Antimatter and Relativity.

By

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Abstract.

Recent research, published in *Nature* (Anderson *et al*, 2023 [1]) shows that antimatter, in the form of antihydrogen, falls freely in the presence of a gravitational field. This ought to come as no surprise to any physicist, as it follows, logically, from the Special Theory of Relativity, which proposes that mass and energy are equivalent, and the General Theory of Relativity, which proposes that mass-energy produces gravitational fields, and is affected by them. As antimatter possesses both mass and energy, if the experiment conducted by Anderson and his colleagues had shown any other reaction to the one it did, they would have disproved both of Einstein's theories. 'Exotic matter', rather than antimatter, is the kind that can be expected to evoke an 'anti-gravity' effect.

Keywords: antimatter; gravitational fields; Special and General Theories of Relativity; mass; energy; 'exotic matter'; 'anti-gravity'.

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Recent research, published in *Nature* on the 27th September (Anderson *et al*, 2023 [1]), demonstrated that antimatter, in the form of antihydrogen (atoms consisting of positrons orbiting antiprotons), was attracted by a gravitational field, that of the Earth, falling towards it in laboratory conditions.

This ought to have come as no surprise to them, or anyone else, for Einstein (1905 [2]) had predicted that mass and energy are

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equivalent, and in Einstein (1914 [3]; 1915 [4]) demonstrated that mass-energy, of necessity, both produced, and reacted positively to, gravitational fields, which are curved space-time. Antimatter, like matter, has mass and energy – indeed, in most cases (with obvious exceptions, such as antineutrons and antineutrinos) antimatter particles are only differentiated from their matter counterparts by their opposite electric charge (Quinn, 2003, p.4 [5]).

Exotic matter, on the other hand, otherwise known as 'negative' or 'phantom' matter, unlike antimatter, possesses negative energy (Forward, 1990 [6]), and can be expected, if it exists, to react negatively to the presence of any gravitational field, which would repel rather than attract it. See Morris and Thorne (1988 [7]); Gibbons (2003, 2018 [8]); and Kim (2009 [9]).

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