetic field. This belt acts to shield the earth from energy generated by the sun (see segment four) in that it offers a resistance to the neutral solar radiation, thus slowing its velocity. Some of this solar radiation is slowed enough to become mass, and is "trapped" within the belt. Each layer of the belt will tend to accumulate a given sized particle : finer particles will be found closest to the outer layer of the belt; larger particles in a layer closer to the inner layer of the belt.

Once converted to mass, all particles seek to stabilize into systems. The fine particles in the outer layers of the belt are not yet assembled into systems, and are therefore neutral, and will be repelled from the north and south poles of the earth. Their velocity is great, and they continue their motion, but now they're held within a layer of the belt and so instead of moving in their previous direction, are now confined to moving along the length of the belt. As they approach one pole in this journey, they are repelled, and so reverse direction. As they then near the opposite pole they are again repulsed, and again reverse their direction of motion. This movement occurs at a tremendous velocity, and the repulsion by the poles ensures the continuation of the oscillation of these fine particles back and forth along the length of their particular layer of the belt. Their velocity remains fairly constant, being very near .9 times the velocity of light, but even at this velocity assimilation of particles through collision occurs, and these very fine particles begin to assemble into minute systems of particles.

Once a particle joins other particles and creates a system, it is no longer neutral, and now begins to respond to the gravitational attraction of the earth. This attraction encourages the new system to filter through to a lower layer of the belt, closer to earth. The new system now carries an electrical charge, but it is so minute as to be a negligible factor, and oscillations along the length of their present position within the belt continues, but the velocity will have decreased somewhat. This weight gain and subsequent reduction in velocity allows for more rapid assimilation into larger and yet larger systems of particles. With each increase in weight (ie., additional mini-systems added), the developing

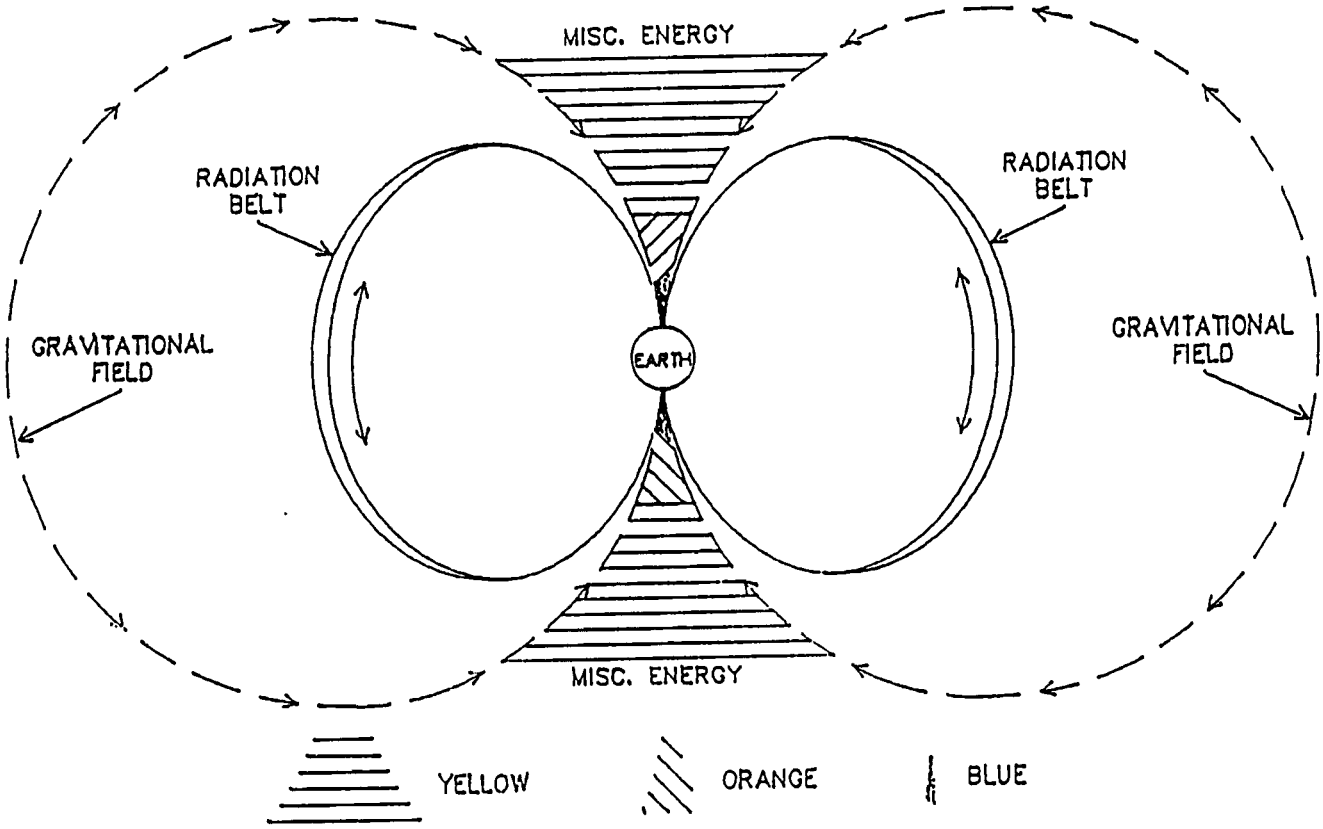
system of particles will be more responsive to the gravitational attraction of earth, and will filter through subsequent layers of the belt, moving ever closer to earth as the system develops into a more complex system.

By the time the original fine particle reaches the layer of the belt nearest earth, it is a member of a complex neutron or proton system, and has undergone a dramatic reduction of velocity during its passage through the layers of the belt. Proton systems will be attracted to the north pole, while neutron systems will be attracted to the south pole. As they move toward their respective attracting pole along this final belt, some will find that their weight and slow velocity can no longer resist the gravitational attraction of the planet as a whole. These systems will then leave the belt at some point along its length and will spiral earthward, where they will continue their assimilation with other systems of particles, eventually forming atoms and then ever more complex structures.

Other systems within the belt proceed toward their attracting pole, and their velocity once again increases as they near the pole and feel the attraction grow stronger. At this point it must be recalled that every falling body experiences a flow of energy whereby energy is extracted at the leading edge of the fall, cycles around the body (creating the gravitational field), and then re-enters the body as input energy. During this cycle many different energies join the flow (both polarized and neutral energies from various sources) and are carried along to ultimately approach a pole area. As this energy approaches a pole it begins to lose velocity, and any neutral energy within the flow polarizes. This loss of velocity occurs because of the extreme congestion within the narrow corridor leading to a pole, which must accomodate energy input from the gravitational field cycle, mass from the radiation belt, and energy input from other sources which are too numerous to be discussed at this time. This corridor is therefore an area of high turbulence, as input energy from all quarters converges here. While neutral energies from the gravitational field are slowing and polarizing, mass from the radiation belt is speeding up, and most of it will convert to energy. Collisions are ongoing, as all of the input is compressed into this relatively small area - still miles above the earth's atmosphere.

For the sake of clarity this re-entry will be described in terms of undergoing three different phases. In reality however, it should be realized that re-entry happens very quickly, and one phase blends into the next - none are completely distinct and separate from the others. The general positions of energies during these three "phases" of re-entry are shown in figure one.

NOTE: gravitational field extends far beyond what is shown in diagram.



During the first phase (yellow), all of the input energies begin to converge as they approach the corridor, and neutral energies begin to polarize. At this point the energies, if measured, would prove to be of very short frequencies, invisible to the human eye. Phase two (orange) finds all of this polarized energy jammed into the narrow space of the corridor proper, where it encounters the input from the radiation belt which is accelerating and forming into short frequency energy. During this phase the short frequency energies from these two sources (and the misc. sources) begin to "bump" into and join with one another, forming longer frequency energy, which comes within the spectrum of light visible to the eye. On earth we have named phase two the aurora borealis, whose presence depends upon the sized frequency being formed, and whose intensity depends upon the amount of input energy being introduced. As this energy now nears the outer atmosphere in its third phase (blue), it encounters additional resistance from mass contained therein, which slows the energies down a bit more. This results in a combining of the mid-sized energy frequencies into yet longer frequencies which again move out of the visual range, causing the aurora to seem to "disappear". The polarized energy then enters the earth to fill the void caused by the extraction of energy, and the cycle continues in perfect balance indefinitely, or until it's disrupted forcibly by outside interference, as has happened in the case of planet earth.

Until the first nuclear war in the mid 1940's, the radiation belt surrounding earth functioned perfectly - as just described. For the next decade bomb testing continued, as man played with his new toy - fission. When Dr. Van Allen undertook to measure the radiation belt, he discovered there were two belts surrounding earth, and made public his findings. Murmurings among the technicians involved with the project caused concerns that the lower belt may be the result of nuclear fission debris.

Perhaps to still rising doubts about nuclear fission and fusion, a project code named Argus was carried out in Aug.-Sept. 1958, where three hydrogen bombs were exploded in space beneath the lower area of the Van Allen belts. The project itself was top secret, but its effects were not. The fused material produced by these explosions was of course very heavy as compared with other fission produced material within the belt, and so it settled in at a lower layer of the magnetic field which had previously been void of debris. Being so near earth and very heavy, this fusion debris was very rapidly channeled back into earth as input. Atmospheric scientists who knew nothing of Argus detected great streaks of lithium in the especially brilliant aurora borealis which occurred on the heels of Argus. Puzzled and fearful, these scientists quickly announced that there was severe fusion occurring in the radiation belt. News of Argus did not come to light until some years later, and is still shrouded in some mystery. Two of the most obvious questions which remain to be answered are, why did they do it, and so they yet realize how very close they may have come to fusing the entire radiation belt and setting off a reaction which could have fused the oceans of earth ?

In 1962, the scientists involved with the space and nuclear programs again measured the radiation "belts", but now found there was only one huge belt, some 35,000 miles thick. It was loudly proclaimed that Van Allen had been incorrect in his measurements, and that he'd mistaken the one large belt for two separate belts. Van Allen was correct. At the time he took his readings there were two belts - one natural and one (the lower) unnatural - full of fission debris. By 1962 the large area between those two belts had been filled in by the vast amounts of fissioned material produced on earth, which then spread out around earth - each different particle finding a niche (layer) within the magnetic field suitable to its particular weight and/or stage of assimilation. The very lowest layers were now also filled in, but these contained fused material created through hydrogen bomb testing. These are very heavy (and close to earth) being more fully assimilated, and contain more complex systems - including basic elements and some simple compounds. Figures two-five attempt to show the stages in the deliberate and ongoing destruction of earth's protective shield, the radiation belt.

Radiation belt prior to 1945

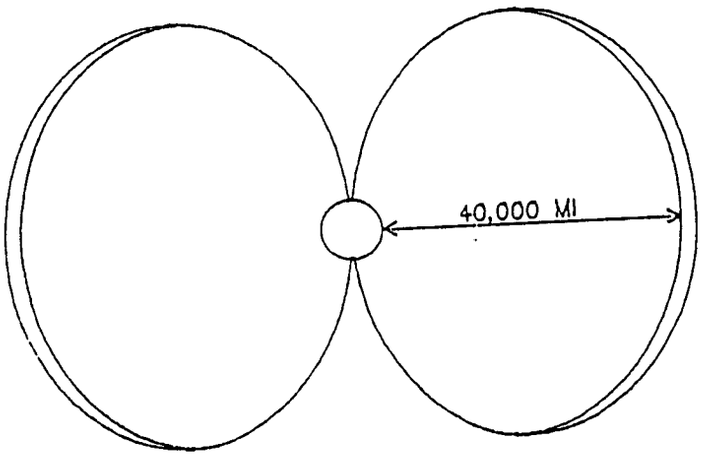


fig. 2

By 1958 there are two belts. One natural, and the lower filled with fissioned debris.

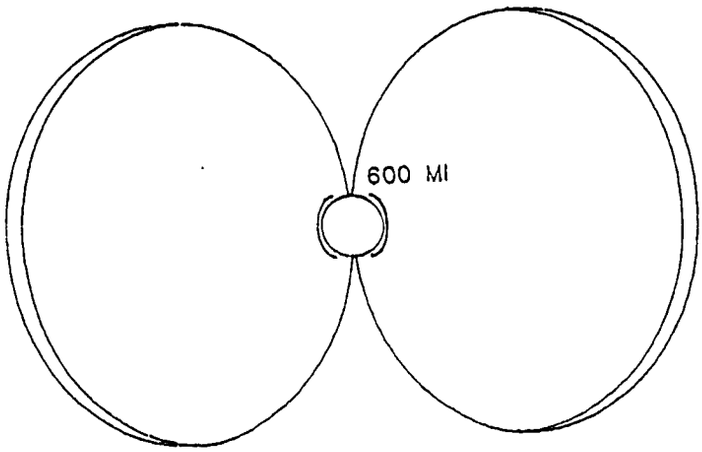


fig. 3

By 1960 (after Argus and testing programs), the lowest belt had formed, filled with fusion debris.

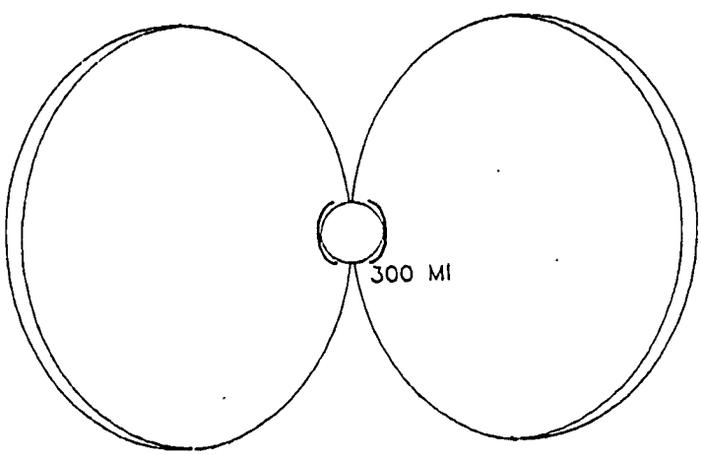


fig. 4

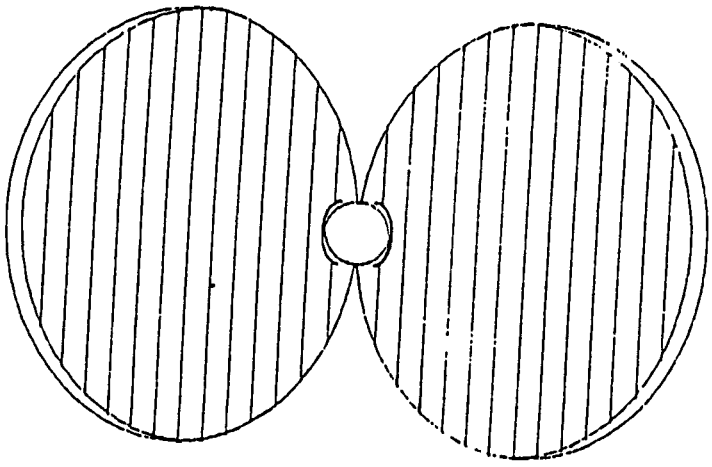


fig. 5

When measurements were taken again in 1962 it was found that there now existed only one huge belt, for by this time ongoing fission programs on earth had added vast quantities of new fission debris to the radiation belt, and the space between the natural and fission belts was begining to fill in.

Today, thanks to the efforts of university teams and other research facilities, the presence of nuclear debris at least in the lower belt is grudgingly admitted by our nation's "responsible" agencies to be the result of the nuclear programs, but concerns for this fact, if any exists, are brushed aside with the old "catch all" argument that nuclear energy is a natural energy. This argument continues on to assure any citizens who are aware enough to be concerned that since fission and fusion are nature's favorite tools, that nature also has built-in mechanisms for balancing out little problems like debris in radiation belts. We fully agree that nature <u>will</u> restore balance, but it will <u>not</u> be in the quiet manner our very learned leaders expect. Nature is about to begin making a great deal of noise, and this brings us to the subject of how restoration of balance will be achieved.

NOTE :

To facilitate this discussion, the overlapping sections of the radiation belt (fig. 5) will be spoken of as though they were three distinct belts.

All three sections of the radiation belt (natural, fission, and fusion) contribute constant input to the pole areas. Earth has no mechanisms for regulating the flow, relying completely on a balanced system (and balanced input), so when the system is not balanced, earth must continue to accept all offerings. Due to the existence and constant input of the unnatural belts the corridors leading to the poles are highly congested (as are the belts themselves) and velocities are reduced. Lesser velocity and more collisions allow many of the protons and neutrons from the natural and fission belts to begin assimilation into more complex systems even before their arrival in the corridor. This additional weight coupled with a further reduction in velocity upon entering the tightly packed corridor prevent many of these systems from converting to energy. Instead, they will collide with similar (highly isotopic) systems in the corridor and continue assimilation with these systems. Many are still incomplete when they reach the earth's atmosphere, but others have managed to assimilate into simple elements, notably forms of hydrogen. These elements are formed under unnatural, extreme conditions, and investigation would reveal that super heavy, abnormal forms of hydrogen are entering earth's atmosphere from these corridors in a steady stream.

While the natural and fission belt inputs are building elements, the heavier, more complex systems from the fusion belt enter the corridor as low velocity, "fused" elements in a highly unstable state. Here they also collide and assimilate with similar systems and form ever more complex systems, including helium, lithium, and beryllium - many of which will also be abnormally heavy, strange elements.

The remaining input from the belts which are not sufficiently slowed to have achieved any great degree of assimilation will be the most easily converted to energy when struck be incoming (gravitational cycle) energies. These energies will then follow the same process described earlier - polarizing, forming frequencies, and joining the other quantities and forms of input in producing spectacular lithium and beryllium streaked auroras.

When these isotopic systems, elements, (and compounds) enter the ionosphere, they collide with the many elements and compounds already present in great abundance, and continue assimilation - forming more complex flourine, neon, and chlorine (etc.) systems. These chemicals are bombarded constantly by both incoming and by outgoing (fission released) particles exported from earth (see segment three).

The net effect of this extreme disorder is an ionosphere experiencing ongoing and abnormal chemical reactions which result in the creation of negative plasmas, fusible hydrogen, and destructive elements and compounds. As long as fission and fusion continue to be the favorite toys of earth leaders, the turbulence in the ionosphere will continue to become progressively worse.

All of this extra input also affects the corridor itself, which is important because it is causing the corridor to warm. As the temperature within this great avenue rises, so also will the temperature of the atmosphere through which it passes begin to warm. The land mass below cannot fail to follow suit as this process progresses, and the cumulative effect of this overall warming will force the ice caps to begin to melt. If this is already being noted, expect it to become exponentially more rapid as earth's cycles become increasingly perverted.

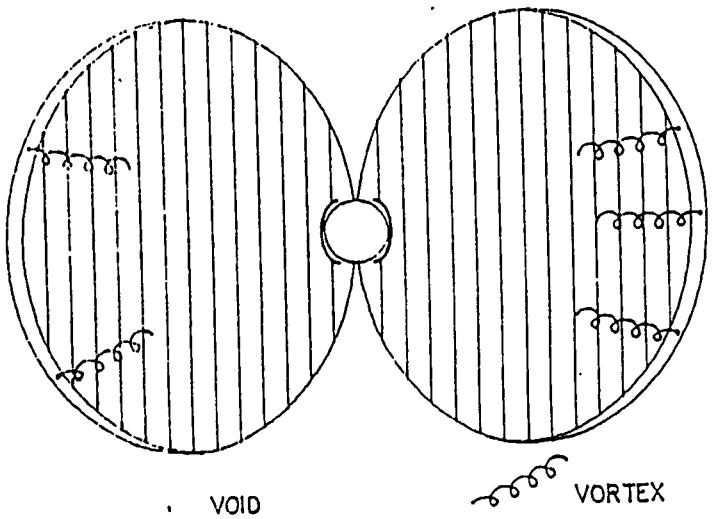
In the past we've tried to show the great interrelation between the major cycles of earth, and their control over all other minor cycles. The overriding cycle is the input/output cycle which determines the gravitational field (and hence repulsive force), the rotation rate, and the value of the magnetic field. Its importance therefore cannot be overstated. It is this grandfather cycle - the basic foundation of all other cycles - which is being <u>directly</u> attacked by fission and fusion. Until only recently the observable effects of this destruction were small, seemingly unrelated warning signs - easily rationalized. Now, however, earth is approaching a critical juncture where rationalizations will no longer satisfy <u>anyone</u>.

Once fission or fusion disrupts an atomic system, releasing unstable particles, we are saddled with them indefinately, for they seldom escape earth's gravitational field (bubble). Those that were not repelled back to earth, picked up by the radiation belt, or settled in at the poles, have joined the flow of the gravitational field cycle, and now also return as extra input energy. At this most critical juncture we face a situation where the radiation belts are full, the gravitational flow is overloaded, and the corridors can no longer maintain any sort of order. Meanwhile, earth operations continue unabated, pumping tremendous quantities of yet more of these particles into an already dangerously overloaded system. The result is clear - our foundation has begun to crumble.

In the past we've spoken of changing weather, greater volcanic and earthquake activity, ionospheric disruption, and hydrogen fusion implosions (etc.). Now, disturbing as it is, we must expand further to explain the future manifestations to expect from within the radiation belts themselves as they seek to maintain some sort of balance. Once again, these actions will be progressive in that at the outset the effects will be puzzling, but will be rationalized away. As the

process continues, however, it will not only accelerate effects previously discussed, but will ultimately come to overshadow all other consequences of fission and fusion in the minds of all, for these actions will not only be highly visible, but will also be deadly. Our team does not have access to data which would allow us to predict when these reactions will commence or how quickly they will pass from one level of intensity to the next, but we can attempt to show what will inevitably occur and why.

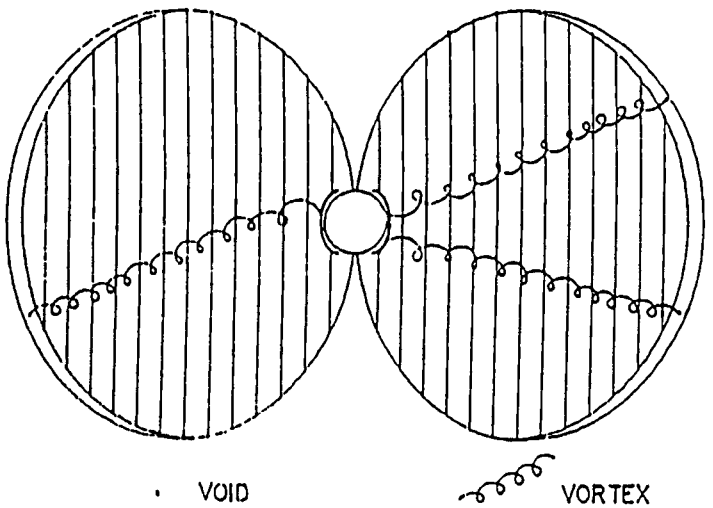
More and more accumulation of mass within the three sections of the radiation belt translate into progressively lessening velocity of the mass therein. When the input corridor reaches full capacity, a further loss of velocity is experienced within the belts, as mass becomes "backed up". Low velocities and dense concentrations are perfect conditions for rapid assimilation of particles into systems, and of systems into more complex systems. Each assimilation requires energy, which in a normal belt would be provided by the outward flow of extracted energy. In the case of our unnatural belt, the flow of extracted energy can never hope to keep up with the demands of the abnormally rapid assimilation. Even so, due to the conditions within the belt and nature's demand that balance will replace imbalance, this mass must continue assimilation. The net result is that as developing systems arbitrarily use up all available energy in the vicinity to achieve assimilation, energy voids are being created within the belt. Nature cannot tolerate such a destabilizing void - balance must be restored - and so energy contained within a lower layer of the belt "feels" the upper level void, and rushes to fill it. See figure six.



Such reactions do not occur in a natural radiation belt, where assimilation is gradual and orderly, but the radiation belt surrounding earth no longer even remotely resembles a normal belt. Continued input of fission/fusion debris from earth assures the progression of this abnormal cycle, whereby velocities will become further reduced, assimilation more rapid, and energy voids larger. What will begin as movements of energy from one layer to the next will progress until huge vortexes of energy are rushing through dozens, and then hundreds of layers to fill upper level energy voids.

To begin with, this movement of energy will be detectable only as increased turbulence, but as the movements begin to span multiple layers of the magnetic field, more visible effects will occur. When a magnetic line (shell) of force is sheared, the energy contained is released at the point of breakage. The manifestation of this released energy is generically labeled "lightning" (current theories which attempt to explain the origin of lightning are silly and explain nothing). Lightning can and does occur in the absence of an atmosphere, and will be seen to also occur in the radiation belt when large vortexes of energy begin to make huge plunges - shearing the magnetic lines of force through which they pass.

It doesn't take a great intellect to understand that as energy moves from one layer to fill a void in a higher layer, that an energy void will be left behind, needing also to be filled. Energy within a yet lower belt will then "feel" this void and will surge to fill it. Eventually, as the belts fill up more and more and velocities become ever lessened, these reactions will reach frightening proportions - spanning the entire width of the radiation belt. See figure seven.

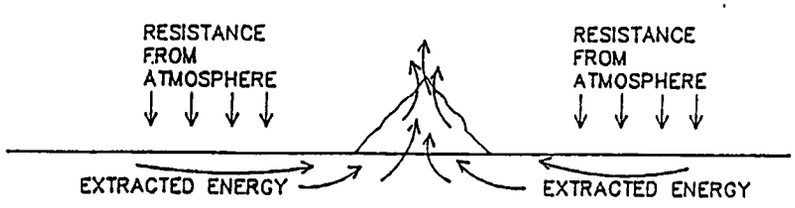


When the inevitable moment arrives and even the fusion belt is tapped to fill an upper level void, earth will be directly affected, for a void in the lowest layers of the radiation belt can only be filled by tapping the energy output of the planet below. Extracted energy from earth is radiated from most of the planet's surface (save the pole areas), but the output is not uniform - some areas radiating greater quantities than other areas. At this point we must digress for a moment to explain one of the specific details not previously discussed, and show what is meant by a "focal point", for these areas will be the first to be tapped to balance fusion belt energy voids.

The largest quantities of extracted (neutral) energy are found along the leading edge of earth's fall, as shown in segment two (note: if earth were not tilted on its axis this line would be the equator. As it is, a few simple calculations will reveal the exact position of this line at any given point in earth's orbit). One of the properties of neutral energy that is identical to other energies is its tendency to follow the path of least resistance, which means it can be conducted.

As this neutral energy leaves the central section of the body earth and approaches the outer surface, it feels the slight resistance offered by earth's atmosphere. If there is no ready alternative to this path, the energy will flow through the resistance, experiencing only a very slight loss of velocity. If, however, there is a pathway of lesser resistance in the vicinity, the neutral energy will have a natural tendency to flow towards it. All energy from the area surrounding such a point of lessened resistance will therefore be drawn to it, creating a focal point of extracted energy. An excellent example of such a natural focal point is a mountain, which possesses a broad base and a graduated incline. Figure eight illustrates this phenomenon.

fig. 8



Tall buildings on a flat plain, ships at sea, and islands are other examples of natural focal points, and any of these structures which resi'n on or near the leading edge will be the strongest radiators of extracted energy anywhere on earth. Therefore, when the moment arrives when an energy void appears within the fusion belt, it will be these focal point areas along the leading edge which will "feel" that void, and will rush to fill it. Rapid movement of energies that normally leave earth at a gentle, regulated pace disrupt balance, and when nature's cycles are tampered with, consequences follow.

As these events begin to occur, subsequent reactions on earth will vary somewhat depending on the location of the focal point affected, but amid all of the variables a definite pattern will emerge. When a vortex of extracted energy detects a void in the fusion belt, it will sweep up and carry surrounding atmosphere with it into the fusion belt. This upward rush of air will cause a low pressure zone to be left in its wake, which must be stabilized. Air from the immediate vicinity will join with ionospheric O^3 and move in to fill the gap, creating high winds and great turbulence. As the area stabilizes, the O^3 will again rise to its original position, but leaves behind foliage and wildlife damaged by over exposure to this gas. As these reactions become more and more regular, plants will slowly smother and die.

Atmospheric gases carried to the fusion belt will create a high pressure zone there, so that when a low pressure zone is "felt" below, these gases will return to balance it. When it does return, it is most likely to be in one of two forms, depending on its moisture content at the moment it was swept away. Air carried to the fusion belt will have undergone rapid cooling upon its arrival. If this air was relatively dry, it will be most likely to return as snow. If it was very humid it will be more prone to latch on to systems within the fusion belt, freeze, and return to earth as radioactive hail. This process is illustrated in the following series of drawings.

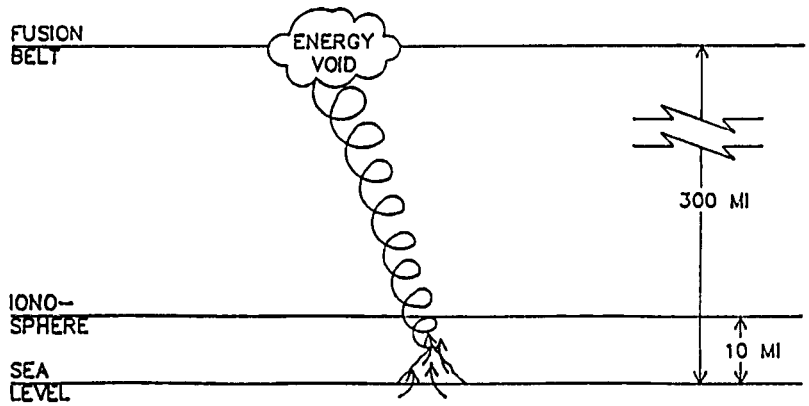


fig. 9

Focal point energies feel fusion belt void and move to balance it.

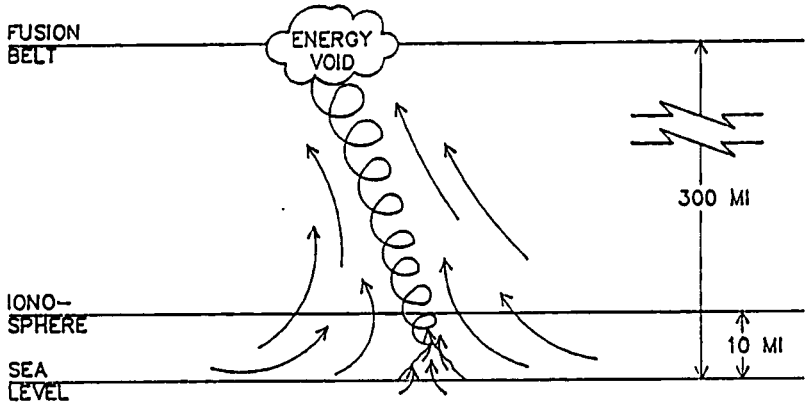


fig. 10

Surrounding atmosphere is dragged with the exiting vortex into the fusion belt.

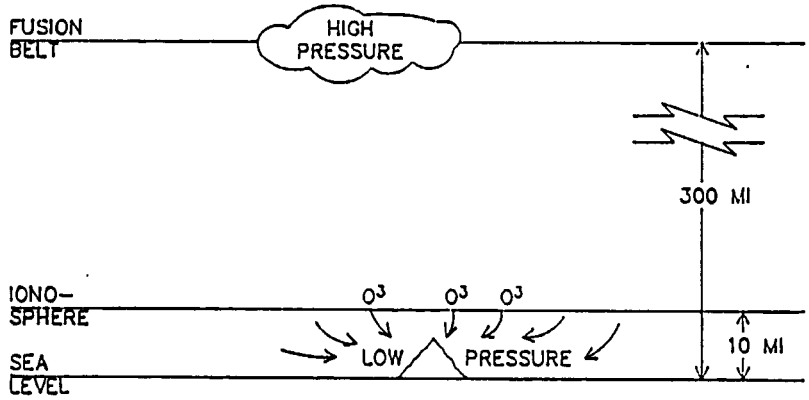


fig. 11

O^3 and nearby atmosphere rushes in to balance low pressure zone left behind.

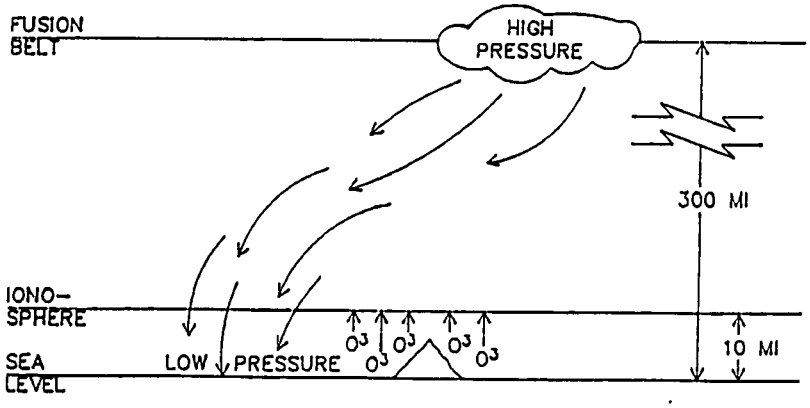


fig. 12

High pressure in fusion belt detects low pressure area somewhere below and returns to fill it, bringing snow AND/OR radioactive hail.

As the radiation belt struggles to accomodate more and more nuclear debris and at the same time attempts to adjust to an ever accelerating energy exchange cycle, these reactions on earth will become increasingly violent. Focal points along the leading edge will have greater energy demands placed on them, and energy vortexes leaving earth will become larger and more energetic. When these huge vortexes surge toward the belts, they will be powerful enough to shear the lines of magnetic force in their path, creating gigantic lightning displays accompanied by literally deafening claps of thunder. Winds near focal points will reach hurricane proportions, with resulting hail (or snowstorms) of equal or greater ferocity. By the time conditions have reached these proportions in the primary risk areas, focal points farther removed from the leading edge will have begun experiencing the initial phases of this phenomenon, as described earlier and illustrated in figures nine through twelve. Progression of this cycle will yield more of the same - only in greater proportions. As exiting vortexes grow ever larger, reactions will simply become more intense, destroying all life within greater and greater areas surrounding focal points. These very large vortexes will easily and regularly trigger avalanches, mud slides, and the like, and as always, focal points farther removed will be but one step behind these leading edge reactions. Before long, nuclear reactors (which also radiate vast amounts of energy) will begin to be tapped to fill radiation belt energy needs as well.

Vast exits of energy from earth to the belts will leave behind energy voids within the focal points themselves, which nature cannot and will not tolerate. To fill these voids, energy from deeper within the planet will move quickly to restore balance. This rapid, abnormal rush of energy will set off interior, <u>physical</u> vibrations - triggering earthquakes of ever greater magnitude as the process continues. To balance these interior energy voids earth must take in more energy at the poles. It isn't difficult to see that this will compound the problem, creating even stronger focal points more sensitive to energy voids within the radiation belt, which will in turn accelerate the exodus of energy from earth. A greatly accelerated input will also cause interior temperatures to rise near earth's core. At first this temperature change will be manifested on earth's surface as "hot spots" (example: El Nino) followed by overall ocean warming, more severe and abnormal weather, and the re-activation of formerly "dead" volcanos. Energy voids within nuclear reactors and the surge of interior energy seeking to fill those voids will make nuclear meltdowns more and more commonplace occurrences. The final stages in this particular process will witness these exiting vortexes dragging earth's atmosphere deeper and deeper into the radiation belt to fill more upper level energy requirements - ultimately carrying it so far distant that it cannot return in <u>any</u> form.

The last gasp of life on earth will be a horrible event, but for better or for worse, not many of us will be alive to witness the demise of our world, because if (or when ?) we arrive at this point, the inhabitants of earth will have simultaneously been attempting unsuccessfully to contend with a less visible but in many ways more dire consequence of an accelerated energy exchange cycle. It is this larger question to which we will now direct our attention.

It's common knowledge that earth experiences an annual "wobble", but there is little agreement and a lack of logical theories as to the reason why the earth wobbles. Without going into laborous terminology, we could simply state that the wobble is due to the dynamic interaction between the sun and its magnetic field and the earth and its magnetic poles and gravitational field. Among other things, this interaction means that when an earth pole comes to face the sun, there will be a repulsion directed at that pole which will "push" that pole away from the sun to a certain (relatively small) degree. In the case of earth, the point of greatest repulsion against the South Pole occurs on and near the winter solstice, with recovery being achieved by the time of the vernal equinox, when the repulsion becomes more equally divided between the two poles. As the summer solstice then approaches, the North Pole comes to face the sun and so has the brunt of this repulsion directed at it, pushing it away from the sun while the other pole is protected. Recovery will have been achieved by the time of the autumnal equinox, when again the poles share the force of this repulsion more equally. The net result of this interaction is a relatively small and harmless annual oscillation of the poles around the earth's axis, or in other words, a wobble.

As the energy exchange cycle of earth continues to accelerate and earth's gravitational field as a result grows larger and stronger, this interaction between earth and sun will also intensify, causing the solstice reactions at the poles to be more vigorous and causing the overall oscillation to become progressively more pronounced. This in itself will be a minor event in that it won't even come close to causing the severe problems some of the other reactions we've discussed will cause, but it is something to look for because once it begins to be noticed it will mean that a closely related but more deadly result of an increased repulsive (gravitational) field will have commenced, ie., earth's irresistible movement away from the sun. This will not be a gentle, regulated "drift" away from the sun, but rather will manifest as a "see saw" motion which will be accompanied by a full spectrum of resulting upheavals on earth's surface.

As the earth's repulsive force becomes stronger it will react against the center of its primary gravitational field, the sun. This repulsion will be more abrupt than gradual due to the abnormal condition of earth's cycles, the result being

that earth will push itself farther outward than the strength of its repulsive force can long maintain. The sun's attraction will at this point again be felt strongly enough to "pull" earth back toward the sun, where the abnormally strong repulsive force of earth again over compensates in its push away from the sun. This back and forth motion will be ongoing, so that from a vantage point in space earth will appear to stagger in her orbit around the sun, and this swaying motion will become progressively more violent as long as earth's cycles continue their deterioration.

The combined action of these two motions will cause the leading edge of earth's fall to adjust continually as the position of the planet in relation to the sun changes. This means that the areas of energy input on earth will also be forced to adjust in order to remain the prescribed 90° from the leading edge. As the input areas (poles) change position, the ionospheric holes will follow, exposing large and varying surface areas below to dangerous ultra-violet radiation. Besides destroying any remaining vestige of normal weather, a constantly shifting leading edge will result in the creation of focal points of extracted energy in areas which were previously relatively safe from interactions with the radiation belt (as described on pages 11-14). As always, we can expect this process to be progressive.

We've attempted to show the interrelation and interdependencies between the major cycles of earth, which it should be realized, earth's close companion, the moon, also experiences. Step by step we've also attempted to show what happens to fission and fusion released particles, which move out in all directions ranging in the spectrum from those that move inward, toward the earth's core, to those that are so energetic that they escape to the outer reaches of the earth's gravitational field. These two extremes do not account for the bulk of the particles which concern us however, as the vast majority are radiated outward but do not retain enough velocity to escape too far, but instead accumulate at a pole, are picked up by the radiation belt, or encounter the highly positive incoming solar radiation which repells them back toward the earth. As previously explained, when we speak of negative vs. positive in relation to these energy particles it is a relative situation, for single particles are neutral - it is their relative size which determines which energies a given particle will repell or be repelled by. In this sense then, fission released particles are very negative in respect to the natural extracted energy of earth, and are even more negative in respect to solar energies. Even though these particles will also be negative in respect to the natural extracted energy of the moon, the repulsion offered by the smaller energies (bubbles) produced by the moon is much less than that offered by earth and the sun. This encourages the fission produced particles which have escaped

through earth's radiation belt to accumulate in the vicinity of the moon - most particularly on the dark side of the moon, where they are shielded from the repulsion offered by both sun and earth. We will now briefly discuss the effect of those particles which find safe haven near the moon.

Like earth, the moon has no mechanism for refusing input energy, and so has and will continue to take in fission released energies as input, which must then exit as extracted energy. More energy in equals more energy out, resulting in the construction of a greater gravitational field. A greater gravitational field about the moon will cause that body to repulse itself more vigorously from earth, which of course represents the center of the primary gravitational field through which the moon falls. Meanwhile, a stronger gravitational field about earth will heighten it's attractive force toward all bodies existing within its gravitational field, notably the moon. The effect of this "tug of war" will be nearly identical to the abnormal interaction to be expected between earth and sun, ie., the moon will begin to "stagger" in her orbit of earth, for the same reasons as described in regards to the earth/sun relationship. Many effects from the moon's see saw orbit will be measurable, but the most visible will be the negative effect on earth tides, which will be most especially noticable and dangerous during periods when the moon draws abnormally close to earth. During periods when the moon is positioned between earth and sun the danger will be most acute, for at these times the moon is always under great pressure. Being fully exposed to the gravitational attraction of the sun, she will repulse herself more strongly from the sun, and the stronger her repulsive field is, the more vigorous will be the repulsion. This, however, will force her closer to earth, where the ever increasing strength of her gravitational (repulsive) field will have disastrous consequences for all coastline areas. As earth and moon cycles become increasingly unbalanced, tides will begin to resemble tidal waves, and coastal dwellers will be forced into regular evacuations until finally there is nothing left to return to.

This paper represents our last planned effort, although we stand ready to answer <u>any</u> questions the reader might have. Throughout, we've done our best to present a glimpse of this planet's future, and taken as a whole, this work gives the reader at least an idea of what to expect and why to expect it. Truly, the proverbial eleventh hour has arrived, and the clock is ticking.

Reflection on our outreach attempt of the last year and the apathy encountered at every turn - with so few notable exceptions - leaves a sense of acute weariness and a feeling that the vast majority of human beings are content to remain insulated in their own small world, where they struggle to maintain at least a degree of control and order, and it seems clear that until the crisis this planet faces intrudes directly into that small world, there are few people who will show any

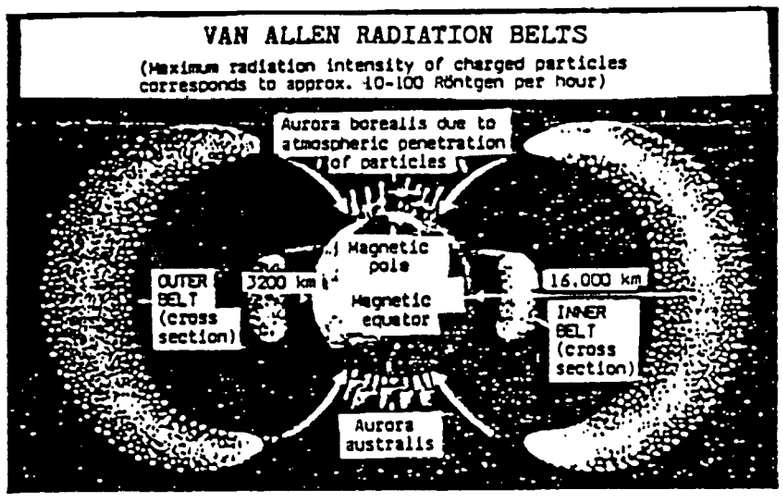
great concern for the larger questions and the fate of a world they will not live to see. For those notable exceptions whose concern extends beyond the immediate and into the future, this final paragraph is reserved.

Ultimately, if nothing is done, this planet will be void of life, and though none of us will be alive to witness the final death rattle of earth, the event will occur in one of two manners. In the more optimistic scenario, earth will simply continue to deteriorate and drift farther away from the sun until all but perhaps the lowest forms of life run out of food and perish. Earth will eventually find a new orbit and stabilize, but it is highly unlikely that higher forms of life would ever again evolve in such a hostile environment as will exist on earth far from the sun. However, it is much more likely that, given the erratic thought processes of earth leaders, that an action reminiscent of the insane rationalizations which allow projects such as Argus to be undertaken will trigger a series of hydrogen implosions, igniting the atmosphere. Such an uncontrollable chain of fusion reactions would consume <u>all</u> available energy, which means the gravitational field of earth will be destroyed, as this field represents the only ready supply of the vast amounts of energy which would be required. Without a flow of energy through the body earth, the magnetic field cannot exist, and lacking any sort of repulsive force, earth will have no resistance to offer against the enormous attraction of the sun, and will begin her fall toward that body. Admittedly, the chances are slight that earth would, in such an event, strike the core of the sun, but it <u>is</u> possible, and so deserves mention. If earth <u>were</u> to strike the core of the sun it could cause the sun to split, in the same manner that a neutron which strikes the center of an atom can split that atom. If the sun were to split, the solar system as we know it would cease to exist, and potential havoc created by the fission of our solar system within the galaxy in general cannot be under estimated or taken lightly. There could be a great deal more at stake here than our small, rather insignificant world, and we'd better think about that very carefully as we weigh our choices. Our team has done what we could, and at present have no firm ideas as to what our next attempt should be. We know what needs doing in the way of development of technologies, but it's impossible for us to accomplish this anytime soon without help. At this point then, all we can really do is ask that each person receiving this material try to pass it along. Perhaps in this way a team can eventually be formed and work can proceed. Until such time, if there are any questions, we will be pleased to answer them.

Project Stardust Team
Lloyd B. Zirbes, Director
April 14, 1987

VAN ALLEN RADIATION BELTS: THEIR DISCOVERY AND IMMEDIATE DISRUPTION

"The Van Allen radiation belts are two doughnut-shaped zones of charged particles trapped in the magnetic field of the earth. The belts are most intense over the Equator and are effectively absent from the poles. ... Because of the offset of the [earth's magnetic] dipole from the centre of the earth, the [lower] radiation belt dips to 400 kilometres above the surface of the South Atlantic Ocean, whereas over the central Pacific its lower edge is about 1,000 kilometres high." [Article " Van Allen Radiation Belts" in Encyclopedia Brittannica.] [see Figure 1.]



These belts contain large quantities of protons and electrons. In the inner belt, the peak intensity of protons with an energy exceeding 30 MeV is about 20,000 particles per second per square centimetre; electrons reach an energy of about 1 MeV, and intensities of max. 10^8 particles/sec/cm^2. In the outer belt, proton intensities are of a similar order, but their average energy is approx. 1 MeV, increasing with distance from earth. Electron intensity and energy in this belt is a complex matter, involving magnetic storms and other phenomena not discussed here.

The existence of the belts was not discovered until April 1958, during the first weeks of operation of America's first satellite, Explorer I. during the International Geophysical Year. They bear the name of their discoverer, J. Van Allen.

"Project Argus"

This, it should be remembered, was the era of atmospheric nuclear testing, and on 19 March 1959, the New York Times published an article revealing that in August-September 1958 the U.S. Navy had exploded three nuclear bombs 480 km above the South Atlantic, i.e. in the part of the inner Van Allen belt closest to the earth's surface. In addition to these three fission-type (1 kiloton, kt) devices, two "hydrogen" (i.e. nuclear fusion) bombs were detonated 160 km above Johnston Island in the Pacific.

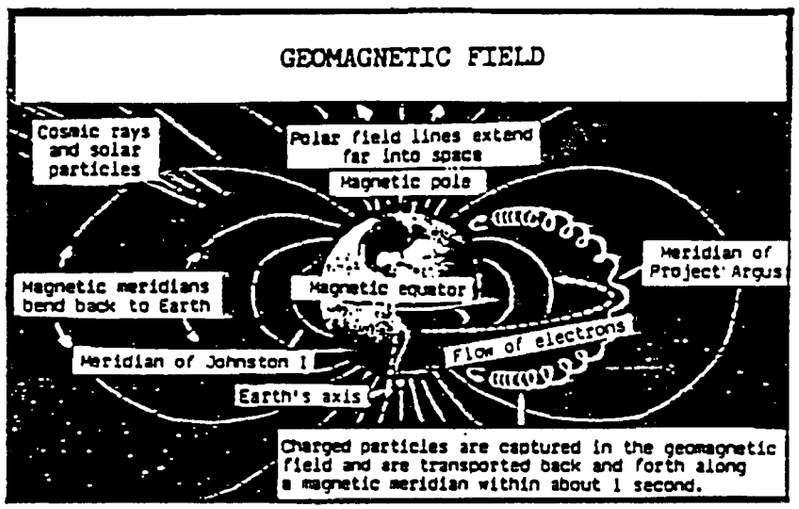
This programme, quoted at the time as being "the biggest scientific experiment that has ever been undertaken", had been set up by the US Ministry of Defence and the Atomic Energy Commission under the name "Project Argus". Its aim appears to have been twofold: to assess the impact of high-altitude nuclear explosions on radio traffic and radar operations (electromagnetic pulse, EMP), and to increase understanding of the geomagnetic field and the behaviour of charged particles therein.

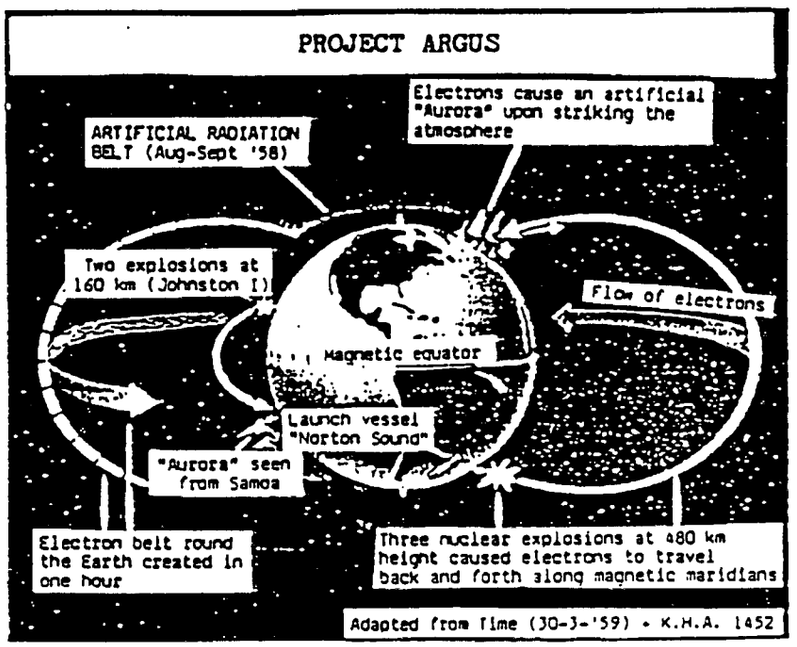
The explosions created new (inner) radiation belts encompassing almost the entire globe, and injected sufficient electrons and other energetic particles into the ionosphere for effects to be registered worldwide.
[See Figures 2 and 3 on next page for a more detailed description.]

"Project Starfish"

Four years later, on 9 July 1962, the United States undertook a further series of experiments, named "Project Starfish". Three nuclear bombs were exploded above Johnston Island: "one kiloton device, at a height of 60 km and one 1-megaton and one multi-megaton, at several hundred kilometres' height." [Keesings Historisch Archief (K.H.A.), 29 June 1962.]

These tests seriously disturbed the lower Van Allen belt, substantially altering its shape and intensity. "In this experiment the inner Van Allen radiation belt will be practically destroyed for a period of time; particles from the belt will be transported to the atmosphere. It is anticipated that the earth's magnetic field will be disturbed over long distances for several hours, preventing radio communication. The explosion in the inner radiation belt will create an artificial dome of polar light that will be visible from Los Angeles on the American West Coast." [K.H.A., 11 May 1962, reporting on the Starfish plans.]





"The ionosphere-[according to the understanding of the time, defined as] that part of the atmosphere between 65-80 km and 280-320 km height-will be disrupted by mechanical forces caused by the pressure wave following the explosion. At the same time, large quantities of ionizing radiation will be released, further ionizing the gaseous components of the atmosphere at this height. This ionization effect is strengthened by the radiation from the fission products. ... The lower Van Allen belt, consisting of charged particles that move along the geomagnetic field lines ... will similarly be disrupted. As a result of the explosion, this field will be locally destroyed, while countless new electrons will be introduced into the lower belt." [ibid.]

"On 19 August ... NASA announced that as a consequence of the high-altitude nuclear test (9 July) a new radiation belt has been formed, stretching from a height of about 400 km to 1600 km; it can be seen as a tem-

porary [sic] extension of the lower Van Allen belt." [K.H.A., 5-8-1962.]

In fact, as the Enc. Brittanica [ibid.] explains: "... Starfish made a much wider belt [than Project Argus] that extended from low altitude out past L=3 (i.e. three earth radii, 3 x 6370 km, from earth centre)", i.e. more than doubling the natural thickness of the belt. Electron fluxes were produced that were as high as 10^9/sec/cm².

Writing sometime in thet 1970s, the author of the Brittanica article states: "How the Starfish electrons spread as far from the explosion site as they did and what produced different electron energies in various sections of the belt remains to be explained. The decay of the Starfish electrons was found to be quite slow at L less than 1.5 [i.e. up to 3200 km above the earth's surface] and to be controlled by their collision with atoms of the atmosphere. Injun and Alouette satellites yielded decay data that indicated lifetimes up to several years for low altitudes, in agreement with the theory of atmospheric scattering. At higher altitudes measured lifetimes were considerably shorter; at L = 2.5, less than a week."

Having protested strongly against U.S. plans to carry out these high-altitude tests, later in 1962 the USSR also undertook similar planetary experiments, creating three new radiation belts between L=1.7 and 3.0.

The pain and the folly

As stated in the Encyclopedia Brittanica [ibid.], "These electrons (i.e. those in the inner Van Allen belt) have not been studied as thoroughly as the protons, partly because the electron fluxes have changed markedly since 1962 as a result of high-altitude nuclear explosions by the US and USSR."

At the time of the 1962 tests, leading astronomers and others protested strongly against the irresponsibility of these experiments. In England, Sir Bertrand Lovell and Prof. Martin Ryle, among the leading astronomers of their time, stressed the crucial point that it is sheer folly to modify the earth's planetary dynamics before they are understood (as well as afterwards, it may be added). According to American scientists of the day, it could take many hundred years for the Van Allen radiation belts to restabilize at their normal levels.

The questions today are clear: What have been the effects, both short and long term, of these massive disruptions of the Van Allen radiation belts and of the injection of such quantities of energetic particles and fission products into the upper atmosphere? In particular, how have these changes affected: the radiochemistry of the upper atmosphere; the ozone balance in the stratosphere; the radiochemistry of the troposphere; general planetary atmospheric/energetic/electromagnetic/geomagnetic dynamics?

Postscript: while working on this text, I came across a short article in K.H.A. 1575 (p. 575) reporting on U.S. military plans (for 13-20 August, 1961) to create a "telecommunications shield" in the ionosphere, at 3000 km height, by bringing into orbit 350,000 million [sic] copper needles, each 2-4 cm long (total weight 16 kg), forming a belt 10 km thick and 40 km wide, the needles spaced about 100 m apart. According to K.H.A., "... the ionosphere is to be be replaced, as it were, because telecommunications are imoaired by magnetic storms and solar flares. ... The International Unions of Astronomers (I.A.U.), at a meeting in Berkeley (U.S.), has adopted a resolution condemning the project as unscientific. The IAU fears that the needles will form an inpenetratable curtain for cosmic radiation, resulting in reduced optical visibility. Their concern is strengthened by American plans to increase the number of needles if the project proves successful."

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...Y, MARCH 29, 1988

Science Tim

The New York Times

Temperature For World Rises Sharply In the 1980's

Some scientists maintain that they are finally seeing results of greenhouse effect.

By PHILIP SHABECOFF

Special to The New York Times

WASHINGTON, March 28 — Average global temperatures in the 1980's are the highest measured since reliable records were first kept over 130 years ago, according to reports now coming in from scientists around the world.

Temperatures have been rising more or less steadily for much of the last century. But, in the view of some scientists, a sharper rise detected in the 1980's is the most persuasive evidence yet that carbon dioxide and other industrial gases are trapping heat in the atmosphere and warming the earth as if it were a greenhouse.

In interviews, meteorologists and others engaged in plotting global climate trends were cautious about blaming the greenhouse effect for the recent sharp increase, saying mathematical models of the phenomenon project much sharper increases than have so far occurred.

But several agreed that if the pattern persisted into the next decade, it would almost certainly mean that an era of global warming, caused by humans and certain to affect them in major ways, has begun.

How hot is the world now? The scientists do not offer a straightforward response, saying that the vast amount of data is still being studied and that comparisons cannot be precise. But the data gathered by American, British and Soviet scientific teams generally show a faster warming so far in the 1980's than in the century before. And most of the readings agree that the three or four warmest years on record occurred in this decade.

One of the scientists, Dr. James E. Hansen of the National Aeronautics and Space Administration's Institute for Space Studies in Manhattan, said he used the 30-year period 1950-1980, when the average global temperature was 59 degrees Fahrenheit, as a base to determine temperature variations. He said his readings showed that the average global temperature rose about as much since the base period as it did from the 1880's to the base period — about half a degree in both cases. He stressed that these were estimates and that it would take millions of measurements to reach an accurate global average.

> New reports say the earth's warmest years on record occurred in this decade.

Mathematical models project that at the current rate of buildup of the gases thought to cause the greenhouse effect, the average global temperature will rise from the 59-degree base by 3 to 9 degrees Fahrenheit by about 2030, with increases substantially greater at higher latitudes but lower increases near the Equator.

Dr. Hansen said the temperature was increasing in this decade even as natural factors were keeping surface temperatures lower than they might have been. These factors, he said, are relatively low radiation from the sun and high volcanic activity, which produces particles that tend to filter out some solar radiation.

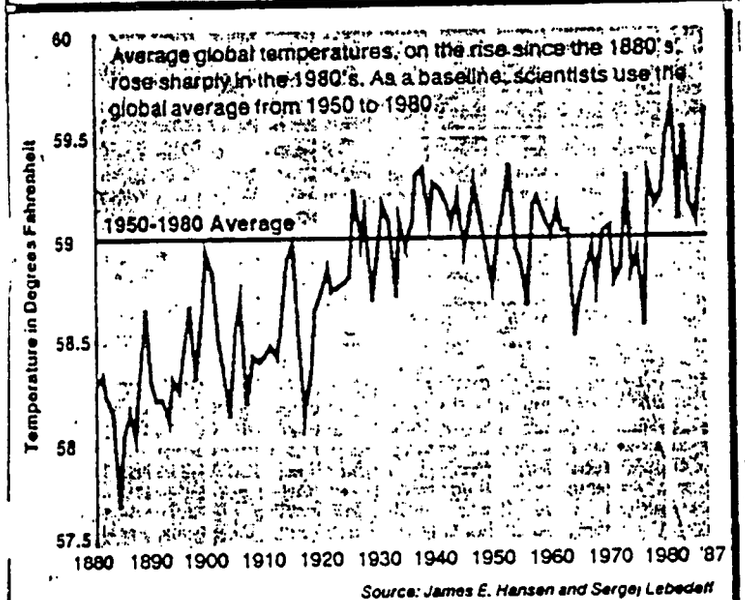
As the earth warms, experts predict major changes in climatic patterns and a gradual rise in sea levels as the warming oceans expand and polar ice melts. Coastal flooding, dust bowls, sharply reduced crops, and dying forests could result in some regions. On the other hand, some relatively barren areas might become farmlands.

Tom Wigley, director of the Climatic Research Unit at the University of East Anglia in Britain, said that his data, taken from stations on the ocean as well as on land,

Continued on Page C4

Global Warming Trend Accelerates in 1980's

Record Warmth in the 1980's



The New York Times/Mar. 29, 1988

Continued From Page C1

found that 1987 was "the warmest year on record" and that the three warmest years in the record were 1987, 1983 and 1981.

He said in a telephone interview, that while some of his data supported the predictions of the greenhouse models, others did not. For one thing, he said, the temperature levels in the higher latitudes of the Northern Hemisphere did not rise as fast as the models predicted.

'Hard to Deny'

But he said that if "the next 10 years are as warm or warmer, it would be very hard to deny the greenhouse effect," adding, "It is very hard to deny now."

"Chances are the greenhouse effect is not as strong as some people say, but you can't say it isn't happening at all," he said.

Both Dr. Wigley and Dr. Hansen said temperatures taken by Soviet scientists were similar to theirs.

Temperatures in the United States in this century did not rise as fast as global temperatures; several explanations are possible, including a different climate circulation over the country and pollution particles that block solar radiation. Still, measurements by the National Climatic Data Center of the National Oceanic and Atmospheric Administration show that the last few years were substantially warmer than any year since the 1950's in the United States.

Thomas Karl, research meteorologist for the center, said that 1986 and 1987 "were both unusually warm" in this country with an average of 54 degrees Fahrenheit for both years.

"Our data are not inconsistent with the greenhouse effect," Mr. Karl said, but "I am more cautious than others. I found you can get in a heap of trouble if you look at a climate time series and draw an inference. You can get swings that last for 10 or 20 years."

Gradual Rise Since 1800's

Global temperatures had already shown a gradual rise since the late 1800's. The century-long warming trend is still considered a "real mystery," although the greenhouse effect is probably part of the answer, said Alan Hecht, director of the National Climate Program, a Federal office.

Dr. Hecht noted that the earth was now in the later stages of an interglacial period, meaning the temperatures should be growing cooler as a new ice age approached.

He said the amount of carbon dioxide in the atmosphere had risen from 280 parts per million to 340 parts per million over the last century, probably because of the burning of fossil fuels and the destruction of forests whose trees use carbon dioxide.

A Lag in Temperature Rise

Given that increase of carbon dioxide, global temperatures should have increased by almost 2 degrees Fahrenheit over the century, under the assumptions of most of the models. But in fact they increased only about 1 degree, said Michael E. Schlesinger, associate professor of atmospheric sciences at Oregon State University.

One possible explanation, he said, is that "the models are more sensitive than nature." A more likely explanation, however, is a lag between the emission of greenhouse gases and the greenhouse effect because much of the extra heat is stored in the ocean rather than moving immediately into the atmosphere.

Dr. Schlesinger said testing the greenhouse models required not just taking readings of global temperatures but also plotting their geographical distribution. He said that he and colleagues were doing that now and that the results were so far mixed.

Meanwhile, human activity is sending carbon dioxide and other gases that trap radiation from the sun, including chlorofluorocarbons, methane and nitrous oxides, into the atmosphere at faster rates. If the models are correct, that means that global temperatures will rise sharply. Chlorofluorocarbons are also believed to be destroying the stratospheric ozone that shields the earth's surface from ultraviolet radiation from the sun.

Michael Oppenheimer, an atmospheric physicist with the Environmental Defense Fund, a group based in New York, said, "If the last few years are taken seriously it means the world is now warming very rapidly and, at the beginning of the next century, the climate warming will be the major environmental problem of the globe."

Rise in temperature occurs despite factors that should b cooling the earth.

THE HOLE TRUTH

Until this past year there was more than one plausible theory about what was causing the "ozone hole," a drastic, though seasonal, drop in concentrations of stratospheric ozone gas over Antarctica. One scenario had unusual weather patterns keeping the gas from reaching the South Pole; another invoked increased solar activity that gives rise to ozone-destroying molecules in the atmosphere.

Whatever the cause, the effect is worrisome. Ozone—an oxygen molecule made of three atoms rather than the usual two—absorbs most solar ultraviolet radiation, which is the cause of sunburn, many skin cancers, and possibly cataracts and immune-system weakening.

By late September it became clear that the most ominous explanation was also the most likely. Indeed, it had been all but proven correct. Although unusual atmospheric conditions were a contributing factor, it was man who was causing the ozone hole—or, more accurately, a group of man-made chemicals called chlorofluorocarbons, compounds of chlorine, fluorine, and carbon.

Although banned from spray cans in the United States in 1978, chlorofluorocarbons are still used as coolant gases in refrigerator coils, as ingredients in foam plastics used to package fast food, and as liquid cleaners in the manufacture of microchips. And almost since their invention in the 1920s these long-lived chemicals have been drifting slowly into the stratosphere, where sunlight dissociates them, releasing active chlorine compounds that can attack ozone.

The ozone hole was first described in 1985 by members of the British Antarctic Survey, who found that the ozone levels dipped lowest in September and then gradually increased over the next two months. NASA records revealed that satellites had been detecting the hole for several years, but the data had been set aside as preposterous. In 1986 investigators confirmed the earlier findings. When they returned to Antarctica in 1987, they made the most detailed measurements of the phenomenon to date. This time, though, instead of staying on the ground, they went where the action was. From the middle of August until late September, they repeatedly flew an instrument-laden DC-8 directly into the lower regions of the ozone hole, at altitudes of 35,000 to 40,000 feet. A second craft, a converted U-2 spy plane, flew directly into the hole.

"One big advantage of flying," says Crofton "Barney" Farmer, an atmospheric physicist with the Jet Propulsion Laboratory, whose team had done research from the ground the year before, "is that you're above most of the atmosphere's water vapor and other gases that obscure what's really going on." Then, too, the hole shifts position from day to day. Says Farmer, "It's far better to go where the hole is than sit on the ground and hope it will pass over."

Farmer gathered his 1986 data with an infrared spectrometer, which showed him what atmospheric chemicals were intercepting sunlight and therefore what chemicals accompanied the ozone hole. He saw a dramatic increase in chlorine compounds that closely paralleled the dip in ozone. He also saw elevations in

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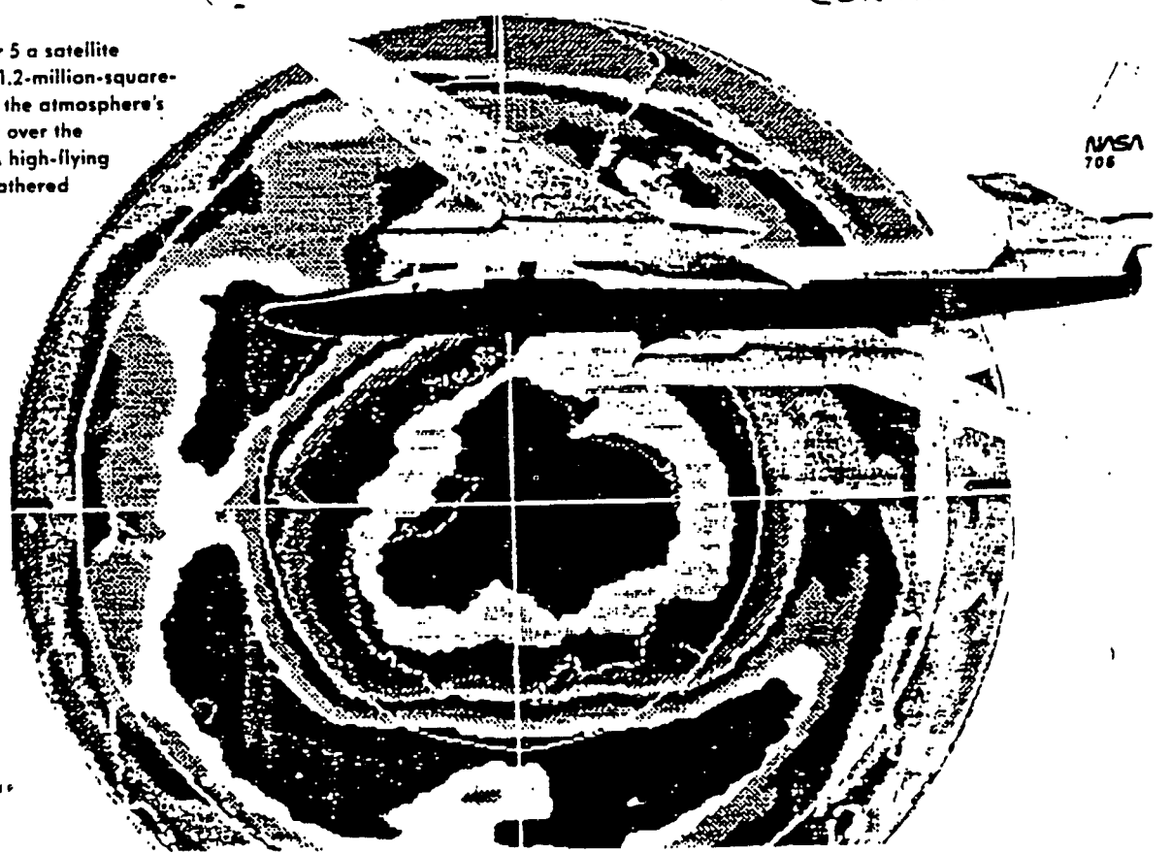


On October 5 a satellite recorded a 1.2-million-square-mile hole in the atmosphere's ozone layer over the Antarctic. A high-flying jet (inset) gathered samples confirming that the protective gas was being depleted by man-made chemicals.

Discover (cont.)

substances containing fluorine. "There are natural sources of chlorine, such as volcanoes," says Farmer, "but all the fluorine in the atmosphere is man-made." And if the fluorine came from chlorofluorocarbons, much of the chlorine almost certainly did, too.

Still, chlorofluorocarbons exist in the stratosphere at temperate and equatorial latitudes, and there are no ozone holes evident there. And worldwide ozone levels have declined over the past few decades—by between 3 and 7 percent, by most estimates—a reduction due at least in part to normal fluctuations. But that's nothing compared with the Antarctic ozone decline of up to 50 percent in a matter of weeks.

The difference, says Farmer, is because of a unique feature of the Antarctic stratosphere at the end of the polar winter: high-altitude clouds of ice particles. "The ice," he explains, "provides a surface where chemical reactions can take place. The same surface chemistry doesn't happen at lower latitudes." And, as others have learned in lab experiments, active chlorine compounds are created far more quickly on a surface than in the air. Peculiar wind patterns amplify the effect. For most of the Antarctic winter (June through September) winds rotate in a vortex around the South Pole, isolating it from the rest of the atmosphere.

The link between chlorofluorocarbons and ozone is so strong that in September the United States and 24 other signatories agreed on a measure, sponsored by the United Nations, to cut worldwide chlorofluorocarbon production 50 percent by the turn of the century. But if Antarctic atmospheric conditions are unique, should the rest of us worry?

"Absolutely," argues Farmer. "In Antarctica we've seen an example of what can happen when you put too much chlorine into the atmosphere. When chlorine gets to a certain point, it runs away, destroying ozone. And if you put enough chlorine up there, there will sooner or later be an excess. The Antarctic hole is nature's way of giving us a warning." —*Michelle Citron*

Earth Sciences

Energetic electrons: An ozone killer?

High-energy electrons riding the earth's magnetic field lines, 40,000 kilometers above the surface of the planet, have already been implicated in the malfunctions and failures of several satellites. Now, scientists from the Los Alamos (N.M.) National Laboratory propose that these electrons rain down from their high-flying orbits and possibly contribute to the loss of stratospheric ozone over Antarctica each year (SN: 5/23/87, p.326). Scientists are concerned with stratospheric ozone because it protects life on earth by absorbing harmful ultraviolet radiation from the sun.

Large populations of these electrons regularly appeared in the earth's magnetosphere every 27 days from late 1981 to 1984, a time that corresponds to a minimum in the 11-year cycle of sunspot activity. In recent years, as the solar cycle builds toward a maximum, the Los Alamos scientists have measured smaller, less periodic fluxes of these electrons, which travel at nearly the speed of light.

Most of the electrons remain trapped in the magnetosphere, but a small portion of them could precipitate out near the earth's poles and penetrate as far down into the atmosphere as 40 km above the surface, Los Alamos's Dan Baker reported at a recent meeting in Baltimore of the American Geophysical Union. These electrons would then ionize air molecules and in turn produce odd nitrogen compounds, which catalytically remove ozone from the stratosphere. In support of this theory, Baker points to a correlation between the years of greatest ozone loss and largest electron fluxes.

Researchers are unsure of the source of the accelerated electrons. In one proposed mechanism, solar winds energize electrons already present in the earth's magnetosphere. A rival theory relies on electrons that originate outside the magnetosphere and are accelerated by Jupiter's magnetic field.

Science News vol. 131
June 13, 1987

EXHIBIT #1

A Fifth Force?

It may counteract gravity

In the famous anecdote, Galileo Galilei clambered to the top of the Leaning Tower of Pisa, simultaneously dropped cannonballs of different sizes and found that they all hit the ground at the same time. He thus convinced the world—and in the years to come, Sir Isaac Newton and Albert Einstein as well—that in a vacuum all objects, regardless of mass, fall at the same speed. Galileo's work went unchallenged until last week, when Purdue University Physics Professor Ephraim Fischbach, three of his graduate students and S.H. Aronson, a physicist at Brookhaven National Laboratory in New York, reported discerning a previously unknown force that causes objects of different masses to fall at different rates.

If Fischbach is proved right, his hypothetical force, which he calls hypercharge, would be the fifth known basic force. (Four forces are known to exist: gravity; electromagnetism; the strong force, which binds the atomic nucleus; and the weak force, which is responsible for certain types of radioactivity.) Hypercharge, Fischbach reports in *Physical Review Letters*, is an extremely weak repulsive force that acts between objects no more than about 600 feet apart and varies in strength from element to element. It is strongest in iron and weakest in hydrogen. Thus, the physicists contend, if an iron ball and, say, a feather were released simultaneously in a vacuum, the iron's repulsive hypercharge would act more strongly than the feather's to counteract the earth's gravity—and the feather would hit first.

The team began looking for evidence of hypercharge after perceiving what Fischbach calls "funny results" in two contemporary experiments, one involving gravity tests in a deep mine, the other the behavior of subatomic particles. "We felt the results could be explained with an additional force," says Fischbach, "so we went back to the data published by Baron Roland von Eötvös in Hungary in 1922 to see if we could find evidence." Eötvös had indirectly measured the speeds at which objects fall and found small discrepancies, which he attributed to limitations in his equipment. Re-examining the data, the team decided that the aberrations were caused by hypercharge. But other physicists caution that more experiments are necessary before a firm conclusion can be reached. Says Harvard University's Sheldon Glashow: "The work suggests an interesting direction, but by no means should be taken as a real discovery." ■

TIME Magazine
January 20, 1986
pages 51-52

← Were these Lloyd's tests which he had sent to Purdue and to Fischbach? Lloyd's tests appear to be the only "gravity tests in a deep mine" which are on record. Dr. Fischbach has been unwilling to acknowledge Lloyd or to respond to any of Lloyd's letters.

10A St. Paul Pioneer Press Dispatch
F Saturday, Dec. 12, 1987

Gravity studies suggest a sixth force of nature

Associated Press

SAN FRANCISCO — Sensitive measurements of gravity made on and near a 2,000-foot TV tower suggest the existence of a new fundamental force that adds a tiny boost to gravity's attraction, scientists said Friday.

The finding "is very exciting because it indicates the force we call gravity is much more complicated that we thought," said Paul Boynton, a physicist and astronomer at the University of Washington in Seattle.

The four fundamental forces of nature are gravity; electromagnetism; the strong force, which holds the centers of atoms together; and the weak force, which makes some atoms break down in radioactive decay.

Studies by Boynton and others previously found evidence for a fifth force, which slightly counteracts gravity's pull over 10- to 1,000-yard distances.

Note: TV Towers are not conducive to accurate testing because they are themselves broadcasting unstable mass particles which which affect the field produced by any falling body

Galileo revisited

"We simply did what Galileo would have done if he'd had our technology," says James E. Faller of the National Bureau of Standards. Working with physicists at the Joint Institute for Laboratory Astrophysics at the University of Colorado at Boulder, he repeated, at much higher precision, Galileo's notorious (because probably apocryphal) Tower of Pisa experiment in which different objects of different mass were observed to strike the ground simultaneously when dropped from the same height.

The team used special vacuum chambers, a stabilized laser, optical interferometry, and copper and uranium masses to test whether different masses do indeed undergo the same acceleration due to gravity. The experiment confirmed this theory "with exquisite accuracy"—better than five parts in ten to the tenth power.

Popular Science Magazine
December 1987, page 12

Note: Faller's test is invalid for several reasons:

(1) He didn't drop the objects a great enough distance for the objects to have obtained a velocity high enough to produce their own fields.

(2) He chose objects with almost matching gravitational factors - uranium & copper

New Data Backs Theory of Another Force in Nature

By THOMAS H. MAUGH II, *Times Science Writer*

Precise measurements of gravity in a hole extending a mile below the Arctic icecap in Greenland have provided new support for the controversial proposal that there exist more than four fundamental forces of nature, researchers reported Monday.

Like another experiment reported last December, the new study suggests that as many as six fundamental forces could exist. While the existence of more than four forces would have few practical effects on everyday life, it could have ramifications for astronomy and theoretical physics.

The work was performed by an international team headed by Mark Zumberge of the Scripps Institution of Oceanography in San Diego and Mark Ander of the Los Alamos National Laboratory in New Mexico.

Until 2½ years ago, it was widely believed that only four fundamental forces—gravity, electromagnetism, and the strong and weak forces that hold the atom together—were necessary to explain all things in nature.

But in January, 1986, physicist Ephraim Fischbach of Purdue University claimed to have seen evidence of a fifth force that acts in opposition to gravity over distances of less than about 600 feet. Such a force would mean that in a vacuum at certain distances, a feather would fall faster than a lead weight.

While trying to confirm the existence of this so-called fifth force, a team of U.S. Air Force researchers measuring gravity along the side of a massive television tower in North Carolina found evidence of a sixth force as well. They reported last December that this sixth force enhanced the normal effect of gravity, acted over somewhat longer distances than the fifth force, and was slightly

Please see FORCES, Page 17

L.A. Times

FORCES: Precise New Measurements of Gravity

Continued from Page 3

stronger.

The new results show no evidence of the fifth force, but they do support the existence of this proposed sixth force. Ander reported at a colloquium in Los Alamos on Monday that the new force is from 1.5% to 4% as strong as gravity and that it enhances the effect of gravity over distances from 1,600 to 5,500 feet.

Their work is considered the most definitive yet and provides strong evidence that theoreticians do not yet have a firm grip on the fundamental nature of gravity.

"This field continues to grow more interesting," said physicist Paul Boynton of the University of Washington. Boynton noted that physicists are gathering in Perth, Australia, next week for a meeting that will cover the fifth force, among other physics topics. "It looks like we will have a lot to talk about," he said.

Implications for Missiles

The discovery of a fifth and a sixth force could have many scientific ramifications. The Air Force researchers, for example, were studying the effect because of small inaccuracies in the ability of inertially guided missiles to hit distant targets.

Confirmation of the new forces could also necessitate recalculating the masses of planets and stars, as well as the mass and estimated age of the universe, according to a spokesman for the National Science Foundation, which supported the research. And most important, it could provide clues to the development of what has long been the Holy Grail of physicists—a unified "theory of everything" (called a unified field theory) that would combine all the forces of nature into one mathematical formulation.

Two-Month Experiment

The new results are based on an experiment performed over a two-month period last summer at the U.S. Air Force's DYE-3 radar station about 60 miles south of the Arctic Circle. In the early 1980s, a team of U.S. geophysicists drilled a four-inch-wide, mile-deep hole to obtain ice specimens containing air from the distant past.

The principal advantage of the site for studying the effects of gravity, Ander said, is that the ice and soil around the hole are uniform with only a few large boulders or other rock formations that might affect the gravitational measurements.

The researchers carefully lowered a 300-pound, quarter-million-dollar instrument down the hole and measured the pull of gravity on the instrument at various distances from the surface. They found that the measured pull of gravity was slightly larger than what they calculated it should be.

The team did not expect the results they obtained. "We were totally surprised," Ander said in a telephone interview. "We tried like hell to make it go away, but it just wouldn't."

Not everyone agrees that the new results mean that a fifth or sixth force exists. Physicist Michael Nieto of Los Alamos, for example, argues instead that gravity is simply more complex than had previously been believed and that there may be a form of super-gravity that is only now being discovered.

Even if that is the case, however, the new results may still lead to the development of a unified field theory, Ander said.

Meanwhile, about 35 groups around the world are studying the existence of the fifth force. Most have yet to be heard from.

SCIENCE NEWS of the week

Evidence for New Force — May Be No. 6

This should be a time of respect for Sir Isaac Newton, what with the 300-year anniversary of his masterwork, the *Principia*. But part of his legacy, the theory of gravity, is certainly taking a beating.

In 1986, physicists reported on experiments that found gravity to be slightly weaker than the value predicted by Newton's theory — a discrepancy they took as a sign of a previously unnoticed fifth universal force. Now a team of Air Force physicists has detected minute *additions* to gravity, which may be manifestations of a sixth force, they reported last week at the American Geophysical Union's fall meeting in San Francisco.

"This is the first indication that there is an additional, attractive force," says Andrew Lazarewicz of the Air Force Geophysical Lab in Hanscom, Mass. "We see more gravity than there should be according to Newtonian law."

The Air Force team had originally set out to detect the controversial fifth force by making precise measurements with a gravity meter on and around a 2,000-foot television tower in Garner, N.C. Earlier experiments had suggested that this force causes objects to repel each other and that the strength of the effect depends on the composition of the material involved (SN: 1/3/87, p.6; 10/3/87, p.212). But the TV tower experiment detected an opposite, attractive force.

It isn't every day that scientists discover a new force. In fact, for the half-century before 1986, physicists confidently believed they could describe the universe in terms of four forces: electromagnetism and gravity, both of which can function over infinite distances; and the subatomic strong and weak forces, which cannot be felt outside the nucleus of an atom. The fifth and sixth forces, if they exist, differ from the others by acting over intermediate distances ranging between a few feet and hundreds of yards.

While these potential forces may become recognized additions to the four-member family of fundamental forces, many scientists believe the recent experiments are revealing a side of gravity, says Lazarewicz, who worked with Christopher Jekeli, Anestis Romaides, Roger W. Sands and group leader Donald H. Eckhardt. In this case, the new "forces" would not exist on their own but would be correction terms to the standard theory of gravity.

If so, they would be small corrections, much weaker than the main Newtonian component. As the Air Force researchers moved up the tower, they measured departures of 0.00005 percent from what Newton's theory predicted the gravity should be. Though minuscule, these discrepancies are 10 times greater than the smallest detection limits of the instruments, giving the group confidence in its results, says Romaides.

To be accurate in their calculations, the researchers had to include the gravitational attraction of the sun, the moon, the air surrounding the tower and even the water table below the earth's surface.

Other physicists were impressed by the experiment. "This is very compelling evidence that there have to be two additional terms [to gravity]," says Mark E. Ander of Los Alamos (N.M.) National Laboratory (LANL).

The Air Force results may seem to contradict the findings of previous fifth-force experiments, but theoretical physicists can explain why this new experiment detected the attractive rather than the repulsive force. "We have two effects that look incompatible but are, in fact, compatible with the only theory that we're taking seriously," says Frank Stacey of the University of Queensland in Australia.

Stacey and others believe that both attractive and repulsive forces fit neatly into new theories that have predicted two additions to standard gravity.

These theories have emerged from attempts to combine all the forces of nature into one Grand Unified Theory. In this work, theoretical physicists have always stumbled when they reached the standard theory of gravity. One of the main problems is that the gravity described by Newton and Einstein simply will not mix with quantum mechanics.

Undaunted, some theoreticians have constructed their own hypothetical force of gravity, molded to be amenable to quantum mechanics. To succeed, they have had to add new terms to the standard equations. Says theorist Mike Nieto of LANL, "It is a generic conclusion of quantum gravity that there will be new aspects to gravity, in particular that there will be a new repulsive force and a new attractive one."

To explain their results, the Air Force physicists hypothesize that the new repulsive force is stronger than its attractive counterpart at close range; but at a longer range, the attractive force can outdistance the other and dominate.

Therefore, the gravity experiments conducted deep within a mine measured the repulsive force, because the instruments were surrounded by dense matter. But these researchers made their measurements on the surface of the earth and on the TV tower. With their instruments removed from the dense earth, they could detect the longer-range, attractive force, says Romaides.

Though the Air Force observations conveniently match some of the predictions of quantum gravity theory, all involved caution that convenience does not constitute scientific proof.

Moreover, several gravity experiments in the last year have failed to measure any departures from standard gravity, and most scientists are unconvinced that there are any new forces at all.

But as more experiments turn up with positive results, scientists are beginning to take notice, says Nieto. "There have been many times in the history of physics where people have thought they've seen important things and they haven't; it was experimental error," he says. "The point is that there are so many people seeing funny things now. It sure looks interesting." — *R. Monastersky*

Solar cycle linked to weather

Atmospheric scientists have discovered a strong statistical link between the 11-year solar cycle and the weather here on earth — a finding that may eventually help explain why some winters are mild while others are unrelentingly harsh. The report was presented last week at a meeting of the American Geophysical Union in San Francisco.

Scientists have known about the solar cycle for more than a century and have long attempted to associate it with weather and a host of other phenomena. "The number of polar bears, the length of women's skirts, the stock market: Everything imaginable has been correlated with the solar cycle," says Harry van Loon of the National Center for Atmospheric Research (NCAR) in Boulder, Colo. "The field has been in ill repute."

The cycle is actually a minute variation in different properties of the sun. During the cycle maximum, ultraviolet and X-ray radiation increase, more sunspots appear on the surface of the sun and the total solar output is greatest.

Previous attempts to find a link between the cycle and the variations in weather have failed. When scientists look at the weather from one year to the next, temperature and air pressure and other aspects vary wildly, with no connection to the cycle. But Karin Labitzke, of the Free University in West Berlin, discovered in March that if she included only certain years, the stratospheric winter temperatures over the North Pole closely followed the solar cycle.

Labitzke grouped years according to a pattern of stratospheric winds over the

Tones of the Oscillating Sun

Helioseismology, the study of the sun's oscillations, promises new insights into solar structure and evolution, and possibly the general theory of relativity as well

By ALLAN CHEN

The sun is ringing like a bell, but astronomers are watching, not listening, to the tones it produces.

By studying this ringing — the oscillations of the sun—they hope to learn about the sun's interior without viewing it directly. "Helioseismologists" may be able to deduce from these oscillations how large the sun's core is, how rapidly the core rotates, how much helium and heavier elements the core contains, and whether or not Einstein's theory of general relativity will need revision. Helioseismology is analogous to seismology on earth, where seismic waves — earth's own ringing caused by earthquakes — are studied to learn more about the structure of earth's interior.

Robert Leighton and his colleagues at the California Institute of Technology in Pasadena first noticed in 1960, while they were studying features on the solar surface, that parts of the sun's surface were oscillating in and out. The period of the oscillation, one in-out cycle, was about five minutes. Over the next 15 years, others studied the disk of the sun, looking for evidence that the whole sun, and not just some of its parts, was oscillating.

The magnitude of the oscillation is so small that it is not possible to detect it visually — fluctuations in the earth's atmosphere cause the sun's image in earth-based telescopes to quiver more than the quivering of the solar oscillations themselves. The early helioseismologists were more successful at observing the oscillation by using the sun's Doppler shift. That is, they observed opposite points on the edge of the sun and measured the shifts in the wavelength of light leaving the edge. The light's wavelength shifted very slightly as the edge's velocity increased and decreased with the sun's oscillating edge. In this way, solar observers eventually demonstrated that the whole sun is vibrating with a period of five minutes.

But from there the situation gets complicated. The sun does more than expand and contract uniformly. Solar astronomers found that it has many different "modes" of oscillation, from the simple uniform expanding and contracting oscillation to much more complicated patterns of motion that make of the sun's surface an intricate pulsating weave of bulges and depressions that cannot be observed visually. In the more complex modes, certain portions of the surface expand while others contract. All of the modes are superimposed on one another.

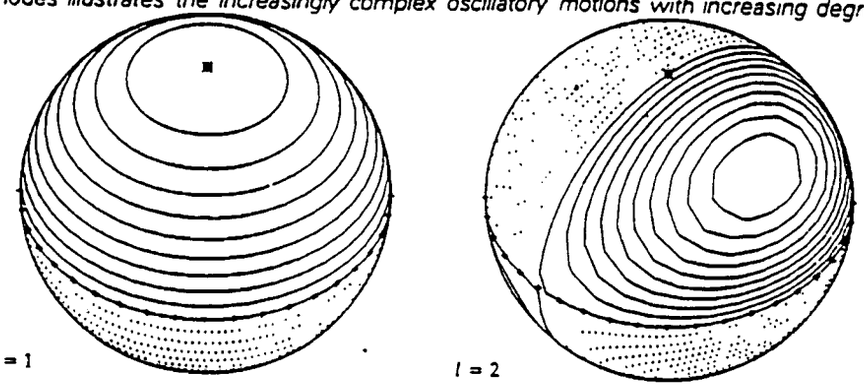
When the Doppler shift of points on the solar surface is measured over time, that measurement represents the sum of many, perhaps thousands, of different modes of oscillation as well as "noise" from local fluctuations on the sun and from within the measuring instrument. Helioseismologists have had to use complicated data processing techniques to "separate out" frequency data corresponding to each mode of oscillation. Identifying a frequency with its mode is still a problem for helioseismologists whose data are not always distinct or complete enough to make the identification possible.

Still another complication is that not all the modes have a period of five minutes. Beginning in 1966, Henry Hill of the University of Arizona at Tucson and his colleagues began to find evidence of longer-period oscillations, ranging from about 20 minutes to one hour long. By 1975 they had amassed considerable evidence that these oscillations, too, were global, not local, oscillations of the sun. And in 1976, a group working at the Crimean Astrophysical Observatory in the Soviet Union reported seeing a 160-minute oscillation. Their result was later confirmed by Phillip Scherer and John Wilcox at the Institute for Plasma Research in Stanford, Calif., and by a French-American team using an observing station at the South Pole to watch the sun continually over several-day periods during the polar summer. Not everyone is convinced that the observations of Hill and the Crimean group truly represent global oscillations, and the significance of these data is still being debated (SN: 4/22/78, p. 253; 4/21/79, p. 270; 8/16/80, p. 100).

No one knows why the sun oscillates. But a step was taken toward explaining how it does in 1970 when Roger Ulrich of the University of California at Los Angeles suggested that the five-minute oscillations were like sound waves in the solar gases, only more complex. In the sun, the sound waves originate in the hot gases of the sun's convection zone, a zone where heat is transferred by the movement of the gas itself, rather than by radiation. A single oscillatory mode can be "broken down" into a set of sound waves of many different frequencies. Helioseismologists characterize each member of this set by using several parameters. One parameter, the "degree," is important because it relates in a rough way a sound wave in the set to its depth range in the sun's convection zone. Different degree waves have different depth ranges. The higher the degree of the wave, the deeper the wave ranges into the sun's core, although degree alone does not determine the wave's depth range. This is important to helioseismologists who would like to observe higher-degree modes so that they can "see" farther into the core.

According to Ulrich's theory, oscilla-

Contour plots of selected modes of oscillation of the sun. The solid lines represent zones modes illustrates the increasingly complex oscillatory motions with increasing degree.



Allan Chen is a former Science News intern.

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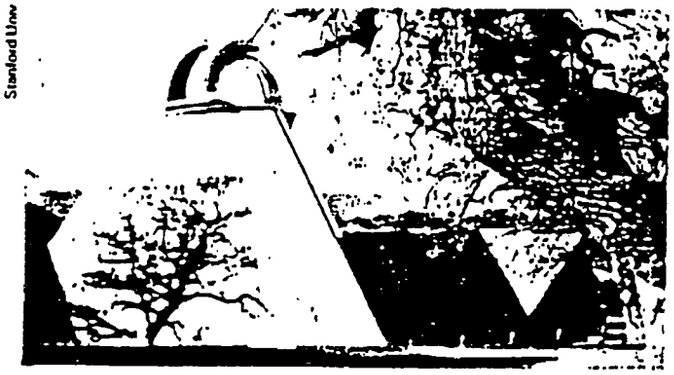


Stanford Univ

The Stanford Solar Observatory in the Santa Cruz Mountains just west of Stanford University. Observations of solar oscillations were begun here in 1975. Other teams have searched the sun from the Crimean Peninsula, the South Pole, the Canary Islands and Hawaii.

tions of a "given" or "certain" degree will stay within certain depth limits of the convection zone. They are free to propagate within the spherical shell marked by these limits. The waves will bounce off the upper limit of the shell because the density of the convecting gases is not high enough to allow the waves to go any closer to the surface. At the lower limit, the increasing density of the gas will cause the waves to refract back toward the surface, according to the theory.

Ulrich's ideas explain all of the modes of oscillation with fairly short periods, including the five-minute modes, as acoustic waves in the convection zone. Since the energy in the waves is transferred by the back and forth motion of heated gases (just as sound is transmitted on earth), the modes with short periods of less than 30 minutes are called p-modes or pressure modes. One of helioseismology's early successes was in helping to establish the lower boundary of the sun's convection zone. Helioseismologists now believe that the zone begins at a depth of about one-third of the sun's radius from its surface, a higher figure than what was gleaned by other methods. The lower boundary of convection has not yet been fixed.

No one has been able to explain what drives the p-modes to oscillate at all. Scherrer says that one possibility is that the convection zone is "randomly exciting itself" through irregularities of its own motion.

Jorgen Christenson-Dalsgaard, currently at the National Center for Atmospheric Research in Boulder, Colo., argues that the sun's p-modes are analogous to "blowing through a flute. The [turbulent convection of the air] at the mouth of the flute excites sounds in the tube. Similarly, the turbulent convection of the sun may excite p-mode oscillations." The cavity of the flute generates tones with many different frequencies, just as the cavity of the sun excites different modes. In the flute, the fundamental tone has a wavelength equal to the length of the flute's cavity. Higher tones have wavelengths of one-half, one-quarter, one-eighth the cavity's length, and so on. Analogously in the sun, convection may excite a wave to form whose wavelength equals the length of the shell, or two waves whose length is one-half the shell, and so on. The fundamental wave plus all of the overtones together form the family of waves that make up one mode of oscillation.

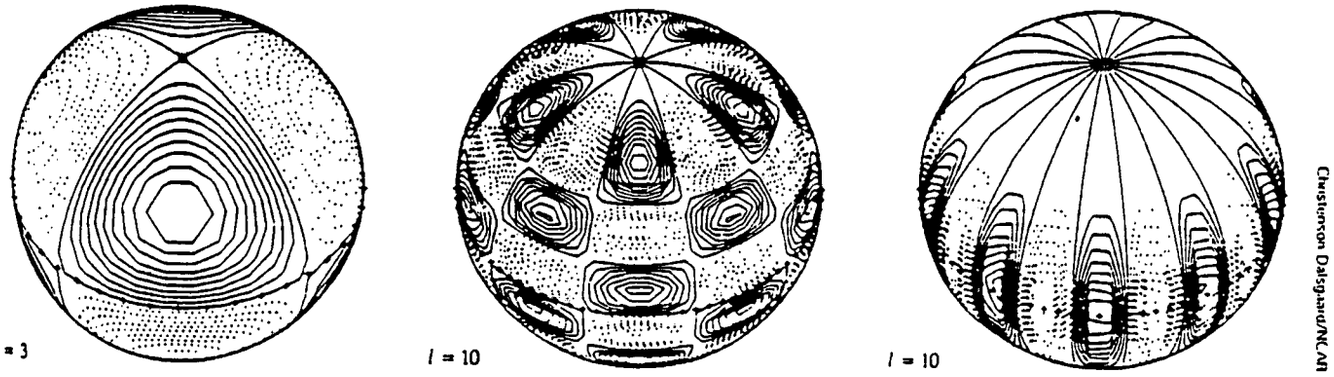
A second type of solar oscillation is the gravitational or g-mode, with periods of more than 30 minutes. Here, the force that maintains the oscillation is the force of gravity itself. Closer to the sun's center, the density of its hot gases increases. When higher-density gas moves up into the lower-density region, a restoring force called "buoyancy" tends to pull the high-density gas back in. The result is an oscillation of the gases within the sun's core maintained by the differential pull of gases of different densities upon each other.

According to Thomas Duvall of the Laboratory for Astronomy and Solar Physics of the Goddard Space Flight Center in Greenbelt, Md., "G-modes are more concentrated at the core...[they] don't propagate in the convection zone." However, because they can't get through the convection zone from the core, they should be difficult to observe. Nonetheless, some helioseismologists, including Scherrer at Stanford and Hill at Tucson, believe that the longer-period oscillations are g-modes. Duvall says, "There's a certain range of frequencies above which g-modes won't exist. The shortest-period g-modes should be around 30 minutes." Scherrer believes that g-modes can be observed because the motions of the sun's core could lift the whole convection zone up and down, and this motion would be visible at the surface. There is still no general agreement that g-modes have ever been observed.

With information about the sun's oscillatory modes, solar physicists can mathematically infer the solar core's size, rate of rotation and composition. But to effectively use the modes, helioseismologists say they need more observations of them, as well as observations of the weaker, higher order modes that they have not yet identified. The problem is that solar observers cannot observe the sun continuously at one station for longer than the length of the day. Scherrer explains, "What you need is to observe [the sun] for several [of its] rotational periods continuously for two to three months without gaps.... In theory, by combining observations at two stations, you can get 24-hour coverage." In practice, instruments at two stations cannot yet be calibrated accurately enough to work in tandem, he says. "Right now, what the modes are is the main question...until observations can be replicated, we can't do any more physics."

Continued on page 395

ansion, the dotted lines, contraction. Only five of thousands of possible modes are shown. l is the degree of the mode. This selection of



l = 3 *l* = 10 *l* = 10

Christenson Dalsgaard/NCAR

...ntinued from page 393

Recent work by Duvall, and J.W. Harvey at Kitt Peak National Observatory in Tucson, Ariz., and by Duvall, Harvey and Martin Pomerantz of the Bartol Research Foundation in Newark, Del., at the South Pole, may provide some of these observations. Reporting on their preliminary results in the March 3 NATURE, Duvall and Harvey say they have observed p-mode oscillations for the first time from degrees 6 to 140. The higher the degree of the oscillation, the deeper within the sun the oscillation penetrates, and the more information about the sun's interior it brings.

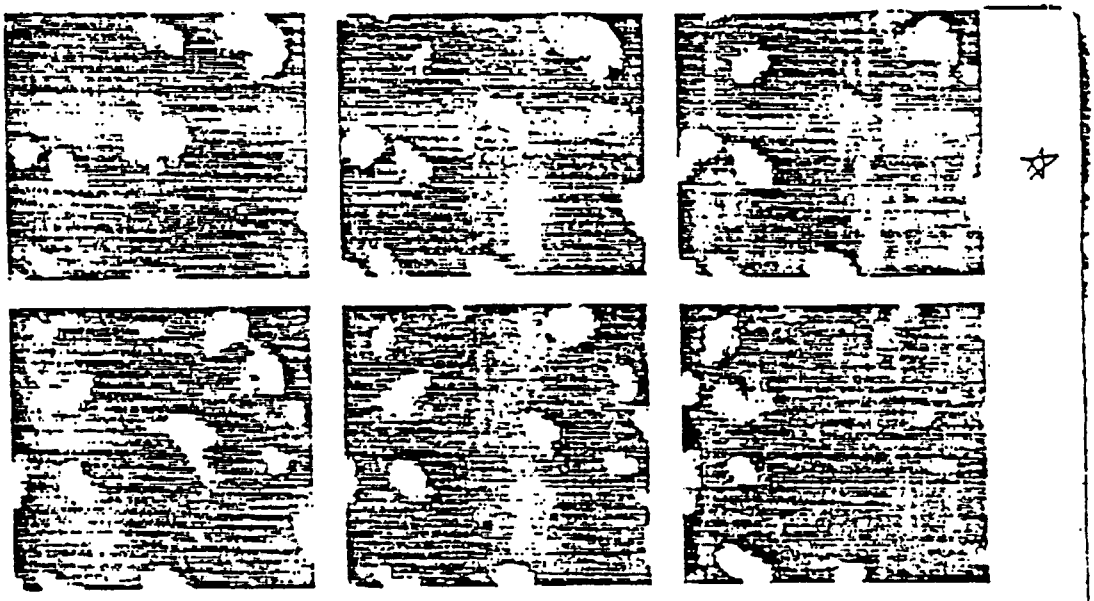
One question on which these data may shed light is the abundance of helium and heavy elements in the sun's core. How the sun burns hydrogen to form helium and heavier elements is poorly understood. There exists a model of the process that depends on knowing the hydrogen, helium and heavy element content. But this model is in doubt because other solar physicists, using a different approach to studying the sun's interior, have not been able to detect a sufficient number of neutrinos, massless elementary particles, that should be produced by the sun's burning core (SN: 6/30/79, p. 420; 2/17/79, p. 103). To explain the lower neutrino count, the theorists may have to assume there is less helium in the sun than supposed by the model. However, Christenson-Dalsgaard believes that Duvall and Harvey's data support the current model's higher helium abundance, in opposition to the neutrino evidence. Further study of the solar modes may help resolve this contradiction.

The solar oscillation data may also solve the riddle of the sun's rotating core, and whether or not Einstein's theory of general relativity will need revision if the core is found to be rapidly rotating. Physicists first suggested in the 1960s that the theory, which concerns the nature of gravity, might need to be revised. Robert F. Dicke of Princeton University and his colleague Carl Brans developed an alternate theory of gravity. They argued that the orbit of Mercury would be affected in a slight but measurable way, if the sun's core were rotating more rapidly than had been assumed when Einstein developed his theory. The core's rapid spinning should cause the sun to flatten out slightly, and the flattening's gravitational influence on Mercury's orbit could be measured. The magnitude of the gravitational effect should be different from what Einstein's theory predicted.

Since 1966, Hill and his colleagues have been trying to determine if a modification of general relativity is necessary by studying the sun's flattening and its oscillations. Hill's team recently published data concerning the long-period oscillations (20 minutes to one hour) in the January SOLAR PHYSICS and the Dec. 13 PHYSICS REVIEW LETTERS that Hill feels call general relativity into question. "These are gravity modes with periods that are large. This is information about the deep core," he says. The team has calculated that the sun's core rotates very rapidly, about once every four days. (The sun's surface rotation varies with position on the surface. It ranges from 27 to 35 days per rotation.)

Dicke, meanwhile, began to change his views around 1973. He now argues that the five-minute oscillations (not the longer-period oscillations of Hill) indicate the sun is rotating only about once every 12.5 days. Still other theorists have also come out with different interpretations of the data. Everyone working in the field contacted by SCIENCE NEWS agreed that no one agrees on how fast the sun's core is rotating. Dicke says, "Anything as fundamental as a [modification of relativity] requires a more strongly based set of measurements than what we have available."

Hill, by contrast, is optimistic that the available and soon-to-be-available data will lead to new developments in the field. He likens the state of helioseismology today to spectroscopy (the branch of physics that probes matter by observing the electromagnetic radiation it absorbs or gives off) in the 1940s. Spectroscopists then had "hundreds of [observations] and 10 models, but only one of those models will fit. This decade is going to be a really exciting one because we have a lot of observational data. The important thing is not whose model is correct, but that we are on the threshold of a new understanding about the sun." □



Many solar granules expand rapidly outward at the end of their lives, as can be seen in this sequence with frames at two-minute intervals. Each field is 8 arc seconds across. These images are from a long sequence obtained by Spacelab 2's Solar Optical Universal Polarimeter and are courtesy Alan Title.

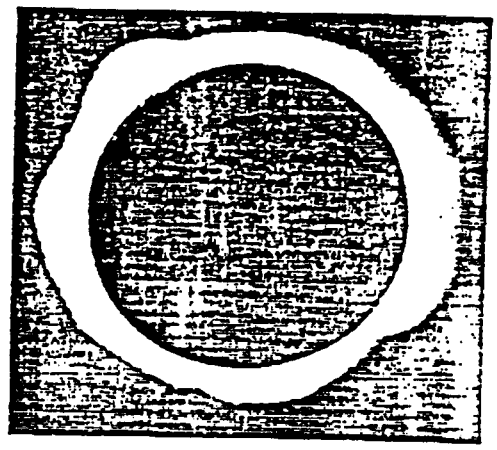
sun. For example, the larger scale turbulence in the convection zone pushes much of the magnetic field at and just above the photosphere to the edges of the supergranulation cells. Radiation from the layer just above the photosphere, called the chromosphere, clearly shows the pattern. Within the supergranule boundaries, jets of material shoot into the chromosphere to an altitude of 4000 km (about 2500 mi) in 10 minutes. These so-called spicules are caused by the combination of turbulence and magnetic fields at the edges of the supergranule cells.

Near the sunspots, however, the chromospheric radiation is more uniform. These sites are called active regions, and the surrounding areas, which have smoothly distributed chromospheric emission, are called plages, after the French word for "beach." Active regions are the location of solar flares, explosions caused by the very rapid release of energy stored in the magnetic field (although the exact mechanism is not known). Among the phenomena that accompany flares are rearrangements of the magnetic field, intense X-radiation, radio waves, and the ejection of very energetic particles that sometimes reach the earth, disrupting radio communications and causing auroral displays (*see* AURORA).

The corona. The outer solar atmosphere, which extends for several solar radii from the disk of the sun, is the corona. All the structural details in the corona are due to the magnetic field. Most of the corona consists of great arches of hot gas: smaller arches within active regions and larger arches between active regions. The arched and sometimes looplike shapes are caused by the magnetic field.

In the 1940s the corona was discovered to be much hotter than the photosphere. The photosphere, or visible surface, of the sun has a temperature of almost 6000 K (10,800° F). The chromosphere, which extends for several thousand kilometers above the photosphere, has a temperature near 30,000 K (about 54,000° F). But the corona, which extends from just above the chromosphere far out into interplanetary space, has a temperature of over 1,000,000 K (1,800,000° F). In order to maintain this temperature, a direct input of energy to the corona is necessary.

Finding the mechanism by which this energy reaches the corona is one of the classic problems of astrophysics. It is still unsolved, although many mechanisms have been proposed. Because recent observations from space have shown the corona to be a collection of magnetic loops, how these loops are heated has become a major focus of astrophysical research.



A total solar eclipse. UPI

The magnetic field can also trap cooler material above the sun's surface, although the cooler material cannot remain stable there for more than a few days. These phenomena can be seen during an eclipse as small regions, which are called prominences, at the very edge of the sun, like jewels in a crown. Frequently they subside, but occasionally they erupt, blowing solar material into space.

Solar wind. Within one or two solar radii from the surface of the sun, the coronal magnetic field is strong enough to trap the hot, gaseous coronal material in large loops. Farther away from the sun the magnetic field is weaker, and the coronal gas can literally push the magnetic field out into space. When this happens, material flows along the magnetic field for great distances in the solar system. The constant flow of material pushing out from the corona is called the solar wind, and it tends to come from regions called coronal holes. The gas there is cooler and less dense than the rest of the corona, resulting in less radiation. The solar wind from large coronal holes (which can last for several months) is unusually strong. Because of the solar rotation, these regions of strong solar wind, called high-speed solar wind streams, tend to recur every 27 days as seen from the earth. The solar wind causes disturbances that can be detected in the earth's magnetic field.

Solar Evolution. The sun's past and future have been inferred from theoretical models of stellar structure. During its first 50 million years, the sun contracted to approximately its present size. Gravitational energy released by the collapsing gas heated the interior, and when the core was hot enough, the contraction ceased and the nuclear burning of hydrogen into helium began

experiments using human blood are under way. He says unpublished work by the Philadelphia group also suggests that a rent phospholipid from another cellular structure works in the same way. Studying ethanol's effects at the membrane level should increase the understanding of alcoholism in general, as well as suggest new approaches to treatment. Last month, a report from the National Institute of Mental Health described a new drug that may prove useful in stopping the intoxicating effects of alcohol by affecting the movement of chloride across membranes (SN: 12/6/86, p.358).
– D.D. Edwards

A more complex solar cycle

The sun is astrophysicists' exemplary star. It is the only one they can study at close range, and what they know of its behavior they extrapolate to other stars. The sun's activity also determines many things that happen on earth, from atmospheric physics and geophysics through paleontology to ecology. Solar physicists used to believe that the sun's physical activities varied over a cycle that takes approximately 11 years. Now it ms that the solar cycle is not so simple scientists had believed.

According to results reported at last week's meeting in Pasadena, Calif., of the American Astronomical Society, the 11-year sunspot cycle seems rather to be part of a larger 19- or 22-year cycle that involves other aspects of the sun's behavior. Furthermore, the beginning of each new cycle overlaps the last phases of the previous one.

It is this overlapping feature, particularly, that will make serious problems for solar theorists as they try to explain the sun's behavior, according to the three astronomers involved in the observations now reported. Those astronomers are Herschel B. Snodgrass of Lewis and Clark College in Portland, Ore., Richard C. Altrock of the National Solar Observatory in Sunspot, N.M., and Peter Wilson of Caltech in Pasadena and the University of Sydney in Australia.

The classic sunspot cycle begins with the appearance of spots in the middle latitudes of the sun. Individual sunspots last only a short while, but as the cycle continues, the range of latitudes where new spots appear gradually narrows and at the same time approaches closer to the ator. When the latitudes at which new ts appear are graphed over time as the cycle proceeds, the graph shows a "butterfly pattern," that is, the appearance of a butterfly's wings, starting out fairly broad and away from the equator and narrowing and moving closer to the equator as time goes on.

The new evidence has been found from studies of small variations in the sun's rotation, along with other evidence from changes in the brightness of the solar corona and yet other evidence from variations in the magnetic polarity of sunspots. These data indicate that this sunspot cycle is part of a larger one that takes between 19 and 22 years to run and begins not in the middle latitudes but near the poles. Thus every 11 years or so, a new cycle begins near the poles, while the previous one still has 11 years to run near the equator.

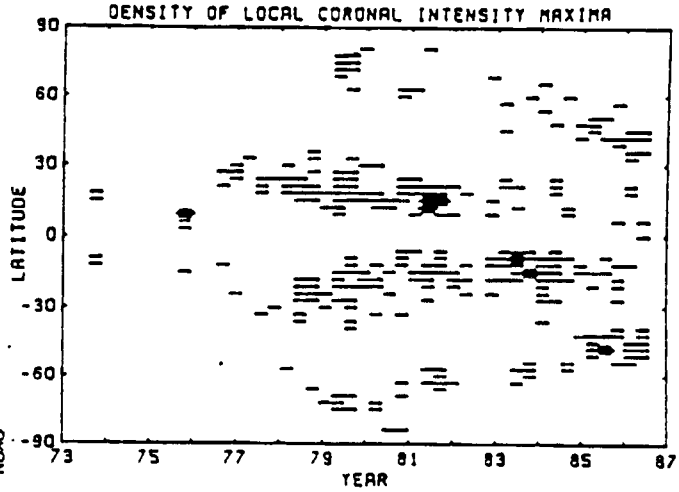
The sun's surface does not rotate rigidly, uniformly at the same speed; latitudes nearer the equator rotate faster than the polar ones. However, observations a few years ago showed that, contrary to expectations, the rotation rate does not increase smoothly from poles to equator. Instead, there is a small wiggle superimposed on the smooth change, so that alternately a slice of the surface will be going slightly faster and the slice next to it slightly slower than they might if the change in rotation speed were smooth.

Work done by Snodgrass at the Mt. Wilson Observatory in Pasadena shows that these zonal variations in rotation speed are cyclic. The zones appear near the poles and gradually migrate toward the equator on a cycle that is at least 18 or 19 years and may be 22. (The numbers are not sharply established: in any case, the sun's variations have never been very precisely timed. The classic sunspot cycle of 11 years has to be qualified with the words "more or less.")

Between the zones of fast and slow rotation is a great deal of torsional shear, producing an effect that some scientists describe as analogous to winds in the atmosphere of the sun. The material that undergoes the shear is an electrically conducting fluid, an ionized gas, and so it drags the sun's magnetic field, concentrating it in the zones where the torsion is greatest. As these torsional zones drift down to the middle latitudes, they begin to produce sunspots, which are magnetic phenomena. The spots are dark because they are cooler than their surroundings, and they are cooler because they represent local concentrations of magnetic field.

The magnetic polarity of the spots also varies cyclically. Spots come in pairs, and if the leader of a pair (as they are carried along with the sun's rotation) has a magnetic field polarized one way, the trailer's field will have the opposite polarity. Wilson reports that to come back to a given polarity relation between the leaders and trailers takes two 11-year cycles, providing further evidence for an overall 22-year cycle.

Finally, the cycle appears in variations in the brightness of the corona, the sun's hot, tenuous outer atmosphere, as Altrock reports. He used the classic technique of studying coronal variations, observing the green radiation from iron that has been ionized 14 times (that is, iron that has lost 14 electrons). He found that these variations, too, come in a cycle of 22 years that begins near the poles and drifts toward the equator.



Horizontal bars indicate solar latitudes having numerous coronal active regions. One cycle starts at ±30° latitude in 1977 and approaches the sun's equator. The newly discovered, overlapping solar cycle begins in 1979 at ±70° to 80° latitude and proceeds toward ±40° latitude.

As Wilson expresses it, the zones of variation in the rotation rate, which seem to drive the other phenomena in the cycle, seem to be caused by convective rolls in the sun's convection zone. Below the sun's outermost surface layers is the convection zone, where heat generated deep in the interior rises to the surface by convection. The matter carrying the heat rises to the surface, cools and then rolls over and descends to be heated again. These rolls maintain their shape in the manner of hair that has been rolled on curlers.

Under this hypothesis, the convective rolls would first appear near the poles and drift toward the equator. The zones where rotation speed differs would be the surface manifestations of the convection rolls, but why the rolls should migrate from poles to equator, the present observers cannot say. They opine that theorists will have a complicated time trying to explain these findings. *– D.E. Thomsen*

News of the week continued on p. 46

New Phase in a Star's Life

Recent findings may solve the puzzle of the missing solar neutrinos.

During its youth, our sun may have passed through a brief and highly tempestuous period—whirling on its axis more than 100 times faster than it does today. This previously unknown stage of stellar evolution, announced at a recent meeting of the American Astronomical Society in Baltimore, may help solve one of the greatest mysteries of astronomy: Why aren't tiny particles called neutrinos streaming from the sun in vast numbers, as current theories predict they should be?

A star is born from a contracting cloud of gas and dust that whirls faster and faster. Its spin originates because of gravitational contraction and what astronomers call the "conservation of angular momentum." Just as a skater spins faster by folding his arms, a contracting star gains rotational speed as its diameter shrinks. Then, when its thermonuclear fires ignite, its spin gradually slows.

There has been a huge gap, however, in astronomers' knowledge of the spin of sunlike stars. They knew that one-million-year-old infants (not yet true stars) rotate every two to three days, and our 4.6-billion-year-old sun every 27 days. But they knew next to nothing about the rotation of stars between these ages and assumed there was a constant, gradual slowdown.

That's why a team of astronomers, observing with the 200-inch telescope at Mount Palomar, focused their attention on stars in the Pleiades cluster, also known as the Seven Sisters. Hundreds of these stars are thought to be similar to our sun when it was roughly 70 million years of age. Logically, they thought, the Pleiades stars, which are between the ages of one million and 4.6 billion years, should fall between the 2- and 27-day rotation rate. "We expected that we would find them spinning at a rate of about once a week," says Douglas Duncan, staff astronomer at the Mount Wilson Observatory. "Instead, we found a star spinning in six *hours*." He is referring to observations made by his team and by another led by astronomer John Stauffer of Harvard.

Therefore, it seems, young stars keep spinning faster and faster for longer periods than had been thought. But what makes them finally begin to slow down? The answer involves the interaction of several factors. Along with their surprising speeds, the Pleiades stars are ejecting a stream of charged particles known as stellar wind at the rate of about a trillion tons each second. The wind is apparently released by intense magnetic activity caused by the stars' churning interior, which acts like an electric generator. The greater the spin, the stronger the magnetic activity and the stellar wind.

Were this tremendous outpouring of mass from these prodigal suns not eventually slowed, the stars would disappear entirely within less than 100 million years. Instead, the charged stellar wind, held in the grip of the star's magnetic field lines, brakes the star's rotation, again through the conservation of angular momentum. The particles of the wind have the same effect as the extended arms of a skater slowing down.

The astronomers calculate that, within a mere 10 million years, a rapidly spinning star will have slowed to a respectable rotation period of about a week, its wild youth only a memory. In the meantime, however, it will have thrown off a lot of material. "The star will have lost approximately five to ten percent of its total mass," observes Duncan.

If our sun underwent a similar period of activity, some theories concerning planet formation would require revision. The planets formed out of the same cloud the sun did. But according to astronomers' calculations, the planets should be more massive than they are. "The strong stellar wind, traveling at two hundred fifty miles per second, may well have blown away most of the raw material of gas and dust that the planets formed out of," suggests Geoffrey Marcy, a Carnegie Fellow at Mount Wilson.

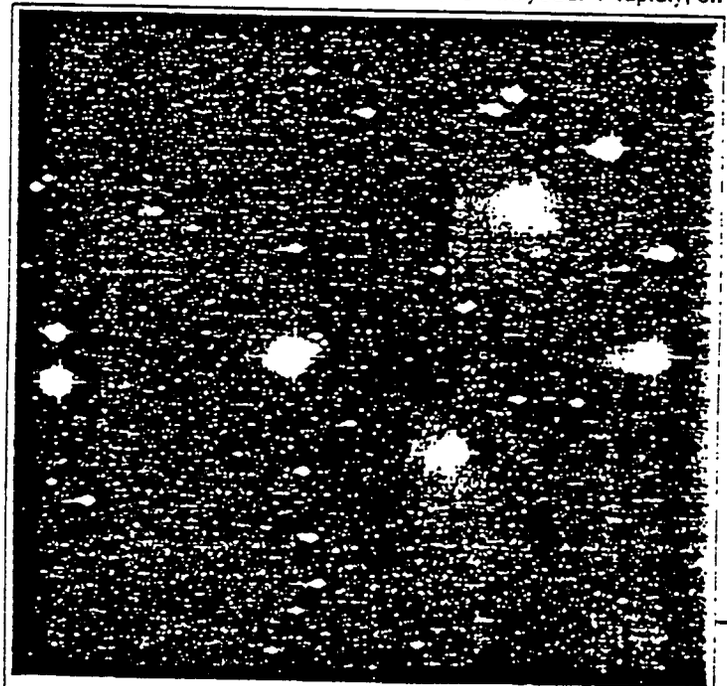
Sun's Spin Debated

Even our understanding of the present-day sun may change and allow us to account for the lack of neutrinos. Although the rotation rate of the sun's surface is well known, some astronomers debate how fast the core may be rotating. If it is spinning slowly, there is little centrifugal force to counteract the force of gravity; thus the upper layers of the sun would crunch the core, increasing its density. If it is spinning rapidly, on the other hand, the strong centrifugal force would hold up the outer layers, and the core's density would be greatly reduced.

Maybe, Marcy speculates, the core never slowed down from its rapid spin during infancy. "The outer layers would have slowed because they lost angular momentum, but the inner part was insulated," he explains. "And it may *still* be spinning much faster."

With a lower density at the sun's core, it would follow that fewer nuclear reactions would take place there. And this low reaction rate, in turn, would mean that fewer neutrinos were produced. Perhaps astronomers haven't been able to detect multitudes of solar neutrinos simply because there aren't that many. ■

–Randall Black



Pleiades cluster stars have glowing nebulas and an odd spin rate.

Triumph of the WIMP

The sun's missing neutrinos spark a heated debate among theorists.

If WIMPs inhabit the sun's center, they may carry heat away from the inner core and thereby limit the number of neutrinos created—which would agree with observations.

ILLUSTRATION BY DAN MCCOY

Like all stars, the sun draws its energy from fusion. The theory explaining fusion is precise, complex and so widely accepted that astrophysicists call it simply the standard theory. The theory's only direct test, however, produces results that have stubbornly refused to agree with predicted findings. But now astrophysicists think that a hypothetical particle borrowed from cosmologists may be able to resolve the disagreement.

The standard theory holds that in the incredible heat and density at the sun's core, hydrogen nuclei collide, fuse and, after further reactions, become the nuclei of helium. This process produces photons, particles of light that we see as sunshine, and neutrinos, particles so unsociable they may zip through millions of miles of lead before they collide with anything. Photons in the sun must undergo a time-consuming process of conversion and diffusion as they make their way to the sun's surface. Therefore, although once reaching the surface they travel at the speed of light, they won't reach Earth until several million years after their creation. The non-colliding neutrinos take only eight minutes. So the only direct way to check the standard theory of the sun's energy sources is to count neutrinos.

Retired chemist Ray Davis of Brookhaven National Laboratory, currently working at the University of Pennsylvania, counts two solar neutrino units (SNUs; pronounced "snooze"), a measure of the number of neutrinos. Yet theorist John Bahcall of the Institute for Advanced Studies in Princeton has predicted that the count should in fact be seven SNUs.

Both theory and experiment have been verified and reverified, and for 17 years the disagreement between them has sparked a lusty dispute.

But perhaps no longer. Most neutrinos are produced by hydrogen fusing into helium. The neutrinos detected by Davis, however, are rare creatures, produced only when boron nuclei decay—an event that happens only in the innermost core of the sun and at the highest temperature. In fact, an infinitesimal drop in temperature means a huge drop in Davis's SNUs. John Faulkner, of the University of California, Santa Cruz, and Ronald Gilliland, of the National Center for Atmospheric Research, suggest that the addition of new particles to the core could lower its temperature enough to affect Davis's SNUs.

To do the job, Faulkner and Gilliland proposed a weakly interacting massive particle, or WIMP, with specific characteristics. First, it must be heavy enough to sink to the inner core. There it would collide with a hot proton, leaving the proton slightly cooler and the particle slightly hotter. Then the particle would head to the cooler outer core, where it would collide with a second, cooler proton, leaving that proton hotter and the particle cooler. Thus, without changing the net temperature of the entire core, the particles could take heat from the inner core and move it to the outer core. In effect, say Faulkner and Gilliland, the right number of WIMPs with the right mass and the right likelihood of hitting a proton would cool the inner core just enough to produce the number of neutrinos Davis sees.

"We didn't publish the idea," says Gilliland. "We didn't know what those particles might be." But William Press and David Spergel, at the Harvard-Smithsonian Center for Astrophysics, unaware of Faulkner and Gilliland's work, reinvented it (although they prefer to call their particles "cosmions").

Cosmologists use WIMPs to solve their problem of missing mass: They do not know what may constitute 90 percent of the universe, but they suspect, for various reasons, that the missing matter is WIMPs. In our part of the universe, WIMPs should orbit our galaxy in an enormous halo.

Press and Spergel proposed that an occasional WIMP might stray too near the sun and be captured. Once snared, WIMPs would have the proper mass and likelihood of hitting a proton to cool the sun's inner core just enough to produce the observed number of SNUs. Given that mass and likelihood of collision, and the number of WIMPs in the galaxy's halo, Press and Spergel calculated how many WIMPs the sun was likely to capture.

They found that the number of WIMPs that would cool the sun's inner core and the number of WIMPs the sun was likely to capture were the same. "Those numbers have no reason to be related," says Press. "It's either a remarkable coincidence, or this model has something to it."

But WIMPs are not home free. WIMP detectors are now being invented, but no one has yet seen a WIMP—they exist only in theory. They ought to exist in equal numbers with anti-WIMPs. Concentrated in the sun's core, they would collide, annihilate each other and be long gone. But perhaps, Spergel notes, nature, as it did with protons, created more WIMPs than anti-WIMPs, and mutual annihilation has resulted in leftover WIMPs.

"WIMPs solve two fundamental and exasperating problems," says Bahcall. "This is such a beautiful idea that if it isn't right, God missed a great opportunity." ■

-A. K. Finkbeiner

The Sounds of the Sun

Acoustic waves are revealing secrets of its internal structure.

BY MICHAEL D. LEMONICK

You've probably never looked inside a science library. Try it sometime: You'll find dozens of journals containing hundreds of articles, most concerned with terribly abstract topics.

It's something only a scientist (or science writer) could love. Yet the very existence of such articles points to an impressive but rarely noted fact: Human beings can talk in detail about things we cannot now and will never see directly—the inside of an atom, or the state of the universe a second after the Big Bang.

The reason we can, of course, is that we have tools—physical ones, which extend the reach of our limited senses, and intellectual ones, which let us infer general principles from what we see (and apply those principles to real-world problems).

The time between inference and application can be short, but there are old discoveries that still bear useful fruit. One fascinating example, explained in detail in the September 1985 *Scientific American*, is the recent emergence of a new discipline called helioseismology—the study of sound waves in the sun—which traces its lineage back to Isaac Newton's seventeenth-century experiments with light. Scientists engaged in such study are probing the inside of our local star, adding another part of the invisible realm to our repertoire of knowledge.

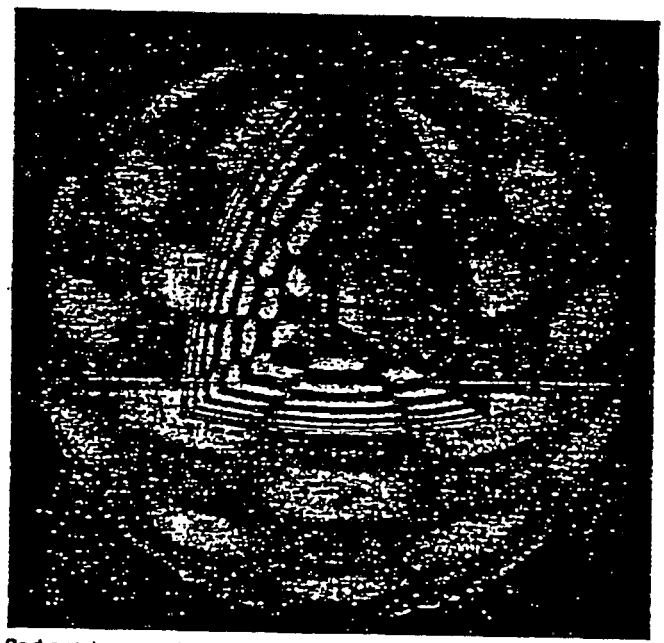
Newton found that a prism spreads sunbeams into rainbows of light, red at one edge and blue-violet at the other. A little over a century later, Joseph von Fraunhofer showed that the rainbows, or spectra, are not simply smooth smears of color but are interrupted by dark lines. And in 1859, Gustav Kirchhoff proved that each chemical element and compound, when heated, emits its own spectrum.

Putting these discoveries together, scientists realized that the dark lines in the solar spectrum come from elements in the sun. The implications were enormous. For one thing, it became possible to analyze the sun's composition. As spectrometers became more sensitive, astronomers could even analyze other stars.

Spectral lines had another major role to play as well. Light is a wavelike phenomenon, and, like any wave, it shifts in frequency when its source moves toward or away from the observer. (Sound does the same thing. An approaching ambulance siren sounds higher in pitch than it really is; as it passes by, the pitch drops. That's because waves from an approaching source are compressed, so more waves enter the ear per second. The frequency is higher, and so is the pitch.)

An approaching light source—a star, for example—also seems higher in frequency, and therefore bluer, than it really is. A receding light source looks redder. The way to tell if a star is approaching, then, is to look for the spectral lines of a familiar element, such as hydrogen, and measure how much and in what direction they're shifted.

Helioseismology is based on this principle. In the 1960s, scientists began training new, powerful spectrometers on small regions of the sun in an attempt to quantify the movements of its seething surface. They expected random motion, and so they were surprised to find that the surface bulges and puckers with a discernible rhythm.



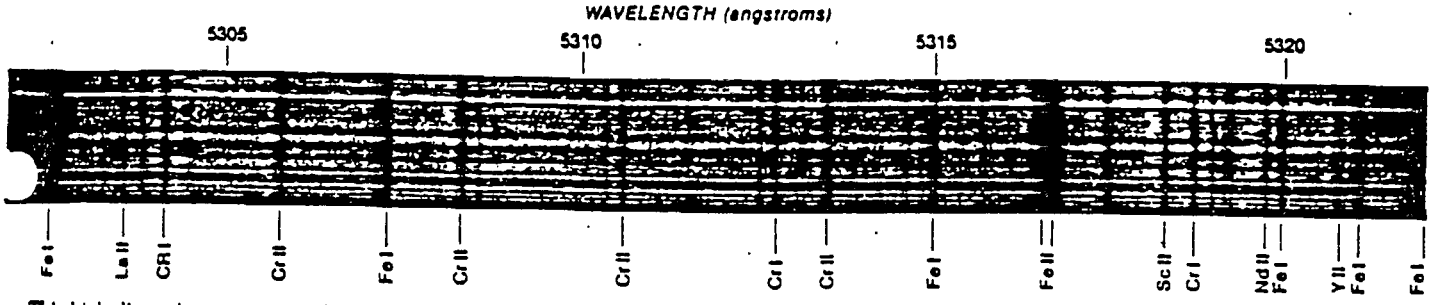
Red patches are depressions in the sun's surface, green areas are bulges. In this computer model of solar vibrations.

They modeled the patterns of these temporary hills and valleys on computers, and what they saw led to a remarkable conclusion. The sun rings like a bell, resonating to sound waves generated deep in its interior. (To a physicist, a sound wave is simply a wave of pressure that moves through any medium. There are sound waves inside the Earth, too; geologists read them to determine the precise position of earthquakes.) And like a bell, the sun rings at many frequencies at once; however, there are several million superimposed resonances in the sun. Some are very low frequency, with just a few large bulges; others have hundreds of small bumps and dimples.

The patterns of oscillation are a direct result of the sun's structure and dynamics at great depth, so understanding how the sun resonates may turn out to be a powerful bit of information. To start with, it could finally solve a major mystery of modern astrophysics: the solar neutrino problem. The sun's core has to burn at a certain temperature, scientists think, in order to create enough pressure to hold up the weight of the outer layers. But at that temperature, the burning should produce vast numbers of massless particles, called neutrinos, as a by-product. And we detect only a third of the expected number.

Clearly, our knowledge is incomplete. Perhaps neutrinos *do* have a small mass, which would cut down on the number reaching Earth-based detectors. Perhaps the sun's core is rotating faster than we think. If so, centrifugal force could hold up the outer layers. Or maybe the mix of fuels is different from what we believe; then the core could be cooler but still strong enough to support the sun's weight. These are guesses; with the supersensitive, space-borne spectrometers helioseismologists are lobbying for, we may finally speak with certainty. ■

Senior editor Michael D. Lemonick writes frequently about astronomy and related topics and welcomes your questions. Please send them to: Astronomy, Science Digest, *1775 Broadway, New York, NY 10019.*



This high-dispersion spectrum of the Sun spans some 21 angstroms in green light and shows faint horizontal striations due to solar granulation. The small irregular wiggles in the vertical absorption lines are caused by vertical motions on the Sun's surface that produce minute Doppler shifts. This Mount Wilson Observatory-Carnegie Institution of Washington photograph was provided by Edward C. Olson.

pens — they become more prominent compared to photospheres! The reason for this unexpected behavior is that the interior zones where organized gas motions occur increase in extent in cooler, lower mass stars. This effect overrides the influence of the slower spins.

From late *A* through *M*, stellar coronas also increase in strength relative to total luminosity as evidenced by their X-ray emission. Later than *M5*, however, the X-ray luminosity drops off for reasons that are not yet clear.

SOLAR ACTIVITY

Superimposed on the Sun's layered structure are active and ephemeral features. Dark sunspots have been known for centuries. They range in size from mere pinpoints to areas large enough to ;een with the unaided eye (when suita- .y protected). These spots are about 1,500° K cooler than the surrounding photosphere and have individual lifetimes of days or weeks. Their numbers increase and then decrease over the 11-year solar cycle, which is but one manifestation of a 22-year cycle of magnetic variability.

Spots are regions of magnetic fields a thousand times stronger than Earth's. They seem to block the flow of radiation from below, rendering the spots cool and, by contrast, relatively dark. Spots are grouped into larger areas called centers of activity. Above them we may see solar flares, which are intense explosive regions in the chromosphere that are also associated with great bursts of energy at radio wavelengths. In the corona, dark sheets of gas can be seen projected against the photosphere. When these "filaments" are outlined against the sky at the solar limb, they appear as bright prominences.

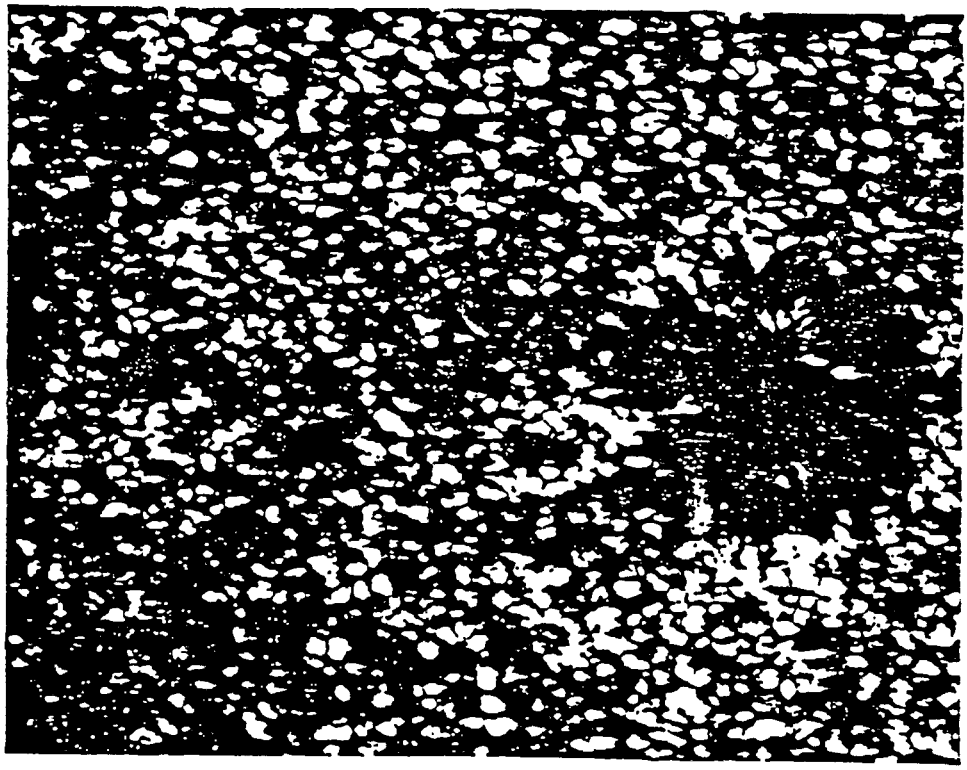
There are several ways of detecting activity on solar-type dwarfs other than the Sun. One method relies on monitoring the strengths of the emission cores of the H and K lines. These features are pro- ;ed in the chromosphere, so that a .'s level of activity affects them strong- . . In addition to a short-term modulation caused by stellar rotation, there is strong evidence for long-period cycles. Similar in many ways to that of solar activity, their observed periods range from a few years upward.

Spots can be detected by the variation they produce in the total luminosity of a star as it rotates. No great area of our Sun is ever spotted, and its light variation would be undetectable at typical stellar distances. However, a few of the stars that show chromospheric activity also show small periodic brightness fluctuations, so these stars seem to be quite heavily spotted (see page 463). Finally, the flare activity observed in dwarf, emission-line *M* stars probably represents an extreme variety of flares observed on the Sun.

THE SUN AS A STAR

The Sun is so close that we can measure a wide variety of its properties precisely, something that is difficult to do for other stars. For example, we can determine its radius and luminosity to a fraction of a percent, and from them calculate the effective surface temperature to within a few degrees. From the character of the Earth's orbit we can deduce the Sun's mass to a precision of one part in 10,000. Gas motions can be determined accurately, as can subtle changes in the magnetic field strength. In contrast, magnetism in other stars cannot even be detected unless the total field strengths are hundreds of times greater than they are for the Sun.

We can even see into the Sun's photosphere somewhat, since the gases there are partly transparent. At the center of the disk we look straight down into the atmosphere, penetrating as deeply as possible into hotter layers below. On the other hand, at the edge of the Sun our line of sight grazes the surface. Thus, we see less



A closeup view of the photosphere and a sunspot, a complex, magnetically cooled region. The solar surface shows a delicate fine structure called granulation, which is related to convection in lower layers of the Sun. The small black areas, called pores, may develop into full-fledged spots, or may quickly disappear. This photograph was obtained with the solar optical universal polarimeter on the Spacelab 2 mission. Courtesy Alan Title.

Cloud Conundrums

Satellites have spied strange plumes coming from the Soviet Arctic, including some rising from an island that served as a nuclear testing ground

By STEFI WEISBURD

In 1810, a Russian industrialist named Jacob Sannikov stood on the New Siberian Islands in the East Siberian Sea, looked to the north and thought he had discovered a new continent.

Sannikov's sighting and similar reports from 19th-century Arctic explorers fueled the belief of many geographers at the time (and of the U.S. Congress, which was eagerly financing Arctic expeditions) that a vast polar continent was just waiting to be conquered. Expeditions were mounted to search for Sannikov's Land. But it was never found, and two parties of explorers perished for their troubles.

Now, Pierre St. Amand, a consultant to the Naval Weapons Center in China Lake, Calif., and a number of other scientists think these continental mirages could have been large plumes rising from the sea — similar to clouds recently spotted on satellite images of Bennett Island, which lies 150 kilometers to the north of the New Siberian Islands.

These Bennett Island plumes were first discovered in infrared images from National Atmospheric and Oceanic Administration (NOAA) weather satellites. These cold clouds are hundreds of kilometers long and tens of kilometers wide, and appear to emerge from the sea, rising to altitudes of 1 to 2 kilometers, according to Michael Matson at NOAA's National Environmental Satellite, Data, and Information Service in Washington, D.C. More than 200 Bennett Island plumes have been spotted in random searches of NOAA imagery taken since 1973.

Most U.S. researchers who have thought about these plumes now suspect that they are caused by the escape of methane from the world's largest natural gas reservoir. But scientists are mystified by even more recently detected clouds that are lofted much higher into the atmosphere from an island on the other side of the Soviet Arctic. Partly because the island has been a Soviet nuclear testing site, some Western scientists have wondered whether these clouds are human-made.

In the Dec. 9 Eos, Matson reports that clouds similar to those above Bennett Island have been seen on satellite imagery of the northern of two islands called Novaya Zemlya, which lie about 2,000 kilometers to the west of Bennett Island. So far, random searches of images of that region have turned up 12 plumes in a seven-year period.

When the first Bennett Island plume was discovered in 1983, many scientists initially thought it had been spewed out by a volcano. But according to a number of researchers, the region has not experienced volcanism for nearly 80 million years. In a 1983 Eos article, Jurgen Kienle, Juan Roederer and Glenn Shaw of the Geophysical Institute at the University of Alaska in Fairbanks noted that the nearest known volcanic site lies 1,300 kilometers to the southwest, in Siberia, and last erupted in 1775. They write that the Geophysical Institute's seismic network could not find evidence for a volcano prior to the plume's appearance, and air samples taken at Barrow, on the northern end of Alaska, contained no traces of volcanic material.

The Air Force Technical Applications Center also found no evidence for volcanism from either its airborne sampling or its seismic network, according to an Air Force spokesman in Washington, D.C.

Moreover, Soviet scientists who investigated the Bennett Island region after learning about the plumes, presumably from U.S. sources, told U.S. researchers that they could find no evidence for a recent eruption. And according to Yevgeni Korotkevich, vice-president of the Geographical Society of the USSR, whose remarks were conveyed to SCIENCE NEWS by Yuri Kupin at the Novosti Press Agency, the Soviet expedition also "did not find any gas plumes. Apparently the vertical streaks [that we see on space] photographs represented a meteorological phenomenon, or could be associated with ice domes in those regions. They cannot be man-made."

Back in the United States, researchers considered, and then discarded, a host of other possible sources, including Soviet cloud seeding experiments and burning coal beds. U.S. scientists investigating the Bennett Island plumes have now settled on the methane theory, which was suggested by geologist James Clarke at the U.S. Geological Survey in Reston, Va.

Clarke thinks the plumes are clouds of water or ice and methane that has escaped from coal beds beneath the sea. He says the beds formed from the decay of plants during the last 1 million years, before the Siberian shelf was covered by a thick layer of permafrost and later inundated by the sea.

The permafrost layer is thought to contain methane hydrates — ice-like compounds in which methane molecules are trapped in a cage formed by water molecules. Scientists believe that heat from the earth has been slowly melting the permafrost. Clarke suggests that as a result, pockets of methane gas build up near Bennett Island, and the methane is released explosively when a fault cracks through the overlying rocks and into the permafrost layer.

NOAA-TESDIS

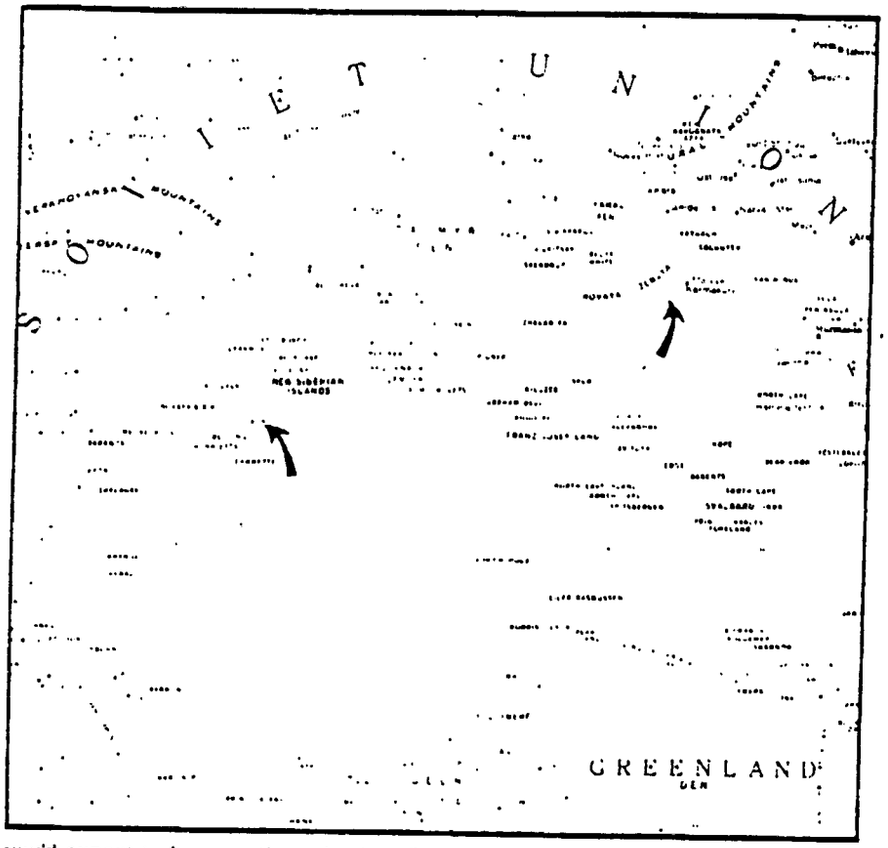
A NOAA satellite infrared image taken on Feb. 5, 1986, shows one of the plumes that have been spotted emerging from Novaya Zemlya in the Soviet Arctic. Such clouds range in length from 90 to 600 kilometers and are as cold as -60°C. Scientists are puzzled by the Novaya Zemlya plumes, which, unlike similar clouds seen rising offshore of Bennett Island to the east, emerge from land.

Clarke says the straight shoreline of Bennett Island suggests there is a fault there. Because methane is much lighter than air, he says, it probably shoots straight up into the atmosphere "like BBs coming from an air gun."

Clarke notes that explosive releases of methane are common in that part of the world. These "mud volcanoes," which can shoot hundreds of feet into the air, occur in Alaska, Canada and the Caspian region of the Soviet Union, he says. In every case, they appear to be related to a fault, according to Clarke.

Because methane cools as it expands

the methane hypothesis would explain why the plumes are so cold (satellite infrared data suggest that they are colder than -40°C) and why, as some scientists believe, the plumes are much colder than the surrounding air. St. Amand also thinks this would explain why the plumes are not emitted continuously: With enough cooling, the hydrates would reform and the permafrost would refreeze, sealing off the flow of methane from the seafloor. Clarke suggests that the particles entrained in the rising methane plume would act as condensation nuclei for water vapor in the air and would cause ice crystals to form, just as condensation trails are left behind airplanes.



While researchers agree that the Novaya Zemlya plumes, like those from Bennett Island, are not due to volcanic eruptions, a few have been less comfortable with extending the methane hypothesis to these clouds. One reason is that the plumes over Novaya Zemlya reach much higher into the atmosphere, rising anywhere from 7.8 to 10 kilometers, depending on the technique used to calculate their height, according to Matson of NOAA. The force behind methane escape, he says, "is like putting your head below water and blowing bubbles – you're not going to get anything up [that] high into the atmosphere. [The methane theory] is a reasonable hypothesis, but there are some problems with it for the Novaya Zemlya case."

St. Amand is fairly convinced that the methane hypothesis cannot explain the Novaya Zemlya plumes, because "the [plumes] are coming right off the island and the rocks [there] are not the sort that you'd expect to have methane in them." He believes the plumes are artificially made. "But what [the Soviets] are doing or why they made them, I have no idea," he says.

Because Novaya Zemlya has been a Soviet nuclear testing site, a few U.S. scientists have wondered whether the plumes arise from some kind of military testing. An Air Force spokesman, however, stresses that, after considerable study, the Air Force has had no reason to think the clouds coming from either Novaya Zemlya or Bennett Island are due to any radioactivity-generating human process, such as nuclear testing. Adds one atmospheric scientist, "What got us excited was the idea that the Russians

A missing methane connection?

Are the Arctic plumes merely a geologic curiosity whose significance is limited to a single area of the globe? To at least one scientist, the clouds – if they are made of methane – hint at a more global importance.

When atmospheric chemist Charles Stevens at the Argonne (Ill.) National Laboratory saw the announcement in the December Eos about possible methane plumes coming from the Bennett and Novaya Zemlya islands, he thought he might have found the explanation for some unusual readings he had taken of methane in air samples from Illinois, Oregon and elsewhere. He had discovered that from 1978 through 1983 the isotopic ratio of carbon-13 to carbon-12 fell slightly in the Northern Hemisphere, while at the same time in the southern half of the globe, the relative abundance of carbon-13 grew.

Stevens could understand the Southern Hemisphere's increase in the percentage of carbon-13, since forest burning and other sources of carbon-13-rich methane have been increasing in that part of the world. But the Northern Hemisphere data were a puzzle.

"The effective decrease in carbon-13 was more than could be accounted for by the increasing fluxes of methane from rice and cattle," sources of methane that release relatively low amounts of carbon-13, he says. Moreover, in the fall and winter of 1984-85, Stevens obtained Northern Hemisphere samples that were much more depleted in carbon-13 than any other previous samples.

"Here were two pieces of evidence. The isotopic data said that funny things were going on in the Northern Hemisphere . . . and here were these data from the satellite that showed possible methane emissions from the ground," says Stevens. Perhaps the plumes – if they are indeed composed of methane – are responsible for changing the isotopic makeup of Northern Hemisphere methane. If so, Stevens estimates that they would have had to be increasing their output by several billion kilograms of methane per year to account for the 1978-83 observations.

The possible connection between the Arctic plumes and recent methane measurements is an interesting idea, but Stevens cautions that at this stage it is pure conjecture. However, if the clouds are shown to come from the release of methane, researchers may well wonder about their atmospheric impact. Perhaps the plumes we see today are, in some small way, signs of what some scientists believe might be in store in the distant future. According to one scenario, the global warming resulting from the human release of carbon dioxide, methane and other "greenhouse" gases will eventually melt the permafrost layer in the Soviet Arctic, free the methane from its icy prison and release it into the atmosphere, where it can warm the planet some more.

– *S. Weisburd*

Cloud Conundrums (cont.)

were doing something nefarious, but to my knowledge there's no evidence whatsoever that that's what's going on."

Korotkevich's only comment to SCIENCE NEWS about the Novaya Zemlya plumes is somewhat cryptic: "Something like this could be observed in the vicinity of the Canadian Archipelago and Greenland, regions with almost the same geographic coordinates."

Matson, however, says NOAA images have not picked up any plumes coming from Greenland. "If this type of plume activity was occurring elsewhere we would have spotted it," he says. "Only these two cases have caught our eye."

Matson says he and a few other scientists are now kicking around the idea that the Novaya Zemlya plumes are caused by "orographic" effects, in which a mountain, or in this case a glacier, pushes air currents up, where they cool enough for water to condense into a cloud. He's testing this idea with the most recent plume, which was detected March 3 and which enabled NOAA scientists for the first time to monitor in real time the development of a cloud from either Novaya Zemlya or Bennett Island.

Clarke maintains that the methane hypothesis *could* explain the Novaya Zemlya clouds, although he says "it's less clear what the situation is [there]." In support of the methane idea, he notes that on the west coast of the northern island there is a very straight fjord, suggesting a fault, that runs right through the area where the plumes arise. But Gregory Ulmishek, a petroleum geologist at Argonne (Ill.) National Laboratory and a Soviet emigrant, says the region is very tectonically complex, with thousands of faults. "So why don't we see plumes elsewhere?" he asks.

Both the Novaya Zemlya and Bennett Island plumes have whetted the scientific appetites of U.S. researchers. And the fact that their Soviet colleagues appear to have little clue to the cause of the clouds — or, if they do, are reluctant to say — has only intensified this curiosity. "We have all these hypotheses and remote sensing data," says Matson, "but we're really not going to know anything until somebody gets to Bennett Island and takes some ground measurements during a plume event."

Matson, Clarke and others are itching to mount a joint U.S.-Soviet expedition to Bennett Island. (Matson thinks it's unlikely that U.S. scientists would ever be allowed to visit Novaya Zemlya because it is militarized.) But the Soviet Union's Korotkevich doesn't appear as tantalized by the prospect. "The study of such phenomena has no practical value," he says, "as they are of a local nature and, therefore, do not deserve to be an object of international scientific cooperation."

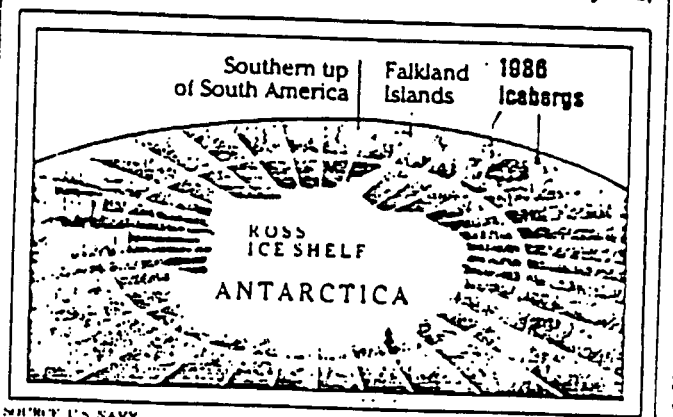
So, for U.S. scientists, the cause of the plumes may remain clouded. ☐

Science News vol. 131 p. 133 March 5, 1987

An Icy Warning of a Global Warming?

When an iceberg twice the size of Rhode Island broke off from Antarctica in October, it was clear that cartographers would have to go back to the drawing board: the "calved" berg had ripped off a chunk of the southern continent's coast; gone except in memories and on maps was the Bay of Whales and its shoreline. What wasn't clear, though, was whether this frozen, 25-by-99-mile behemoth signaled an ominous global warming.

Since the Industrial Revolution, world temperatures have risen about 1 degree. Most researchers attribute this to carbon dioxide, which enters the atmosphere from the burning of such fossil fuels as coal and oil, traps heat and thus creates a "greenhouse effect" that warms the planet. In the last 100 years, sea levels have risen about six inches, simply because water expands as it heats. If polar ice melted, too, that worrisome trend would become a global disaster. A further swell of two feet would flood most major ports.



U.S. NAVY — BJORKLUND—NEWSWEEK

Frozen behemoths: *A trio of icebergs 'calved' from Antarctica*

Breakaway bergs: Has a balmier earth now begun to affect polar ice? In 1986 two other big bergs fell into Antarctica's Weddell Sea. In 12 years of peering at the oceans, satellites hadn't seen breakaway ice cubes of this proportion. It's too soon to blame the warming earth for all these bergs but, warns Bernhard Lettau of the National Science Foundation, "Global warming will undoubtedly have effects on the antarctic ice sheets."

AMPTE Looks into the Invisible

It has long been known that the earth is a vast magnet, and the very first satellite ever successfully launched by the United States (Explorer 1 on Jan. 31, 1958) discovered that one of the geomagnetic field's major consequences is the presence of the "Van Allen belts" of trapped radiation that circle the planet. The "magnetosphere," as the field's domain is called, and the radiation belts have since been intensively studied, yet some of the most fundamental questions about both remain unanswered.

What portion of the particles that populate the belts is sent in from the sun by the solar wind (once thought to be the whole explanation) and what comes up from earth's own ionosphere? In fact, how much of the solar wind actually gets in at all, somehow penetrating the intense shock wave formed by the solar wind's supersonic collision with the magnetosphere? And what strange process is it that soups up the particles in the belts until they are from a thousand to a million times more energetic than they were when they left either source?

On the morning of Aug. 9, three satellites — one West German, one British and one from the United States — are scheduled to be launched from Cape Kennedy in Florida aboard a single Delta rocket. Deployed into separate, carefully calculated orbits so precise that their rocket will have to take off within a certain 10-minute "launch window" on any given day — part of the reason that they will not be riding the space shuttle — the probes will be addressing just such questions.

And the answers to all of them are invisible.

That problem is at the heart of the mission, known as AMPTE: the Active Magnetospheric Particle Tracer Explorers. To AMPTE's scientists, merely flying a load of instruments through the solar wind or the magnetosphere is not enough. How to tell, for example, whether a few million hydrogen ions (protons) came from the sun or the ionosphere? AMPTE's answer is to inject "tracers" of barium and lithium ions, easily distinguishable from solar and terrestrial outpourings, into the solar wind's flow and the lines of the geomagnetic field, like pouring visible dyes into the tributaries of a river to observe their mixing.

Such tracers have been used many times from sounding rockets and even on a few occasions from satellites to study earth's magnetic field, usually by visually tracking the glowing blue and purple clouds of ions as they reflect the sun. The satellite doing AMPTE's injections (the German Ion Release Module), however, will begin its work about a month after launch by deploying a lithium cloud in the solar wind before the solar wind ever reaches the shock wave, the first such experiment ever conducted outside the magnetosphere. Lithium ions are invisible (and would be unobservable in any event since the cloud would have to be viewed against the sun), but they will be tracked by instruments aboard both the German satellite and the nearby United Kingdom Subsatellite, which is equipped with its own propulsion system to vary the distance between the two probes. The U.S. satellite, meanwhile, called the Charge Composition Explorer, will be stationed *inside* the magnetosphere's boundary to see how much of the lithium, driven by the solar wind, actually gets through.

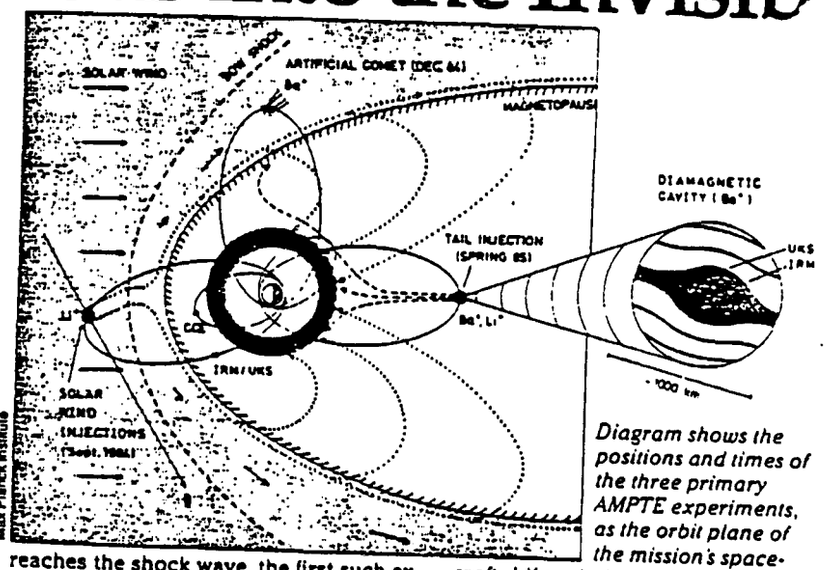


Diagram shows the positions and times of the three primary AMPTE experiments, as the orbit plane of the mission's spacecraft shifts relative to the sun. In September (left), lithium clouds will be released sunward of earth's magnetic "bow shock" as tracers to study the penetration of the incoming solar wind. Three months later (top), an "artificial comet" of barium ions will be produced over the dawn quadrant. And next spring (right and inset), additional lithium and barium clouds will be generated in the magnetic field's tail to see how ions introduced into the tail are transported toward the earth to form the Van Allen radiation belts.

About six months later, the satellite's orbits will have shifted so that the probes will be able to repeat the experiment well down in the "tail" of the magnetosphere, on earth's night side. The tail is formed because the solar wind drags the magnetic field lines out beyond the planet, but evidence from other satellites has indicated that some particles from the tail are somehow directed "upstream" toward the earth. Here, AMPTE's clouds of barium and lithium (with a visible Europium tracer of its own) will be tracked both visually (with earth-based telescopes) and by the satellite's instruments.

AMPTE's most spectacular experiment, however, is planned for late December, when the Ion Release Module generates an "artificial comet" of barium to study the effects on a comet of the solar wind and magnetosphere. The powdered barium, deployed like the other tests from an exploding cannister, is expected to form a glowing cloud that will be visible from earth, where it will appear about one-third the size of the full moon. How fast will the solar wind sweep it away? AMPTE will take the first look.

—*J. Eberhart*

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OBSERVATIONS

REALITY ANYONE?

BY GERALD JONAS

If you want to find out about rutabagas, you ask a rutabaga expert. That's what experts are for, to keep track of all the stuff that the rest of us can't keep track of. By the same token, if you're cur - about physical reality—all the stuff that goes to make up our world of matter and energy—you ask a physicist. So, when we heard recently that a group of physicists were meeting in Manhattan at the Vista International Hotel at the World Trade Center to discuss what they know and don't know about reality, we decided to attend and satisfy our curiosity.

The title of the four-day meeting was "New Techniques and Ideas in Quantum Measurement Theory." This led us to expect a somewhat sedate atmosphere in which the silence of cerebration would be broken only by the click of a projector, the scratching of chalk on blackboard, and occasional breathy murmurs of "Q.E.D." To our surprise, we found ourself in the midst of an intellectual free-for-all. At issue were wildly conflicting interpretations of quantum mechanics, the branch of physics that deals with the behavior of subatomic particles such as electrons and photons.

The conference was dedicated to Professor Eugene Wigner of Princeton University, who shared a Nobel prize in 1963 for work that improved and extended the methods of quantum mechanics. The equations of quantum mechanics predict with admirable accuracy the results of laboratory experiments, and they have been applied with great success to the development of lasers, transistors, computers, and nuclear reactors. There is no controversy about what quantum mechanics can do. The controversy begins with what it fails to do—which is to offer any support for our commonsense notions of reality. Speakers at the conference kept referring to the subatomic world of quantum mechanics as "strange" or "weird" or "crazy." In the experiments they described, a single particle can apparently exist in two places at the same time, an experimenter can apparently influence the behavior of a particle not only in the present but also in the past, and there appear to be indissoluble links between certain pairs of particles even when the particles are separated by room-size distances and are flying away from each other at the speed of light.

Albert Einstein, a formidable critic of quantum mechanics in his day, once said that he could not believe in a physics that involved what he called *spukhafte Fernwirkungen*, or "spooky actions at a distance." That was before some undeniably "spooky" effects had been demonstrated in the laboratory.

Bizarre challenges to commonsense notions of reality are raised by what are known as "delayed choice" experiments. In these experiments a particle is shot into a tabletop apparatus in such a way that it seems to take two paths simultaneously to a target. But if the experimenter activates a particle detector in either of the paths *before* the particle reaches the target, the particle will always be found in one of the two paths, and there will be no evidence that anything traveled in the other path. Apparently, the experimental setup "decides" whether the particle takes one or both paths through the apparatus. This is true even when the experimenter delays making a choice until the particle has already entered the apparatus. One way to explain these results is to note that the equations of quantum mechanics speak only of probabilities; they tell you what the odds are of finding a particle in one place or another. In the vivid image of John A. Wheeler of the University of Texas, Austin, the particle is like a "great smoky dragon" that cannot be localized in space or time—except at its "feet," when it is shot into the apparatus, and at its "head," when it is detected. Does this mean that the experimenter's choice literally determines the shape of reality? In the words of Carroll Alley, Jr., of the University of Maryland, College Park, "The experimental evidence suggests that we have a role in *creating* the universe."

"The Blank Signature," by René Magritte

As an alternative to such speculations, some physicists, like Herbert Bernstein of Hampshire College, in Amherst, Massachusetts, and Anton Zeilinger of the Atominstitut der Osterreichischen Universität, in Vienna, prefer to interpret the equations of quantum mechanics as referring not to objects in the physical world but to objects of knowledge. "At present," Zeilinger said, "I take the extreme position of giving up reality as much as I can." Zeilinger's extremism is anathema to Abner Shimony, a professor in the departments of philosophy and physics at Boston University, who declared himself "an unabashed metaphysician who believes in the objective reality of electrons." But to square this belief with the experimental evidence, Shimony has been forced to postulate a new physical property that he calls "passion," which allows two widely separated particles to match behaviors instantaneously without interacting through any of the forces known to classical physics. Other physicists find *this* notion anathema. When Shimony's "passion" came up for discussion at the conference, Jean-Pierre Vigier of the Institut Henri Poincaré in Paris took the floor to comment, in a clear but heavily accented English: "I don't understand what is passion without interaction."

The principal organizer of the conference, Daniel Greenberger, of the City College of the City University of New York, said that the real issue raised by quantum mechanics is, "What are you willing to swallow as the truth? Quantum mechanics is telling us something about the nature of causality and reality. Nobody understands it, but we can't just ignore it." Even this is debatable. Several speakers made the point that anyone who so desires can get on with his work by concentrating on what quantum mechanics *does*, while ignoring the philosophical implications altogether. In fact, Professor Roy Glauber of Harvard University assured us that this is precisely what most physicists do. The only people interested in such matters, he said, were "the older physicists and the strange ones." When we asked him why he was attending the conference, he said, "I'm afraid I fall into both categories." ■

Gerald Jonas frequently writes articles and books about science.

ASTRONOMY

Is Man Back in the Center?

Quantum physics suggests we may really be the focus of creation.

Is Earth the center of the universe? The question seems preposterous in these enlightened times, but for millennia the answer was an obvious yes. A few Greek philosophers argued that the Earth revolved around the sun, but any fool could look up in the sky and see they were wrong. And though centuries of scientific thought have given proof to the contrary, now, despite all this, some philosophically minded physicists and others are pushing the notion that we are indeed the most important planet in the cosmos. In a sense, they argue, the creationists are right, and man is in the middle—not because God says so, but because the apparently ironclad laws of quantum mechanics say so.

The ancients reasoned from the evidence at hand: Humans, with their power to dominate other animals and to change the environment, were clearly the most important species in creation.

Science found evidence to back up this anthropocentric view. The Greco-Egyptian astronomer Ptolemy, for example, constructed an Earth-centered cosmology that stayed popular for well over a thousand years. It even accounted for the apparent backward motions of the outer planets, which we now know are caused by the faster-moving Earth catching up with them.

It was Copernicus in the sixteenth century and Darwin in the nineteenth who finally dislodged us from our place at the center of the cosmos. Copernicus argued that the motions of heavenly bodies could be explained more straightforwardly and more accurately by assuming Earth to be just one planet among equals, all circling the sun. And Darwin offered a convincing mechanism by which humans could have evolved from lower organisms, without divine intervention.

The notion that Earth is just another planet (circling a nondescript star in a nondescript galaxy, it turns out), and humankind just another species, underlies most of modern science—certainly modern astronomy and physics. But now that that principle has become firmly established, a few scientists are starting to question it again with an idea known as the anthropic principle.

It comes in two flavors. The milder, called the weak anthropic principle (WAP), points to the fact that the universe has, in a sense, conspired to create us. If certain physical constants were just slightly different, we wouldn't be here at all. If, for example, the electromagnetic force (which makes the protons in an atomic nucleus want to fly apart and electrons want to stay bound to the nucleus) were a bit stronger or a bit weaker, the elements we're made of wouldn't exist. If the Earth were a bit farther from or closer to the sun, we wouldn't exist. And so on.

The WAP isn't all that compelling. We can always, after the fact, find examples of highly improbable events that happened anyway. If you close your eyes and throw a dart, for instance, it will stick *somewhere* in the wall. Before the throw, chances were overwhelmingly against hitting that particular point. You hit it anyway, but so what?

Then there is the strong anthropic principle (SAP), which states that the universe exists *because* we exist. It would be easy to dismiss this on the grounds of pure common sense, but that's the kind of approach the Earth-centered cosmologists took, too, and they were proved wrong. In any case, the SAP comes from the bizarre world of quantum mechanics, where common sense is hardly welcome.

One of the apparently nonsensical dictums of the reigning school of quantum theory is that the observer creates the phenomenon observed, at least at the subatomic level. An often-cited analogy is that of Schrödinger's cat paradox. Imagine a cat, sealed in an opaque box. Inside the box is a radioactive substance; there's a fifty-fifty chance that one of its atoms will decay in any given hour. If that happens, a hammer falls and breaks a vial of poison gas. The gas escapes and kills the cat.

You put in the cat, then wait an hour. Common sense tells you that at the end of the hour the cat is either alive or dead—you'll find out when you open the box. Quantum theory says the cat is both alive *and* dead at the same time. Only when you open the box and look inside will it become one or the other. The observer creates the outcome.

That fact, apparently true for subatomic particles, is literally true for the universe, argue SAP philosophers (who include such eminent physicists as John Wheeler). Our existence as observers is a necessary prerequisite to the existence of everything else. If that's true, the cosmos is centered around humanity in a way that even the most chauvinistic of ancient philosophers couldn't imagine.

–Michael D. Lemonick

Michael D. Lemonick is a former senior editor at Science Digest. *He is, at the moment, a freelance writer based in Princeton, New Jersey, specializing in astronomy and physics; he is writing a book on the former*

Stringing together a unified theory

Physicists are eagerly pursuing a unified field theory that will explain everything in physics, even though the search has frustrated Albert Einstein and a number of other intellects over the years.

The latest approach, which promises to overcome some of the difficulties of the others and to be unique where they are troublesomely multiple, leads to what are called superstring theories. They get their name from the change they make in the basic mathematical way in which fundamental particles are represented. The fundamental particles in all these unified theory attempts are the quarks (out of which neutrons, protons and a host of others are built) and the leptons (building blocks of electrons, muons and neutrinos). It has been customary to represent them as geometrical points, dimensionless objects without any spatial extension. That simplifies the mathematical operations. The superstring theories, however, represent them as strings, geometrical objects that extend in one dimension.

Such a change is necessary to provide a theory that will include gravity and subatomic phenomena and be consistent with the quantum mechanics that govern the subatomic domain, according to Michael B. Green of Queen Mary College of the University of London (now temporarily at California Institute of Technology). Such a union of gravity and subatomic phenomena has been the sticking point of other approaches.

Superstrings are no longer than 10^{-35} of a meter, as Green pointed out at last week's meeting in Crystal City, Va., of the American Physical Society. But that is enough to give theorists "the hope...that this will provide a realistic unified theory that will explain observations with few or no free parameters," he writes in the April 4 NATURE. Free parameters are mathematical terms that can be adjusted more or less at will to make predictions of experimental values come out correctly. Theorists don't like free parameters. A good theory should predict correct experimental values without any such fiddling.

Superstrings are so short that they almost look like points. But choosing them yields a mathematical derivation that determines almost uniquely the mathematical group that can be used to represent the symmetries of physics. Superstrings also specify uniquely the number of dimensions in which to calculate. These two features get rid of a lot of free parameters.

Symmetry is a basic principle on which physical explanations or theories are built. Physicists notice symmetries in the properties of subatomic particles and in the processes and interactions they engage in. They try to represent symmetries with mathematical groups. Mathematically, a group is a collection of related objects with a rule that allows one member to be generated out of other members. For instance, the real numbers are a group, with the ordinary rules of arithmetic. Other groups come from geometric operations, such as the possible rotations of an equilateral triangle or those of a regular hexagon (with appropriate combining rules).

These geometrically derived groups are particularly useful for representing physical symmetries. In general, the larger the group, the more physical symmetries can be included in a given formulation. Theorists have tried quite a variety of them. Superstring theory limits the choices to two, thereby chucking a lot of free parameters.

The two allowed groups, Green says, have the advantage of being huge. They start out with the ability to contain very many symmetries, so, as the theory is broken to subtheories of different classes of phenomena, the smaller groups into which these two can be broken have more than enough symmetries to accommodate any needs. They also contain nature's one notorious asymmetry, known as chirality (from the Greek word for hand). In some phenomena, nature distinguishes between left-handed and right-handed things. Other approaches to unified field theory do not successfully explain chirality, Green says.

Superstring also determines that 10 dimensions should be used. Frustrated in attempts to derive a consistent theory in the four dimensions we experience (three of space and one of time), theorists have gone into more dimensions, hoping that when they were finished they could return the theory to our experienced four dimensions by "compacting" the extra dimensions. That is, the extra dimensions are so tightly curved that an object moving along them comes back to its starting point after no more than 10^{-35} meter; we are not able to notice such tightly curled dimensions. In other approaches, various numbers of dimensions from five to 26 have been tried. By specifying 10, superstring gets rid of many important free parameters.

Superstring theories have a long way to go, however, before they reveal the mass of a top quark or of a tau neutrino or other similar things they are supposed to tell us, but NATURE's editor, John Maddox, writing in the April 4 issue, calls them "...the best hope yet that theories of particle physics will be united with gravitation...." —*D. E. Thomsen*

Sci News
5/4/85

Magnetospheric Workings: AMPTE Draws a Blank

Geophysicists poring over some recent results from the Active Magnetospheric Particle Tracer Explorers (AMPTE) are wondering what went wrong. Like dye dropped in a rushing river, the lithium and barium that they had released in and around Earth's magnetosphere was supposed to let them trace the path taken by solar wind particles as they moved toward Earth, perhaps to take up residence in the radiation belts. But six times tracers were released and six times they were never seen again. As researchers heard at last month's American Geophysical Union meeting in Baltimore, something was obviously wrong with the models of magnetospheric behavior developed during the past 20 years that the experimenters used as a guide. How fundamental or intractable the problem may be is unclear, but, as one researcher observed, "it is fair to say that it's a little unsettling."

Tracing anything through the magnetosphere presents a considerable challenge. Formed by the 400-kilometer-per-second solar wind blowing on Earth's magnetic field and pulling part of it into a long tail, the magnetosphere is more than 200,000 kilometers across and filled with magnetic and electrical weather more poorly understood and more difficult to predict than the kind on Earth. Once the solar wind's charged particles such as protons manage to penetrate the barrier presented by the outer magnetosphere, this weather carries them toward Earth and accelerates them until they may be a thousand or a million times more energetic than when they entered.

How all this happens has been studied for almost three decades through satellites that measure natural magnetospheric particles and fields. Stamatios Krimigis of the Johns Hopkins Applied Physics Laboratory in Laurel, Maryland, and Gerhard Haerendel of the Max-Planck Institute for Extraterrestrial Physics in Garching, West Germany, thought they could take a more active role. A satellite could release lithium or barium, rare elements in the magnetosphere, either upwind of Earth outside the magnetosphere or in the magnetotail itself while a second satellite waited closer to Earth near the radiation belts. When, how, and in what quantities the tracers arrived at the second satellite would help reveal the mechanisms responsible for their transport and acceleration. Such tracer experiments became a central component of the AMPTE program, which also includes passive observations and the creation of "artificial comets."

The first two tracer releases occurred last September upwind of Earth outside the magnetosphere. Once ionized, the lithium spiraled toward its target. Twenty-one percent hit the bull's-eye—the central leading face of the magnetosphere—the first time and 69 percent the second, according to model predictions of their paths in the solar wind. According to other models, some would simply blow by, but some would presumably enter the magnetosphere and be detected near Earth. None were.

The initial presumption was that although the vacillating solar wind had not blown the tracer off target, when the tracer struck it found the magnetosphere tightly closed. Constrained by operational circumstances, the experimenters had to release the first tracer when the magnetic field carried by the solar wind paralleled the northward field of Earth. By generally accepted theory, that condition bars entry by charged particles.

The failure to detect any tracer during the first two experiments seemed merely bad luck, until the four magnetotail releases this spring. Again no tracer appeared where predicted although no entry barrier need have been overcome. The amounts predicted to appear at the detecting satellite ran 2 to 30 times higher than the maximum amounts that could have been hidden in background readings.

"In some ways," says Krimigis, "these results are bringing us to a hard question: Are all the things we've done for 20 years wrong? Or, are there more mundane answers?" Everyone agrees that the models were not accurate enough and are probably too simple, but few see an impending revolution in the field. Data are sparse enough and opinions diverse enough that someone's model may soon fit the negative observations. But perhaps only more tracer experiments can resolve the mystery.

ZIRBES ENTERPRISES

Division of

UNIFIED ATOMIC RESEARCH

Mr. Paul Boynton
Univ. of Seattle
Seattle, WA

March 3, 1987

Dear Mr. Boynton,

I have become aware that you've taken an interest in searching for a repulsive force in nature which "counteracts" gravity, and I am writing to offer a suggestion as to how you can gain immediate proof that such a force does indeed exist. Since you are in effect at square one in your search, I will recommend you begin with a simple and straightforward test first conducted by myself and an associate in the early 1960's which I guarantee yeilds a dramatic result and offers irrefutable proof that Galileo's work was incomplete at best.

For this particular test I suggest using a ten pound sphere of carbon and a ten pound sphere of iron. The circumference of the carbon sphere will of course be greater than that of the iron, but this factor is very important to the result of the test, as you will soon see. You will also need to construct a drop box large enough to accomodate the two spheres and to incorporate some sort of a triggering mechanism which will ensure the spheres are released simultaneously. To acquire the absolute proof you are looking for, the distance of the drop should be at least 2000 feet. We used an open mine shaft in Northern Minnesota, and that site worked out very well. After taking into account air flows, lunar winds, etc., make your drop. In our tests we had set up a high speed camera near the impact plane to record the results, but if you have an extra person at hand to make a visual observation the camera wouldn't be absolutely necessary - the result is so pronounced that it cannot be missed.

You will find that even after all possible interfering factors are accounted for, the carbon sphere will impact after a 2000 foot fall long before the iron sphere strikes the impact plane. We found this particular test to be of great value because it eliminated the possibility that air resistance was the major factor in discrepancies we'd found between rates of acceleration of different elements in some of the other tests we had conducted. Our result showed that

The iron sphere was still six feet from the impact plane at the instant the carbon sphere impacted, proving that different elements falling in a gravitational field accelerate at different rates. The striking, unmistakable result yeilded by this test qualifies it as an excellent starting point, and I recommend it highly for the reason that it quickly establishes a solid working foundation from which to proceed.

I realize that you may not have the facilities at hand to allow you to easily arrange to run this test, and so as you will notice I have sent an identical letter to some of your fellow researchers who are also now looking for the repulsive force. It is my great hope that if it is beyond your present means to run this simple test, then perhaps it will be within someone else's means.

After more than twenty-five years of talking about a repulsive force, it is gratifying for me to see persons such as yourself exploring this avenue of research, and I congratulate you. Should you continue this quest into the actions of and reasons for the repulsive force, it will ultimately lead you to unity of all things, and many new technologies vital to the survival of this planet in her time of crisis. If I can be of <u>any</u> assistance to you in suggesting further tests, sharing the results to the numerous tests I've conducted, or in answering any questions you may have, I will be happy to oblige.

cc: R. Newman : U of CA
J. Faller : Boulder, CO
E. Adelberger : U of WA
P. Theiberger : Brookhaven
V. Fitch : Princeton Univ.
D. Sudarsky : Purdue Univ.
A. Szafer : Purdue Univ.
C. Talmadge : Purdue Univ.
S. Aronson : Brookhaven
E. Fischbach : U of WA
G. Bock : U of IL
H. Cheng : Purdue Univ.

Sincerely,

Lloyd B. Zirbes
Director
Project Stardust