CONCERNING THE EXISTENCE OF A MONOPOLE

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It is suggested that the existence of the Dirac monopole is forbidden by conservation of parity in electromagnetic interactions. Such an hypothesis explains in a natural way the negative result of attempts to observe the monopole experimentally.

At one time Dirac hypothesized the existence of an isolated magnetic charge—the monopole;[1] the relation $g_0 = e_0/2\alpha$ was established for the minimum pole strength g_0, where α is the fine-structure constant and e_0 is the elementary electrical charge. Experiments[2-4] dedicated to the search for a monopole with the properties predicted by Dirac gave negative results. The upper limit on the cross section for the production of a monopole-antimonopole pair lies between 10^{-35} and 10^{-40} cm^2/nucleon, whereas this cross section, according to a theoretical estimate (see [3]), must be greater than 10^{-34} cm^2/nucleon. Thus, a considerable discrepancy exists between the predicted and the actually observed values. This suggests the existence of a strong restraint which inhibits the production of monopoles.

In the present note we wish to call attention to the fact that parity conservation in the electromagnetic interactions may be such a restraint.

Actually, Maxwell's equations in the presence of monopoles take the following form:

$$\partial F_{\mu\nu}/\partial x_\nu = \frac{4\pi}{c} J_\mu^{(e)}, \qquad \partial F^*_{\mu\nu}/\partial x_\nu = \frac{4\pi}{c} J_\mu^{(m)}, \qquad (1)$$

where $F_{\mu\nu}$ is the electromagnetic field tensor; $F^*_{\mu\nu} = \frac{1}{2}\delta_{\mu\nu\rho\sigma}F_{\rho\sigma}$ ($\delta_{\mu\nu\rho\sigma}$ is the Levi-Civita tensor); $J_\mu^{(e)}$ and $J_\mu^{(m)}$ are the four-currents associated, respectively, with electric and magnetic charges.

The behavior of Eqs. (1) under the inversion transformation depends essentially on what properties are attributed to the current $J_\mu^{(m)}$. If $J_\mu^{(m)}$ is a pseudovector, then parity is conserved, whereas the hypothesis that $J_\mu^{(m)}$ is a vector corresponds to parity nonconservation. It is necessary to emphasize that both possibilities are a priori completely equal in rights, and it is impossible to give preference to either one of them.[1)] However, the second is more attractive, since it relates in a natural way the absence of monopoles to parity conservation in the electromagnetic interactions. On the other hand, the extent of parity nonconservation in electromagnetic interactions can be estimated by independent methods, as is done, for example, by Sachs.[5] This enables one to establish an upper limit on the probability for the production of monopoles in nucleon-nucleon collisions, and also in any other processes associated only with the electromagnetic interaction.

Following Sachs, we write the pseudoscalar part of the electromagnetic interaction Lagrangian in the form

$$L_{ps} = \xi J_\mu A_\mu,$$

where ξ is a dimensionless parameter, J_μ is the vector current, A_μ is the pseudovector potential. The parameter ξ, according to Sachs' estimate, has a small value: $\xi < 10^{-13}$.

It is obvious that the introduction of the parameter into the interaction Lagrangian is equivalent to a reduction of the coupling constant (the new coupling constant $e' = \xi e$). Since expression (2) for L_{ps} gives an upper limit on the magnitude of the pseudoscalar part of the Lagrangian for the interaction of a monopole with an electromagnetic field, then it is easy to verify that the coupling constant of a monopole with an electromagnetic field is reduced no less than 10^{14} times[2)] in com-

[1)]In the article by Sachs,[5] for example, $J_\mu^{(m)}$ is assumed to be a pseudovector; in the article by Cabibbo and Ferrari,[6] it is assumed to be a vector; moreover, the essentially arbitrary nature of each of these assumptions is not emphasized in either of these articles.

[2)]The numerical estimates given are based on the assumption that Sachs' estimates[5] are correct.

parison with the Dirac value $g_0/\sqrt{\hbar c}$. Consequently the effects of the interaction of the monopole with matter (in particular, its ionizing ability) become negligibly small, and the corresponding cross section must be at least 10^{28} times smaller than that cited in [3]. Such values lie far beyond the limits of experimental feasibility.[2-4]

If it turns out that monopoles will be observed with a probability greater than that which is allowed by the degree of parity conservation in the electromagnetic interactions, then this will speak in favor of the pseudovector nature of the current $J_\mu^{(m)}$. But then the question of the reasons why monopoles are not produced in nucleon-nucleon collisions with a probability greater than 10^{-34} cm^2 per nucleon remains open.

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