Comment on "Does Antimatter Fall with the Same Acceleration as Ordinary Matter?"

In a recent Letter [1], Adelberger *et al.* have shown that "equivalence-principle experiments with ordinary matter probe the gravivector acceleration of antimatter in the same way as do direct measurements of antimatter in free fall and set stringent upper limits on the gravivector acceleration of antimatter." I subscribe to this conclusion for electrically neutral antimatter (e.g., antihydrogen), but I wish to note that for the free fall of charged particles the formula $\mathbf{E}=(m\mathbf{g}+q_e\mathbf{V})e$ for the gravitational electric field used by Adelberger *et al.* [1] [their Eq. (3)] is incorrect. Although the neutral case is at present the only one of interest (and the remarks here certainly will not simplify the charged free-fall experiments), it seems useful to clarify this point so that this error does not propagate.

It has been shown [2] long ago that the calculation by Schiff and Barnhill [3] leading to the above electric field of the shield does not take into account the effect of gravity on the lattice of the shield and thus underestimates the shield electric field by about 3 orders of magnitude. (Why the outcome of the experiment of Witteborn and Fairbank [4] on the gravity of electrons was—apparently—in agreement with the formula of Schiff and Barnhill is unclear; the experiment has never been repeated and the analogous one on positrons planned by Fairbank was not concluded. In fact one may ask how meaningful is the result of Ref. [4] since the patch electric field, although considered, was not directly shown to be negligible in Ref. [4].)

Indeed it has to be stressed that the above electric fields from the gravitational effects in the shield are orders of magnitude smaller than those arising from patches on the inside walls of the shields. A typical potential difference between two points separated by a few cm on a sheet of a given metal "uniformly" cleaned and machined can easily be 10 mV [5]. If the pipe inside which the particles fall has a height of, say, 10 m and a diameter of 1 m, it does not seem trivial to reduce the average patch electric field along the trajectory of the falling particle to below 3×10^{-8} V/m, which corresponds for a proton to an acceleration equal to that of gravity. Thus the Schiff-Barnhill and Dessler-Herring electric field is in practice most likely submerged in the patch field. As already stated, the only *hope* of a direct measurement, if one still wishes to pursue this line after the results of Refs. [1] and [6], is comparing the fall of a neutral system and its antisystem.

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[4] F. C. Witteborn and W. M. Fairbank, Phys. Rev. Lett. **19**, 1049 (1967); Nature (London) **220**, 436 (1968).
[5] This can be measured by a vibrating reed electrometer. It also results from our experiments that search for quarks [M. Marinelli and G. Morpurgo, Phys. Rep. **85**, 161 (1982)] and is confirmed by the analogous experiments of P. F. Smith *et al.* [Phys. Lett. B **181**, 407 (1986)]. Actually, Witteborn and Fairbank stated (Fairbank used this also in connection with his search for quarks) that the patch effect in Cu at the liquid-He temperature was very small. This may well have been so in one case, but patch effects are typically erratic (depending on the conditions of the surface) and it is hard to see how a decrease in temperature can make the potential on a metal surface uniform.
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