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**FUTURE PHYSICS AND ANTI -GRAVITY
PRESENTED BY
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ABSTRACT

Some evidence for existence of a phenomenon which might be classified as anti-gravity is explored. First historic experiments are discussed which indicate that there are anomalies in gravitation-related experimental data which do not fit the widely accepted Einstein theory of gravitation. Several recent diverse experiments which demonstrate small magnitude forces which may be gravitational in nature are then discussed in detail, along with the postulated explanations of the observed phenomena. Certain similarities among the theories proposed to explain the experimental phenomena lead to the tentative conclusion that each of the phenomena may result from the same physical mechanism. The evidence seems to indicate that gravitational, or anti-gravitational, effects could be associated with the gyration motion of charged particles.

INTRODUCTION

Is the search for anti-gravity a realistic goal of scientific research? The basic theory of gravitation, which was published by Einstein in 1922, does not allow a dual nature for gravity, that is, both attraction of massive bodies and, under different circumstances, repulsion. To date the theory has passed the major cosmic-scale tests to which it has been subjected. However, there is experimental evidence of both a historic and contemporary nature, which will be reviewed here, which cannot be explained by existing gravitational theory. The interrelationships among these experiments and the prospects for achieving anti-gravity through further theoretical and experimental research are discussed herein.

There is a tendency in physical science today, and physics in particular, to assume that all observations of physical phenomena can be explained in terms of physical laws as they are presently known and accepted. This attitude among scientists is not at all unique to the present time. New concepts which demand a major reorientation of accepted theories are always slow to be accepted. When Copernicus concluded that the earth moves around the sun, he did not dare to present his theory to the scientific community. It was finally made known thirty years later, after his death. When Galileo developed a description of the mechanics of the solar system and published it, the document was confiscated and Galileo was sent into exile for the remainder of his life. On the other hand, when Newton formulated his laws of motion, they were based upon accepted observations of nature and accordingly, were not opposed by the other scientists of Newton's day since the laws clarified, rather than refuted, the existing concepts.

The ease of acceptance of a new theory by one's peers is dependent upon whether the theory is evolutionary or revolutionary. A modification of existing theory is evolutionary if it implies an upgrading to take into account the observation of facts which are not accommodated by the original theory, without undermining the basic limited validity of the theory. On the other hand, a new theory is revolutionary if it requires the adoption of a concept which shows that one or more of the basic tenets of the original theory are invalid. The most revolutionary twentieth century theory pertinent to the present discussion is Einstein's relativity theory, which postulated the principle of equivalence. This principle states that experiments conducted in an accelerated chamber, such as in an accelerating rocket free of the earth's gravity, and those conducted in an equivalent gravity field will give identical results. However, when Einstein was awarded the Nobel Prize for 1921 for his work in mathematical physics, his discovery of the law of the photoelectric effect was highlighted without giving any mention to the theory of relativity which he published in 1905.

Revolutionary theories can give rise to a period of scientific insecurity for the older generation of scientists and so are often opposed by this group. Revolutionary theories are more readily accepted by the younger group. Most of the scientific revolutions based upon experiment have not been derived from the activities of normal science, but have been generated from some novel technology or novel experiment, or were the result of some chance observation. While physicists theorize on the nature of the physical world as they see it, its true nature is unknown. New experimental facts will bring forth new theories. Indeed, old and forgotten observations made a half-century ago may lend support to new theories.

There have been many instances of scientific measurements, and phenomenological observations, which do not conform to accepted physical theory. The UFO phenomena represent one category of unpredictable, anomalous phenomena. Reports of UFO observations frequently refer to a hovering object. A vehicle normally hovers by use of an upwardly directed thrust equal in magnitude to its weight. The thrust can be created by induced flow of the air to produce lift, by a reaction propulsion engine such as the rocket or turbojet, or by the pressure thrust from buoyancy in the atmosphere as with a helium balloon. Some observers of UFO's have reported a flow disturbance beneath the vehicle, lending credence to the conjecture that the air is accelerated around the vehicle to produce thrust. However, there are many other reports of hovering objects in the near vicinity of the ground which apparently levitate in still air. It is this latter category of observation which might suggest that the force of gravity is being neutralized, or in other words anti-gravity forces are being employed. For purposes of the present discussion; anti-gravity is defined as referring to a technique which is capable of generating an apparent gravitational field, of directly counteracting the earth's field or of reducing the effective mass of an object. Therefore, electrostatic or magnetic suspension of objects in the earth's field would not be considered anti-gravity effects.

For the present discussion anti-gravity is not considered as a means of propelling a vehicle through space, though that may indeed be feasible. It is considered only as a force or effect which can provide an increase or decrease in the effective gravitational pull of the earth upon a given object. The objective here is to provide a limited survey of the status of anti-gravity research. Admittedly, the survey does not encompass all work in the field, for, because of the nature of the subject and its general lack of acceptance by the scientific community as a whole, publications on the subject are not readily available.

In the scientific community there is much doubt about the possibility of an anti-gravity force. However, there is some conjecture that anti-matter may exhibit anti-gravity properties with respect to normal matter (1).* The anti-matter particles, such as positive electrons, negative protons and anti-neutrons, may have negative gravitational masses. Although these particles can be created in the laboratory, since their resultant velocity is near that of light, it is not presently feasible to measure the bending of a beam of such particles due to terrestrial gravity and thereby to test their gravitational properties. Fortunately, there are other experiments, such as will be described in the following paragraphs, which may provide the impetus for anti-gravity research.

HISTORIC EXPERIMENTS

A number of experiments associated with studies of gravitation have been performed with interesting and controversial results from the standpoint of being inconsistent with accepted theory. Several of these experiments will now be reviewed to determine what clues may be provided regarding the true nature of the gravitational field.

In 1920 in Turin, Italy, Professor Q. Majorana conducted experiments on the absorption of gravitational force by an intervening medium (2). He suspended a 1.3 kilogram (kg) lead sphere within a 104 kg mercury shield and found that the weight of the sphere diminished by a small amount (0.00098 milligrams) when shrouded in mercury. Subsequent experiments in 1926 employing a 10-ton shielding mass of lead to improve accuracy lead to an improved measure of the gravitational attenuation (3) The attenuation constant n was found to be $2.8 \times 10^{-13} \text{ m}^2/\text{kg}$ where the attenuation factor for a shielding material having a density d and a thickness t becomes e^{-ndt} . His theory predicted that the sun is considerably more dense than estimated, but the gravitational effect is not evident because of its self-shielding. Einstein's theory of gravitation makes no provision for such shielding of gravity effects.

The concept of ether lost favor in the early twentieth century because of the Michelson-Morley experiments, which failed to show the expected difference in the velocity of light as a function of the direction of motion of the earth through a stationary ether. As a result of these experiment, it was concluded that there was no ether. However, other experiments tend to refute this conclusion. D.C. Miller undertook an extensive series of over 200,000 measurements in the Michelson-Morley experiment over a period of 25 years, some in collaboration with Professor Morley.

* Numbers in parentheses designate References.

He demonstrated a positive ether drift effect, which at Mount Wilson was determined to be 10 kilometers per second (4). G. Sarnac experimented with a rotating interferometer with interfering light beams projected in opposite directions. A noticeable interference pattern was obtained with a rotation rate of 2 revolutions per second, demonstrating a difference in light velocity in the direction of rotation compared with the opposite direction, as would be expected if the apparatus were rotating in an ether (5). In 1925 Michelson reported on a similar type of experiment consisting of an interferometer attached to a evacuated twelve-inch pipeline in the configuration of a rectangle of dimensions 2010 by 1115 feet. A light beam displacement was observed which corresponded to that expected for the earth's rotation (6). In 1959 the Nobel Laureate, L. DeBroglie, proposed the concept of an ether consisting of a sea of neutrinos, which are small subatomic particles with the mass of an electron but with no electric charge (7). More recent examination, of the question by B. Kuclowicz gives a particle density of 10^{12} per cubic centimeter (8) with an effective energy density exceeding one joule per cubic centimeter.

One of the early objections to the theory of ether was that the earth would slow down as a result of passing through it. Actually whether ether produces a frictional retardation on the earth or not depends upon the model chosen. But if ether does retard the earth and other celestial bodies, this has possibly been observed by Thomas C. Van Flandern of the U.S. Naval Observatory, whose studies show that the orbital speed of the earth around the sun and the orbital speed of the moon around the earth are both decreasing at a rate exceeding that due to tidal friction (9). His tentative explanation is that gravity is weakening with time, at the rate of one part in ten billion per year. However, an alternate explanation might be that the earth and moon are being retarded by virtue of their motion through the ether. Perhaps the concept of a gyrostatic ether, which is compatible with Maxwell's electromagnetic wave theory (10), offers a possible explanation. This ether concept offers no resistance to compression or distortion, but it resists rotation.

One may ask why the concept of ether is being examined when the subject of interest is gravitation. The answer is that an ether-like medium is probably necessary for anti-gravity phenomena. The gravitational forces are considered to be extremely weak compared to electrostatic and magnetic forces. How can the gravitational field of a massive body like the earth be perturbed sufficiently to counteract the earth's attractive force? It does not seem feasible if gravity travels through empty space. However, if space is filled with an ether-like substance which is also essential to the propagation of gravity, then it becomes conceivable that one may be able to control this ether so as to be able to manipulate gravity by making use of the energy contained in the ether itself. Therefore, the above described evidence that there is an ether makes more plausible the concept of anti-gravity.

MODERN EXPERIMENTS

Many abnormalities have been observed in measurements of geophysical phenomena which imply that gravitation does not behave precisely according to the predictions of Einstein's theory. A laboratory demonstration of an anomalous effect was performed by Maurice Allais, using a pendulum free to rotate in any direction, but with a support arrangement designed to produce a slight elliptical motion (11). The pendulum was operated as a Foucault pendulum, for which the rotation of the earth produces a rotation of the plane of the swing at a rotation rate dependent upon the latitude at the location of the experiment. Allais's experiments, running for a month at a time, revealed both a 24-hour and a 25-hour period, with large deviations from a linear angular progression over a given 24-hour interval. Also the plane of oscillation was found to shift by 15 degrees during a total solar eclipse, but the shift maximum preceded the eclipse maximum by 20 minutes, as illustrated in Figure 1. As a result of his work, Allais can say that his results are statistically significant, that they are not accounted for by the current theory of gravitation, and they are not accounted for by other known periodic phenomena, including thermal, barometric, magnetic, seismic, tidal and experimenter effects. The 25-hour period is consistent with the revolution of the moon around the earth. But the sun also rotates around its axis with about the same period. The hypothesis is that of a new field associated with either the motion of the moon or the sun.

Supporting the above research is the observation of irregularities in Foucault pendulum experiments, abnormalities in tides, abnormalities in leveling operations dependent upon the direction in which work is progressing, and other anomalous effects (12). The significant connection among all these effects is that their relative order of magnitude deviations are all the same, namely, 5×10^{-6} . Perhaps all have the same cause. In any event the anomalies cannot be traced to any known phenomenon.

There have been recent experiments which indicate that a rotating object is capable of generating an inertial field (13). The inertia of objects within this field is said to be modified. One experimental arrangement was such that the change in frequency of a tuning fork could be detected (14). An Accutron watch containing an electronic-driven tuning fork was placed above the axis of a 13.4 kg flywheel rotating horizontally at 7600 rpm as shown in Figure 2. The watch was reported to have lost time at the rate of 0.05 seconds per minute over a test period of 1000 seconds. The time loss was attributed to an increase in inertia of the tuning fork with an attendant reduction in its frequency of oscillation. The experimenter DePalma claims that the effect is proportional to the radius and mass of the flywheel and to the square of its rotational speed. This may be interpreted to mean that the effect is proportional to the centripetal force expected by the flywheel as a result of its rotational motion.

A method of utilizing beams of microwave radiation to effect a reduction in the local gravitational field has been pursued by Niels T. Sorensen (15). As illustrated in Figure 3, dual lobe radiating elements were arranged in circular symmetry so that each beam was oriented toward the apex of a 90 degree cone. A null region then occurs at the apex of the cone, which represents a region of apparent gravitational attraction.

Experiments were performed with this configuration at a power level of 5 kW CW and a frequency of 9.2 GHz. A 100 gram weight suspended along the axis of the system was found to lose weight when located just below the apex and to gain weight when just above it. The weight change in passing through the apex point was 70 milligrams, based upon statistical averaging of hundreds of measurements by a well-shielded strain gage from which the weight was suspended. These experimental results may be interpreted as representing an apparent modification in the local gravitational field.

In 1971-72 a series of experiments were performed by W. Peschka at the Institute for Energy Conversion and Electrical Propulsion at Stuttgart Germany which demonstrated that a force could be generated by a system without the expulsion of mass or mechanical motion, and without the interaction of electric and magnetic fields with the environment (16). The device, which is very simple, is sketched in Figure 4 . It consists of two quarter-wave length conductors in a chamber of dielectric material filled with purified water to which has been added some salt to provide conductivity. The electrodes are capacitively coupled, without mechanical connection, to a source of high frequency electromagnetic energy. The device is attached to a rotating balance, as shown in Figure 5, equipped with an oil damper to eliminate small oscillations. The rotational movement of the balance is measured by the reflection of a light beam from the rotating mirror.

With application of high frequency energy to the device, deflection of the balance was observed. The experiment was carefully controlled to avoid the effects of electric or magnetic fields, air movement, and seismic or vibrational disturbances. 200 experiments were conducted over a two-year period. Most were run for two days, but several lasted six to eight weeks. The microwave frequencies employed were 30-40 MHz, 120-130 MHz and 200-350 MHz. In conducting the experiments high frequency energy was applied at levels ranging up to one hundred milliwatts for periods of several minutes. Forces of 1 to 10 dynes (10^{-5} to 10^{-4} N) were produced over periods much longer than the period of application of the energy. This represents a very unique result, since no means of transmitting a force was evident, and the force persisted long after the energy source was shut down. An example of the experimental results is shown in Figure 6.

During the series of tests it was demonstrated that, if the applied frequency is maintained constant to 10-100 Hz for a period of one minute, then the application of high frequency energy at about one milliwatt for two minutes was effective in producing a force of 5 to 10 dynes for the following two hours. Viewed as a means of propulsion, the performance expressed in impulse per unit energy was 6 newton-seconds per joule, which is 10,000 times greater than that available from chemical propulsion systems.

Peschka does not present an explanation for the force effect except to note that a gravitational change should be considered. The persistence of the effect can be interpreted as follows: at an appropriate resonant frequency a spin orientation of the water molecules occurs. Nuclear spin resonance may also take part in the phenomenon. The spreading of the electromagnetic waves through the water may result in a population inversion in the electron energy levels just as occurs when a laser rod is excited by visible light prior to producing stimulated emission of radiation in the form of a laser beam.

If the inversion state has a long lifespan, then the effects of a short period of excitation will be evident long after the energizing radiation ceases, as was observed in the experiments.

A remarkable anti-gravity effect was observed by Marcel Pages using the experimental arrangement shown in Figure 7 (17). Two discs of mica of 14 cm diameter, each having a conducting surface of metal foil, were mounted on the ends of a 14 cm mandrel. The assembly was supported in equilibrium on a beam balance. When the two discs were charged oppositely by means of a Wimshurst electrostatic generator, there was a sudden elevation of the disc assembly. After two minutes the charge would dissipate and the discs would return to a balances position. For an applied voltage of 200 kV the observed loss in weight was 5 grams. One might at first suspect the weight loss to be due to the electrostatic field of the earth, which has an upper limit near the earth's surface in clear weather of 550 V/m. At maximum charge the force on one disc due to the earth's maximum field would have been only one gram. However, the two discs were oppositely charged, so the upward and downward forces should have balanced. Besides, when both discs were given the same charge, positive or negative, there was an apparent increase in weight due to the electrostatic attraction with the framework of the balance. Therefore, it was concluded that a new field effect of unknown origin has been observed. Other experiments with a high voltage alternating field also demonstrated a loss of weight.

Later experiments were performed with a single mica disc which rotated at a high rate when subjected to the high voltage of a Wimshurst machine, even to the point of lifting off its support when subjected to 300 kV (18). Pages attributes the greater anti-gravity effect for the rotating disc to the rotational motion of the electric charge.

Pages theory of gravitation assumes the existence of a graviton gas which permeates space, where gravitons are discrete energy packets of gravitational waves, postulated by Dirac. The protons and electrons of the atoms are bathed in this graviton gas. The weight of each particle is diminished by the weight of the graviton gas it displaces. When the electron is orbiting about the proton, as in a hydrogen atom, a cavitation effect is produced by electron, which in effect gives it a larger effective volume and thereby reduces its effective weight. As justification for this hypothesis he notes that the mass of an atom of any element is less than the sum of the masses of the individual particles comprising the atom. (This mass deficit in physical theory is attributed to a transformation of mass into the electrostatic and magnetic energy of the atomic nucleus.) The mass deficit for nickel, for example, is obtained as follows:

Composition:	28 protons + 28 electrons + 30 neutrons
Atomic Weight, A.W. =	57.959 kg / kmol
Mass of proton, m_p =	1.67252×10^{-27} kg
Mass of electron, m_e =	9.1091×10^{-31} kg
Mass of neutron, m_n =	1.67482×10^{-27} kg
Atom per kmol, N_A =	6.02252×10^{26}

Synthesizing a kilogram mole of nickel from its component parts, the mass deficit is seen to be

$$(28m_p + 28m_e + 30m_n) N_A - A.W. = 0.520 \text{ kg}$$

The mass deficit is said to be due to the displacement of the graviton gas. Accordingly to M.M. Doligez, in his book, "Gravitation", the theoretical mass of the graviton is 10^{-60} to 10^{-80} gram. But the graviton energy density, according to de Broglie, Bohn and Wigner, is 10^{27} joules per cubic centimeter, which, converted to an equivalent mass, is ten million tons per cubic centimeter. The graviton gas seems to have the properties of a superfluid, as it offers no resistance to motion. As the electron orbits about the nucleus of the atom at a velocity of about 200 km/s, only a slight amount of cavitation could result in an appreciable change in effective mass. Thus, Pages accounts for antigravity by a reduction in the effective mass through displacement of the graviton gas, just as the effective weight of a helium balloon is reduced by increasing its size, thereby increasing the displacement of air.

Pages has obtained French Patent No. 1,253,902 (19) on an "Engine for Cosmic Flight" which has the shape of a lenticular UFO. It contains a toroidal acceleration chamber which would have to provide a 3000 ampere electron flow at a velocity of 2.9×10^8 m/s (97 % of light velocity) in a magnetic field of 0.4 T (4000 gauss) in order to counteract the gravitational attraction for a mass of 1000 kg.

FUTURE PROSPECTS

The physics of the future will have to explain the anomalies of present day experiments. The extensive experimentation of Allais on the paraconical pendulum has demonstrated that anomalous gravitational effects exist which cannot be explained by existing gravitational theory. Sorenson discovered that focused microwave beams in a specific radiative configuration produce an apparent localized gravitational field. Peschka's work on microwave excitation on an isolated, water-filled chamber demonstrated that an unknown force acts upon the cylinder. DePalma has demonstrated that there is an inertial field generated by the motion of a large flywheel which affects the inertia of nearby bodies. And Pages has shown weight loss with application of high voltage fields supposedly attributable to the spin alignment of the elementary particles of the atoms. There appears to be a common link among all of the above phenomena, and that is, that the experiment may have influenced the spin alignment of the molecules of the experimental device. The microwave radiation could have interacted with the atoms of the test object to produce an alignment of atomic spins, and mechanical rotary motion could have produced a similar effect.

It is pertinent to note that in Germany, Horst Hanschmann made a patent application, No. 2,134,182, in 1975 on a gravitational device which is said to produce gravity waves by phasing the spins of the electrons and protons of the atoms of a crystalline substance using magnetic fields, and then raising the energy state with electromagnetic radiation. Although the effect is said to be small, here again the explanation is based upon the concept of spin. Perhaps the gyrostatic ether concept, in which the ether can react with rotating matter, has validity.

While it is true that, when a theory is well entrenched, it becomes easy for the scientist to ignore those facts which do not fit the theory, a point will be reached where the number and kind of discrepancies from the accepted theory are such that they can no longer be ignored. The author believes this to be the case with gravitational theory.

In an evaluation of the probabilities of achieving breakthroughs in future science, R.M. Wood has assigned a probability of 0.5 to 0.8 of achieving gravity amplification by 1990 (20). While the experiments to date do not offer great promise for achieving practical anti-gravity because of the small magnitude of the observed effects, they do provide the data upon which new theories are built. Once a valid theory is developed it will become feasible to study optimization of the critical parameters to maximize the anti-gravity effect. At that time physical theory may have solved the mystery of anti-gravity and UFO levitation, and the day of the weightless vehicle will have arrived.

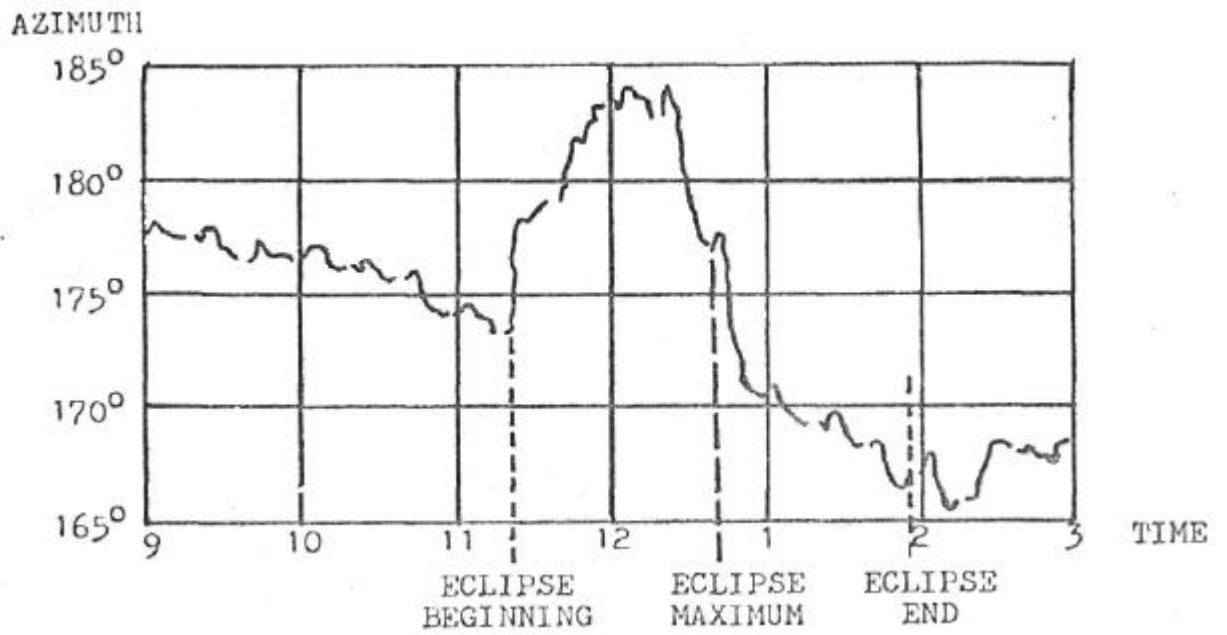


FIGURE 1. PENDULUM AZIMUTH CHANGE DURING ECLIPSE OF SUN

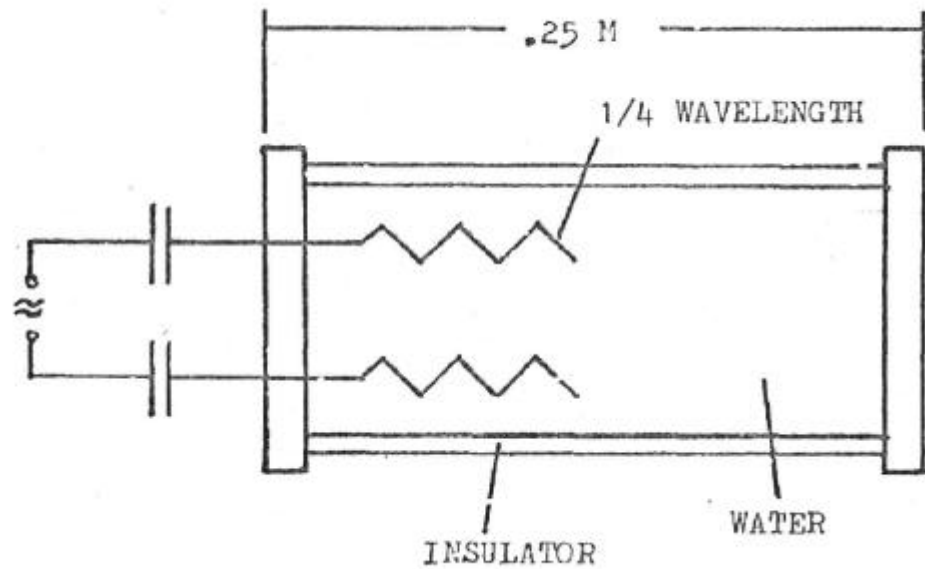


FIGURE 4. FORCE GENERATING DEVICE

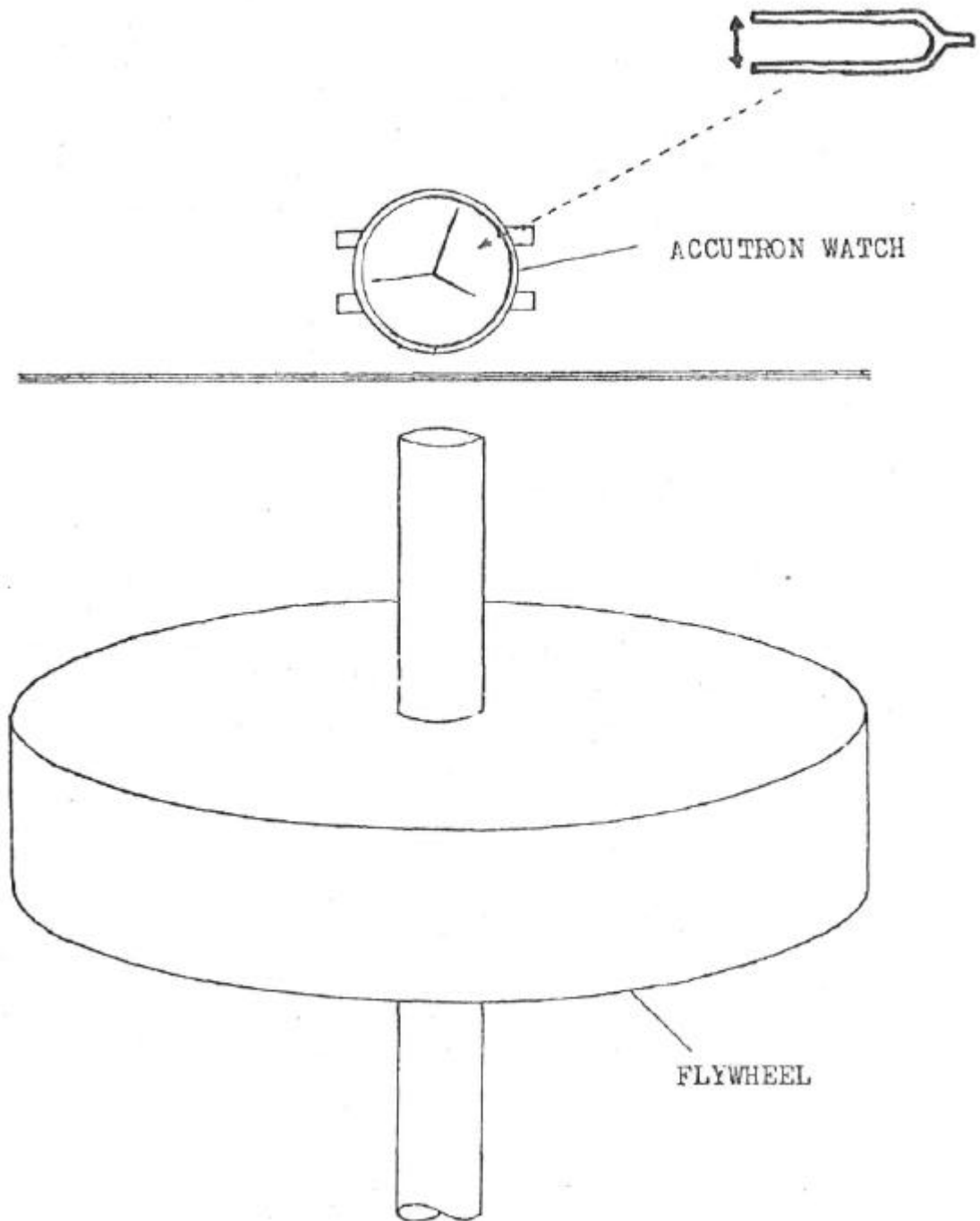


FIGURE 2. INERTIAL FIELD EXPERIMENT

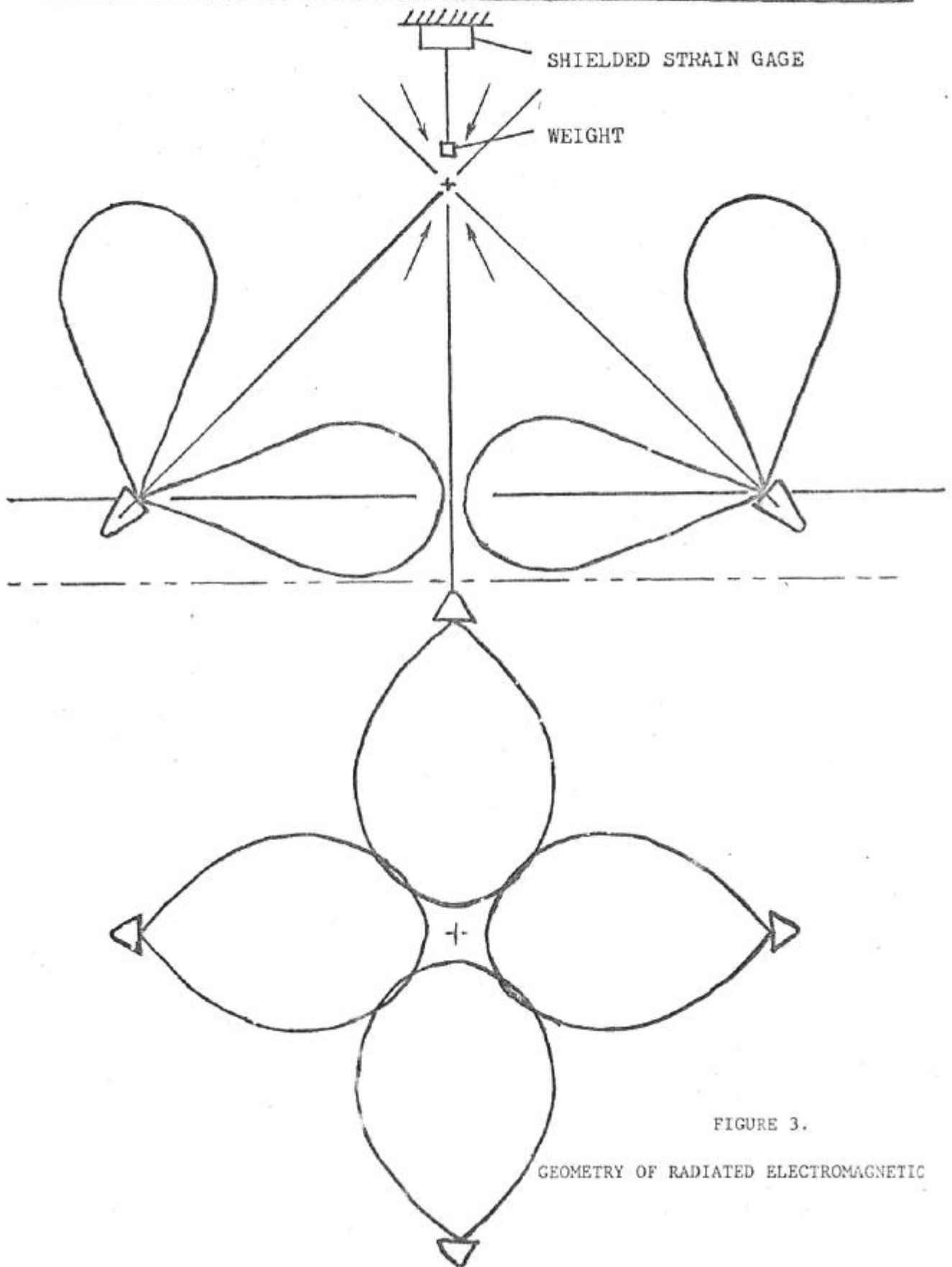


FIGURE 3.

GEOMETRY OF RADIATED ELECTROMAGNETIC

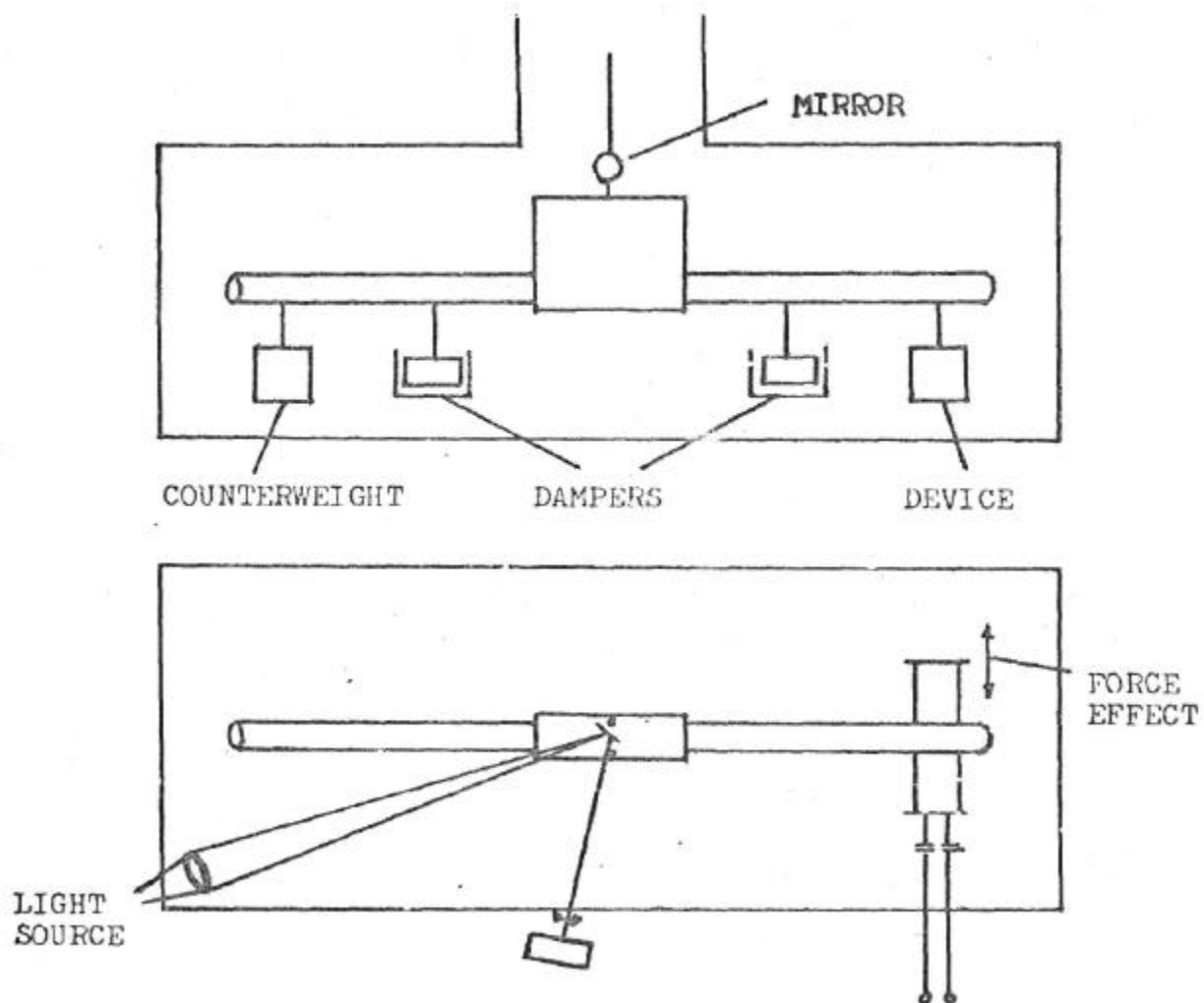
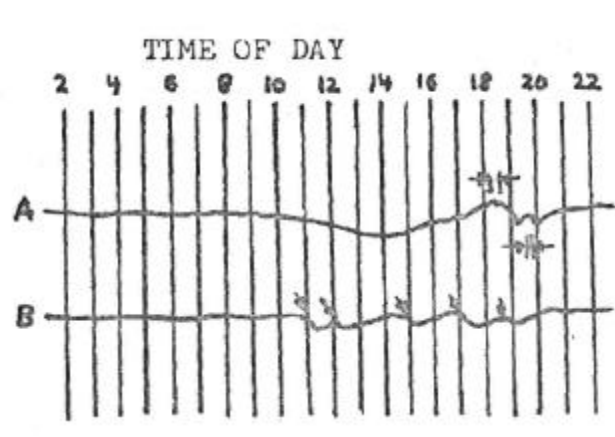


FIGURE 5. ROTATING BALANCE ARRANGEMENT



ARROWS INDICATE R-F APPLICATION .

FIGURE 6. TYPICAL DEFLECTION CAUSED BY MICROWAVE EXCITATION

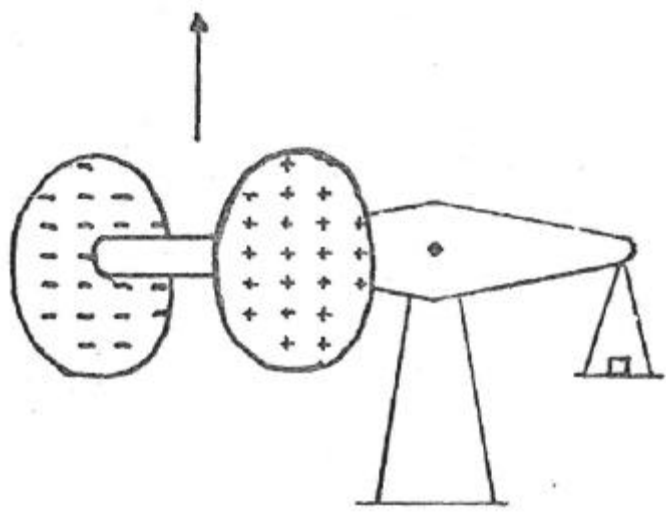


FIGURE 7. ELECTROSTATIC WEIGHT REDUCTION EXPERIMENT

Hans A. Nieper

Theorie der Energieabschirmung als Ursache von Gravitationswirkungen
(Shielding Theory of Gravitation)

Die von Isaac Newton im 17. Jahrhundert und von Albert Einstein in der allgemeinen Relativitätstheorie von 1917 aufgestellten Gravitationsgesetze geben trotz ihrer bisher nicht ernsthaft widerlegten Gültigkeit keine Auskunft über den eigentlichen Mechanismus der Entstehung von Gravitationskräften. Auch die heute oft in den Vordergrund gestellten Versuche von Joseph Weber (1) erhellen nicht diese entscheidende Frage, sondern weisen bestenfalls minimale Inhomogenitäten von Gravitationskräften nach, während die Gravitationswirkungen als solche zweifellos in den Bereich sehr hoher Energien gehören. Nach unseren Recherchen haben sich bisher nur sehr wenig Forscher ernsthaft Gedanken über einen hypothetischen Mechanismus von Gravitationswirkungen gemacht und die praktische Aussagearmut der bestehenden Gesetze kritisiert, gelegentlich mit einem Seitenblick auf tiefgreifende Strukturschwächen der theoretischen Forschung. Solche Autoren sind A. Magyari (2), K. P. Stanyukovich (3) und der Arbeitskreis um Anatol J. Shneiderov (4). Nieper hat unabhängig von diesen Autoren seit 1953 ähnliche Ideen verfolgt und einen Vorläufer der hier ausgeführten Theorie bereits 1954 veröffentlicht [5]. Magyari hat durch seine kritischen Briefe zur „Physica Nova“ Aufsehen erregt, sowie durch seinen Gravitationsversuch mit Hilfe des Budapester Radioturmes und dessen Antenne während der Eklipse am 15. Februar 1961. Magyari kommt dabei zu dem Resultat, dass die Gravitationsbeschleunigung Folge einer Druckwirkung oder eines Schubmomentes ist, und dass der Mechanismus der Gravitation „is power absorptive in character“. Auf die Lektüre der Publikation von Magyari sei hier besonders verwiesen.

Die Vorstellung einer Massenanziehung oder einer „Erdanziehung“ wird auch von Nieper, Shneiderov und Stanyukovich seit langem als sehr unwahrscheinlich abgelehnt. Der Grund dafür liegt vor allem in der Überlegung, dass die Ausbreitung von Gravitationskräften mit Lichtgeschwindigkeit eine Bindung an elektromagnetische Wellen wahrscheinlich macht, die ihre Energie nur in Form eines Impulsmomentes mitteilen können. Auf jeden Fall scheiden trahitorische Kräfte dabei vollkommen aus. Deswegen kann es auch keine Massenanziehung und keine Erdanziehung geben.

Alle vorgenannten Autoren nehmen an, dass der Weltraum erfüllt sei von einem Energiefeld, dessen elektromagnetische Wellen von allen Richtungen in alle Richtungen des Raumes gehen und außerordentlich energiereich sind. Shneiderov nimmt hypothetisch eine Wellenlänge von etwa 10-37 an, Nieper eine etwas geringere Frequenz. Shneiderov meint, diese Strahlung (radional field) könne die großen Massen nicht durchdringen. Jedoch schaffe die reflektorische Emission von „Radionen“, die geringer sei als der Einfall, zwischen den Massen ein Impulsdefizit, wodurch diese aufeinander beschleunigt werden. Shneiderov zieht bereits gedankliche Verbindungen zwischen elektrostatischen; magnetischen und gravitatorischen Kräften.

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