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Matter-Antimatter Gravitational Interaction

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Abstract

This paper formulates gravitational interaction between matter and antimatter by applying the referenced model[1].

Introduction

In the model, gravitational interaction between matter and matter was formulated. Antimatter-antimatter gravitational interaction was found to be similar to matter-matter gravitational interaction.

The question about matter-antimatter gravitational interaction remains wide open. No theory predicts the relation between electromagnetic and gravitational interactions. Experiments are needed to determine the sign of matter-antimatter gravitational interaction and of antimatter gravitational mass.

Customarily inertial mass is positive, and so is gravitational mass of matter. We now formulate matter-antimatter gravitational interaction under two options.

Assumptions (options):

(a) Gravitational mass of antimatter is positive; **or**

(b) Gravitational mass of antimatter is negative.

Gravitation under assumption (a)

The referenced model is applicable. Separation distances less than inter-momenta distance ($r < S_{12}$) will be considered here. Gravitational interaction between matter and antimatter is *attractive*.

Gravitation under assumption (b)

We denote inertial mass by m_i and gravitational mass by m_g. Force and momentum are in the same direction. Inertial and gravitational masses of matter and antimatter may be related by:

For matter: $m_i = m_g = m$ (1)

For antimatter: $m_i = -m_g = m$ (2)

From (1) and (2) and by analogy with electrodynamics, the *attractive* force between matter ($m_1 = m_{g1}$) and antimatter ($m_2 = -m_{g2}$), due to their separation in space, is mediated by their mass fields, which is expressed in (3). (In the referenced model, this interaction between matter and matter or between antimatter and antimatter is repulsive.)

$$F_s = G_s \frac{m_1 m_2}{r^2}, \qquad (3)$$

where G_s is the *static gravitational constant*.

From (1) and (2), similarly, the *attractive* force between matter ($m_1 = m_{i1}$) and antimatter ($m_2 = m_{i2}$), due to their momenta p_1 and p_2 relative to the Primordial Point, is mediated by their momentum fields, which is expressed in (4). (In the referenced model, this interaction between matter and matter or between antimatter and antimatter is attractive.)

$$F_d = G_d \frac{p_1 p_2}{r^2}, \qquad (4)$$

where G_d is the *dynamic gravitational constant*.

Gravitational interaction between matter and antimatter is *attractive* – throughout the universe.

Gravitational sign under General Relativity

Under Assumption (a), the space-time physical curvature due to antimatter would have the sign same as that due to matter. So, matter-antimatter gravitational interaction is *attractive*.

Under Assumption (b), the space-time physical curvature due to antimatter would have the sign opposite to that due to matter. So, matter-antimatter gravitational interaction is *repulsive*.

Experiment

We are unable to make any suggestions for determining the sign of antimatter gravitational mass.

We suggest the following experiment for determining the sign of matter-antimatter gravitational interaction. Figure 1 is schematic.

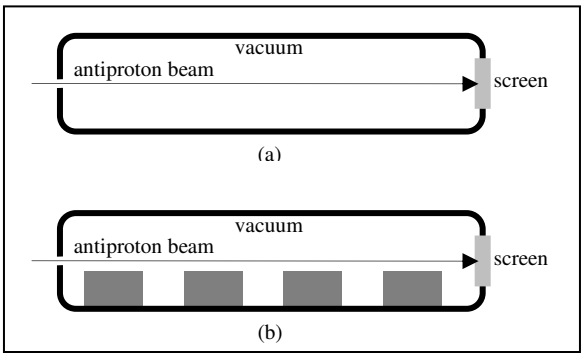

Figure 1. Schematic diagrams for determining the sign of matter-antimatter gravitational interaction.

In Figure 1 (a), a beam of antiprotons (or heavier antiparticles) is sent and a reference point of impact on the screen is noted. In Figure 1 (b), blocks of dense mass are placed underneath the 'path' of beam, a beam of antiprotons is sent, and a new point of impact on the screen is noted. The chamber needs to be 'long' enough to notice the difference between the impact points.

A downward shift of the impact point indicates attractive matter-antimatter gravitational interaction. An upward shift of the impact point indicates repulsive matter-antimatter gravitational interaction.

Summary

Table 1 summarizes the signs of matter-antimatter gravitational interaction as inferred in the previous sections. (AGM means antimatter gravitational mass, GR General Relativity, and RM the referenced model.)

Table 1. Matter-antimatter gravitational interaction.

	AGM positive	AGM negative
GR	*attraction*	*repulsion*
RM	*attraction*	*attraction*

Only if antimatter gravitational mass is negative that General Relativity and the referenced model predict opposite signs for matter-antimatter gravitational interaction. Knowing the sign of antimatter gravitational mass is an important step to understanding gravity further.

Reference

1. Raghubansh P. Singh, *A Constructive Model of Gravitation*, General Science Journal, July 20, 2010.