



Very good.

Clear & to the point.
anti neutrons
protons

positronium

Good Experiment with
high energy accelerator

THE USE OF ANTI-MATTER

as a Means of Overcoming Gravitational Attraction

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INTRODUCTION

The following discussion relates the recent verification of the existence of anti-matter to the possibility of its use to overcome the effects of gravity. Future efforts to utilize gravitational energy would be greatly benefitted by direct experimental measurement of gravitational forces existing between matter and anti-matter. A method for accomplishing such an experiment is described and application of the theory toward the construction of a gravitational shield is pointed out. The feasibility of such a plan rests on the experimental proof that complete symmetry of charge exists and that anti-matter is actually repelled by gravitational forces.

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THE USE OF ANTI-MATTER
AS A MEANS OF OVERCOMING GRAVITATIONAL ATTRACTION

It is generally believed, although there is no direct experimental evidence for this, that the inertial mass as defined from Newton's second law is identical to the gravitational mass. It should be remembered, however, that all the experimental verifications and observed consequences of gravitational forces to date have been carried out with ordinary matter.

Until recently the actual existence of anti-matter was theoretical. However, the number of anti-particles now necessarily known to exist has increased considerably in the last few years. Especially important was the discovery of the anti-proton and anti-neutron, and the ability to produce them under high energy. With this information and equipment available, it is now feasible to talk of actually constructing atoms composed of anti-nucleons and positrons, forming what is referred to as anti-matter.

Experimental confirmation has shown that the anti-proton, anti-neutron, and positron mass is the same as that of the proton, neutron, and electron. Furthermore, the electrostatic forces are known to be symmetric with respect to charge, and due to the charge independence of nuclear forces, anti-matter will have the same properties as matter. Even the spectra will have the same characteristics.

Since the physical characteristics of matter and anti-matter are so closely related, it should also be possible to relate their behavior under the influence of gravitational forces. The connection lies in the great deal of similarity, especially in mathematical form, existing between Coulomb's Law and the Gravitational Law. As previously mentioned, the electrostatic forces are known to be symmetric with respect to charge, and governed by Coulomb's Law. That is, like charges are known to repel, while unlike charges attract.

It is quite conceivable that the Gravitational Law will have the same type of symmetry with respect to matter and anti-matter. It is known that gravitational forces between matter and matter are attractive. The points not actually observed so far are the following:

1. Gravitational forces between matter and anti-matter.
2. Gravitational forces between anti-matter and anti-matter.

If in the first case the force is repulsive, and in the second case attractive, the symmetry of the gravitational law will be analogous to Coulomb's law.

According to recent theoretical claims made at the International Conference on Gravitation held at Duke University in the spring of 1957, a repulsive force between matter and anti-matter can be reconciled with the existing Relativistic Field Theories. However, this cannot be established from theoretical considerations alone. Therefore, in order to further future efforts to utilize gravitational energy, a direct experimental

measurement of gravitational forces between matter and anti-matter would be of great value.

Any experiment which requires an observation of anti-matter in the presence of matter must take into consideration mass to energy conversion, since a particle and its anti-particle will annihilate each other giving rise to intense gamma radiation. Since anti-matter cannot be stable for any considerable length of time, due to its annihilation properties, a direct experimental verification of gravitational forces between them is very difficult.

The following experiment is proposed which overcomes this difficulty:

With the high energy accelerators available, it is possible to obtain a beam of anti-protons. If a short pulse of this beam is introduced into a region of uniform magnetic field under the conditions that:

1. the magnetic field is vertical
2. the anti-proton beam is horizontal

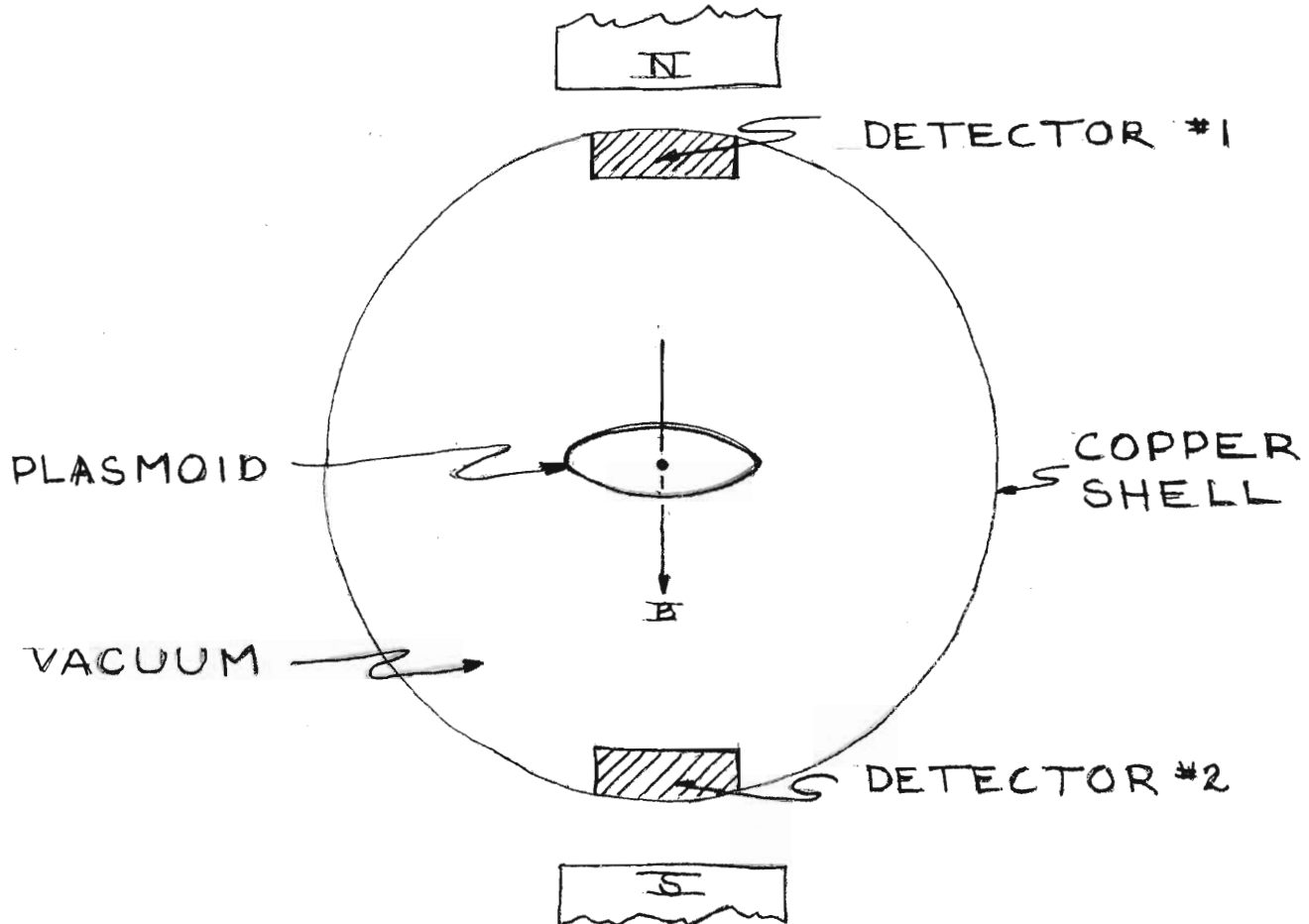
then the anti-proton pulse will be confined to a ring as a plasmoid.

If the gravitational force between this plasmoid and the earth is attractive, the plasmoid will be accelerated downward. If the force is repulsive, the observed acceleration will be reversed.

To prevent the loss of anti-protons due to annihilation, the plasmoid will be confined in an evacuated shell. This spherical

shell will also be useful as an electrostatic shield, which is necessary in view of the relative magnitude of electrostatic and gravitational forces.

Diagram of apparatus



We have now eliminated the electrostatic forces by constructing the sphere of some good conductor, such as copper, to serve as a shield. Since we wish to observe only gravitational forces exerted on the plasmoid, the magnetic field must be adjusted parallel to the earth's gravitational field. This will eliminate electromagnetic forces in the direction of the gravitational forces.

The space density of the anti-protons in the plasmoid should now be adjusted to a reasonably low value, since the electrostatic forces between them will change the dimensions of the plasmoid. If the density is low, the time taken for any appreciable change in size can be made smaller than the time taken for the plasmoid to reach the detector.

The detectors are situated directly above and below the central position of the plasmoid. The observation consists of: measurement of the time it would take for the plasmoid to reach one of the detectors from the center of the sphere.

The detector can be a large NaI(Th) crystal with a photo-multiplier. If an anti-proton enters this crystal it will produce annihilation gamma rays which will be detected by the crystal.

If it is observed that the top detector gives a pulse, and the bottom detector does not, it will be concluded that anti-protons experience an upward force in the earth's gravitational field. Therefore, it will be established that the gravitational forces between matter and anti-matter are repulsive.

One of the consequences of the Dirac Theory is the creation of particles in pairs. This implies that in the beginning when protons, neutrons, and electrons were created, and equal number of anti-protons, anti-neutrons, and positrons came into being. One can speculate that these anti-particles have formed some stars which are existing in our universe. The light emitted by these stars will have the same spectral characteristics as the

light from a star of ordinary matter. Therefore it will not be possible to differentiate between them.

However, according to the Special Theory of Relativity, matter determines the geometry of physical space. A positive curvature in space is introduced in the proximity of matter. If anti-matter is repulsed by matter, the curvature introduced in the physical space by anti-matter should be negative. As a consequence of this deformity in space, a ray of light will be bent towards a concentration of matter and away from a concentration of anti-matter.

The first effect has been experimentally observed in the form of a relative shift in the position of stars in the vicinity of the sun. Similarly, if the light ray travels in the gravitational field of a star which consists of anti-matter, the ray of light will be deviated in the opposite direction.

Applications of gravitational energy with respect to anti-matter may be made in connection with rocket propulsion, based on the theory that a missile composed of anti-matter will be repelled by gravity under suitable conditions and without recourse to the tremendous quantities of fuel now consumed.

A further application, based on the establishment of the symmetry of gravitational law, is the feasibility of constructing a shield for neutralizing the gravitational field. Once this symmetry is established, no difference will exist between the Coulomb law and the gravitational law. Therefore, by forming a suitable conductor of anti-matter, a shield can be obtained for the gravitational field similar to that used for the electrostatic field.

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Biographical Sketch

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At present I am a physics major at the University of Miami completing my last year before receiving my B. S. I am employed by the Physics Department there as a research assistant to Dr. Marietta Blau and Dr. Mohammed Hakeem under a government sponsored project dealing with cosmic rays and high energy particles.

Originally I am from Cleveland, Ohio, but have lived in Miami for the last ten years. I am married and have one child, a boy two years old. I plan to continue my work toward a M.S. and possibly a Ph.D., after which I would like to do work on rocket propulsion and the satellite.