

57

AN EXPERIMENTAL SEARCH FOR GRAVITATIONAL REPULSION

BY Norman Strax, Princeton, New Jersey

In the past, attempts to harness gravity have been severely limited by the universal inability of mankind to find any exception to the rule that all masses, regardless of their nature, experience a gravitational attraction toward all other masses in the universe. If men could only find at least some instances in which masses were repelled by gravity, then useful applications would be almost certain to follow. By constructing objects with a suitable amount of ordinary attractive mass, one would be able to make the two effects cancel -- and thus produce objects which were completely weightless. Engineers would then be able to design a great variety of wonderful weightless machines, ranging from railroad trains to spaceships.

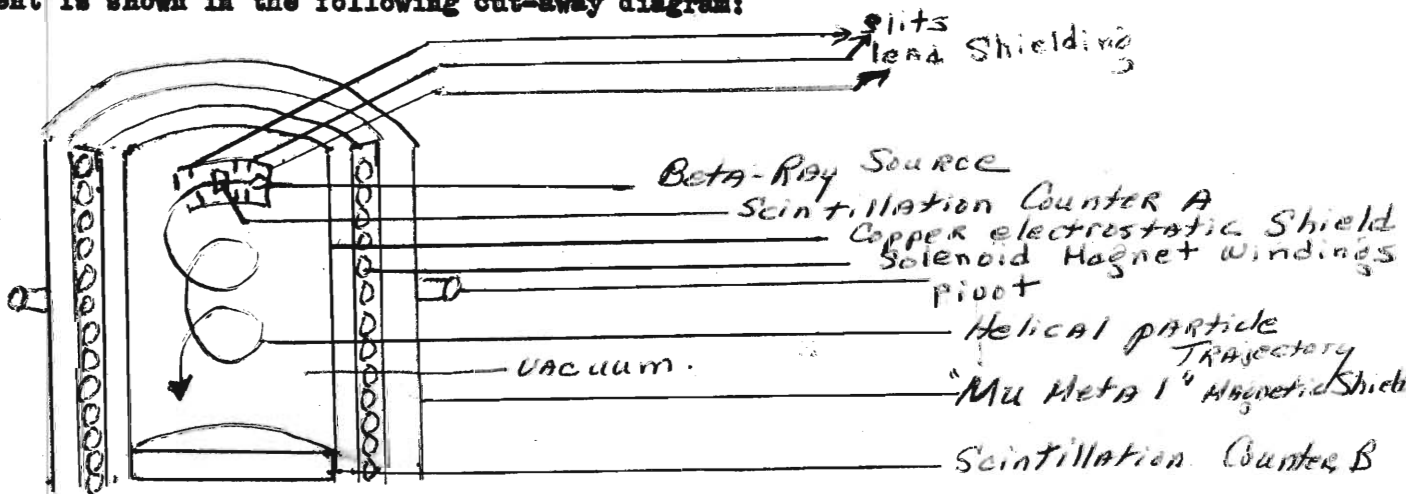
In any search for repellent gravitational mass, one is initially discouraged by the one universal result of both everyday experience and many very accurate experiments -- namely, that matter in bulk experiences gravitational attraction (which, furthermore, is always proportional to its inertial mass). There are, however, at least two fundamental manifestations of mass whose gravitational behavior has never been checked experimentally. The first is anti-matter, and in particular, the positron; the second is the electron. (If atomic electrons did exhibit any unusual gravitational behavior, it might well be masked by the behavior of the much more massive atomic nuclei and thus not be detected in bulk matter experiments.)

Incentive for an experimental search for gravitational repulsion in anti-matter and electrons is provided by at least two considerations. In a great many ways (charge, magnetic moment, etc.), antiparticles are known to exhibit precisely opposite properties from those of the corresponding particles -- thus it is tempting to hope that their gravitational properties will also be different. In addition, it is probable that the mass of electrons or positrons is largely electromagnetic in character, while that of nucleons (and bulk matter) is not. There might be a remote chance that this would cause a difference in their gravitational behavior.

In accordance with this reasoning, the author proposes to perform an experiment during the coming summer which, it is hoped, will be able to determine whether or not either electrons or positrons exhibit gravitational repulsion. If sufficient accuracy is obtained, it might also be possible to obtain a quantitative measurement of the magnitude of their acceleration in the earth's gravitational field.

There are two basic difficulties which present themselves in an experiment of this kind. In the first place, the very small inertial mass of electrons or positrons causes their velocity to be very great, even if their kinetic energy is low. This high velocity makes it difficult to observe the particles for a time long enough for gravity to produce a noticeable effect on them. The proposed experiment attempts to meet this difficulty by making use of a magnetic field to keep the particles within the apparatus for a sufficiently long period for gravity to act. The second difficulty consists of the large effects that any stray electric and magnetic fields present in the apparatus will have on the motion of the particles -- for even very small electromagnetic fields will exert forces on electrons or positrons which are greater than those of gravity. The proposed experiment attempts to meet this difficulty through the use of a method of data-taking which exhibits the gravitational effect on the particles as a difference between two separate measurements, each of which is subject to the effects of fairly closely identical stray fields. Both electric and magnetic shielding is also employed in an effort to reduce the extent to which stray fields are present.

An outline of the experimental arrangement to be used in performing this measurement is shown in the following cut-away diagram:



Low energy positrons (or electrons, depending on which kind of particle is under study) are obtained from a suitable beta-ray source. The system of slits is arranged to form a collimated beam of particles and direct them downward along a helical path through the solenoidal magnetic field. The pulses produced when a particle passes through counters A and B are displayed on an oscilloscope screen which is then photographed to allow the measurement of the particle's time of flight. After the distribution in the transit times for a large number of particles has been obtained, the entire apparatus (including the system of shields) is turned upside down. Now the distribution in transit times of the particles (which are now moving in an upward direction) is again recorded. The differences between the distributions obtained with each of the two apparatus orientations will serve as a measure of the direction and magnitude of the gravitational acceleration. By careful adjustment of the slit systems, one should be able to make the initial direction of the particles very close to horizontal and thus obtain helical trajectories with very closely spaced loops; this will greatly increase the number of particles with very long transit times and enhance the feasibility of the Experiment considerably.

Of course, many of the technical details of this experiment have not been mentioned in the brief description given above. These details are mostly concerned with the production of trajectories that yield transit times long enough to show the effects of gravity on the particles clearly, and the construction of a system of shields adequate to attain a sufficiently low level of stray electromagnetic field strength.

If these technical details can be carried out satisfactorily during the coming summer, the author may be able to complete a search for gravitational repulsion in electrons and positrons.

SUMMARY

In the past, no exception has been found to the rule that all masses in the universe exhibit gravitational attraction toward each other. However, it is also true that the gravitational behavior of certain manifestations of mass, namely the electron and the positron (as well as anti-matter in general), has never been investigated experimentally. This essay outlines an experiment which the author has proposed as a means of observing this behavior and checking to see if either of these particles might exhibit repulsion in the earth's gravitational field.