Does anti-matter matter?

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Abstract. Inability to explain the exact nature of gravity has been puzzling scientists and engineers on Earth since the times of Galileo and Newton. We clarify the definition of "mass" and consider the basic integral properties of matter together with anti-matter in the context of the entire Universe. We demonstrate a practical way of generating repulsive gravity force by imitating the integral properties of anti-atom in the macroscopic form. Experimental verification of presented gravity generation technique is obtained by explaining the expansion of the Universe that has been observed by astronomers[2].

It is universally agreed that in the early Universe amounts of matter and anti-matter were similar[1]. The apparent dominance of matter over anti-matter in the observable Universe today is one of the greatest and most fundamental unsolved problems in physics. Here we show that the observed expansion of the Universe[2] is a clear sign that the amounts of matter and anti-matter in the Universe are and always have been similar. By exploring basic integral properties of anti-matter we show that stable anti-matter in the Universe can only exist as anti-hydrogen in the intergalactic space.

Everything in the Universe is in essence electromagnetic. Despite this quite obvious hint that the force of gravity should also originate in electromagnetism, centuries of research has failed to establish any sensible link between gravity and the electromagnetic reality of matter. As strange as it seems, laws of gravity today remain totally independent of universally observed electromagnetic reality of the Universe.

All forces in Nature have their opposites – they can be either attractive or repulsive. In many centuries of research on Earth no one has ever observed repulsive gravity. What could be a reason for this?

Let's begin with examining a definition of "mass".

"Mass" has been defined by Newton as a "measure of inertia" – a coefficient of proportionality between applied force and resulting kinematic acceleration in an inertial frame of reference. Mass defined in this way turned out to be a convenient way to measure the "amount of matter" in wide range of situations and helped to reinforce the separation between mechanics and electromagnetism. Some cosmological models distinguish between "inertial mass" and "gravitational mass", which only amplifies the confusion.

Let's try to consider "mass" as one of the *integral properties* of electromagnetic oscillation reality. We can actually consider mass as the "energy integral" of electromagnetic oscillations - a measure of their total embedded energy. Einstein has demonstrated[3] that mass is indeed a good measure of embedded electromagnetic energy. As energy integral contains only positive terms, result of integration can only be positive.

Adopting an embedded energy approach, we can predict that the amount of energy embedded in an anti-atom of anti-hydrogen should in essence be very similar to the amount of energy

embedded in atom of hydrogen and therefore "mass" of anti-hydrogen, understood as a measure of its embedded electromagnetic energy required to maintain the structure, should be similar to "mass" of hydrogen.

However, *other integral properties* of anti-hydrogen and hydrogen may differ due to the fact that electromagnetic oscillations in anti-matter are arranged differently: in anti-matter positively charged positrons oscillate around negatively charged anti-proton nuclei.

Specifically, when we integrate the force of interaction between two distant atoms and anti-atoms, we can expect that residual (resultant) force between two distant anti-hydrogen (a***H***) anti-atoms will be opposite to that between two distant hydrogen (***H***) atoms - simply on the basis of general properties of integrals in mathematics.

So, if two distant atoms of ***H*** attract one another due to residual electromagnetic force, two distant anti-atoms of a***H*** should be expected to repel one another with a similar force.

Decades of research and astronomic observations have failed to find an anti-matter star or even a single anti-atom of anti-helium. In view of the above considerations, this is to be expected. Anti-atoms of anti-hydrogen (a***H***) actually repel one another "gravitationally" so that they cannot form a star. It becomes clear, that if anti-matter exists in the Universe in a stable form – it should exist mainly as anti-hydrogen, because conditions for synthesis of heavier anti-matter nuclei are unlikely to arise too often.

Could optical distortions (lensing) of astronomical objects be caused clouds of intergalactic anti-hydrogen? Anti-hydrogen is likely to delay light that travels through it and hence its edges should refract light, forming suspiciously transparent "lenses".

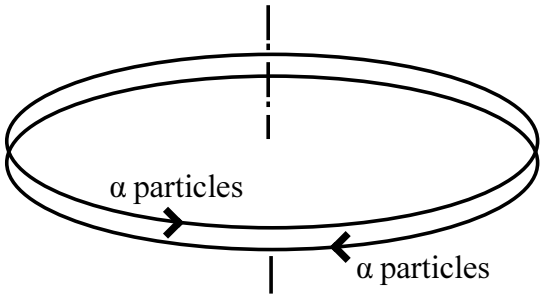
Let's try to consider residual electromagnetic force interaction between matter and anti-matter based on the limited information available on Earth today.

If there existed an attraction force between atoms of hydrogen (***H***) and anti-hydrogen (a***H***), they would have annihilated one another in the early Universe. A repulsive force between ***H*** and a***H***, however, can explain the observed expansion of the Universe from its earliest stages of existence until today.

If repulsive force between ***H*** and a***H*** exists - all residual attraction and repulsion forces in the entire Universe do not cancel out to zero if the amounts of matter and anti-matter in the Universe are similar. The global result is repulsive and hence a young Universe in which amounts of matter and anti-matter are similar is expected to accelerate its expansion at a constant rate.

Have we found an alternative to mysterious "dark matter" and even more enigmatic "dark energy" that dominate current cosmological models? Could intergalactic space be filled by sparsely distributed anti-hydrogen atoms that repel one another as well as matter and hence cause the observable expansion of the Universe?

What experiment can we do on Earth to verify the above considerations? Can we mimic configuration of anti-atom in laboratory conditions? Imagine two coaxial cyclotrons, moving positive ions, such as α-particles for example, in opposite directions.



This is the simplest possible "macroscopic model of anti-atom" that produces no magnetic field if operating parameters of each cyclotron ring are the same, just like an anti-atom. However, in contrast to statistically isotropic electromagnetic oscillations in anti-atom, oscillations in the above system are anisotropic. For this reason, our experiment should create "gravitational anisotropy" detectable along the axis of cyclotrons and proportional to the amount of energy embedded in oscillations of positive charges. Cyclotrons about 1 meter in diameter should be sufficient to demonstrate the effect.

Other strategies for investigating interaction between matter and antimatter are:

1. Study "gravitational" perturbations along axes of existing cyclotrons on Earth that carry positively charged particles
2. Find "cyclotron objects" in the Universe that *eject* large amount of matter along their axes of rotation and study them. For example, consider the process of star formation and the observed fact that during specific stage of star ignition the associated star-forming cyclotron ejects huge jets of matter along its axis of rotation, even though star-forming gravity compression is so strong that atoms of hydrogen are forced to fuse into atoms of helium. Could a presence of sufficient number of Helium nuclei (alpha particles, the simplest positive ions in the world of matter) cycling sufficiently far away from the axis of the cyclotron explain the ejection of mass in two jets both larger than our Solar System? Can the ejection of mass along the axis of star-forming cyclotron be explained any other way?
3. Detect and measure "gravity" acceleration of cold a***H*** atoms created by large particle colliders. In essence this experiment is an "inverse" of the experiment of Galileo: use a vertical vacuum tower and introduce cold a***H*** anti-atoms at the bottom of the chamber. If considerations presented above are reasonable, a***H*** should aim to leave Earth (and then the Solar System) with constant acceleration before colliding at speed with some obstacle composed from atoms and annihilating. Acceleration of a***H*** before collision with matter should be observable in a vacuum tower.

Conclusions

Our conclusions about the electromagnetic Universe that we are part of are based on perceiving and interpreting a very limited set of *integral properties* of a limited number of components of this Universe.

Integration, like averaging, inevitably leads to huge information loss. However, we should have in mind that lack of information is also information and that even in situations when we do not know all details of the processes being integrated - we can still rely on properties of the integration process itself.

Adopting such an approach we can investigate possible properties of gravity force, even if we do not fully understand its origin. We cannot directly integrate electromagnetic interaction forces between two distant atoms to find a resultant (residual) force simply because our models of electromagnetic oscillations in atoms or our equations of electromagnetism are not yet good enough.

However, Nature performs this integration in real time and puts the result in front of our eyes: we all experience gravity force in every moment of our lives. Gravitational attraction between systems comprising many atoms is cumulative, simply because of fundamental properties of an integration process.

Currently unexplained expansion of the Universe with constant acceleration may be a consequence of basic integral properties of anti-matter and matter that co-exist in similar quantities in the Universe, but in different locations. While matter is concentrated in galaxies - anti-hydrogen occupies the intergalactic space.

From considerations presented above it becomes obvious that the Universe should have its Center. Since coalescing matter gradually squeezes anti-hydrogen away from the Center, in a middle-aged Universe the Center should become distinguishable by not expanding, but gravitationally contracting locally, simply because of depleted quantity of locally available intergalactic anti-hydrogen. Can we identify a zone on the Universe that contracts even though "on average" the Universe continues its expansion? As anti-hydrogen is squeezed away from the Center, all matter in the "ageing" Universe will eventually collect in the Center to provide the energy for the next Big Bang. It is possible that our Universe is a result of evolution that took many Bangs that gradually become larger and produced longer lasting and more interesting Universe.

The matter-anti-matter spherically expanding model of the Universe suggests that the background radiation could be originating from decaying anti-hydrogen that exists beyond what we can call an "edge of matter". Observer located away from the Center would perceive the space expanding in all directions, but should be able to detect 'anisotropy" in space expansion along the direction defined by his location and the location of the Center.

It seems that anti-hydrogen delay and anti-hydrogen lensing need to be considered in interpretation of astronomical observations.

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