Comment on "Gravitomagnetic Pole and Mass Quantization"

It appears to us that some conceptual issues which were raised by Zee[1] in his Letter need to be clarified.

The first is the question of whether it is the total energy or the rest mass which is quantized in the field of a gravitational monopole. Our analysis,[2] based on an exact analogy between rotation in stationary spacetimes and magnetic fields, shows quite clearly that it is the conserved energy of the test particle which serves as the gravimagnetic coupling constant. Hence it is the conserved energy which is quantized. A related question is whether the photon energy will be quantized. Our approach,[2] which does not rely on the post-Newtonian approximation, applies to photons as well and shows again that the conserved frequency of the photon is quantized.

Quite independent of the subtleties of gravitational monopoles or the Newman-Unti-Tamburino[3] (NUT) solution, within the framework of conventional quantum mechanics, energy quantization in units of E would imply a time periodicity of all wave functions with period $T=2\pi\hbar\epsilon^{-1}$. If ϵ were as large as Zee suggests (10^{-23} eV), events would repeat every thirteen years or so, which could not have been missed.

Zee's motivation, as made clear in his Erratum, was not to study solutions of the standard theory, but to search for a more general theory. We point out that the pathology of closed timelike curves is not special to the NUT solution, but afflicts gravitational monopoles in general. In particular, this also applies to the gravitational analog of the 't Hooft–Polyakov monopole, should such a thing be found. If there is a two-dimensional surface S over which the gravimagnetic flux integral ($\int_S \mathbf{B}\cdot\mathbf{d}$ in Zee's notation) is nonzero, it can be shown[2,4] quite generally that closed timelike curves exist.[5] This argument is independent of Einstein's field equations and so has general validity. Thus, going to a more general theory will not help.

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[1]A. Zee, Phys. Rev. Lett. **55**, 2379 (1985), and **56**, 1101(E) (1986).

[2]J. Samuel and B. R. Iyer, "A Gravitational Analog of the Dirac Monopole" (to be published).

[3]E. T. Newman, L. Tamburino, and T. Unti, J. Math. Phys. (N.Y.) **4**, 915 (1963); C. Misner, J. Math. Phys. (N.Y.) **4**, 924 (1963).

[4]S. Ramaswamy and A. Sen, J. Math. Phys. (N.Y.) **22**, 2612 (1981); A. Magnon, to be published.

[5]In the language of fiber bundles, there are no nontrivial line bundles over S^2, but only S^1 bundles.