SOVIET PHYSICS USPEKHI VOLUME 8, NUMBER 2 SEPTEMBER-OCTOBER 1965

538.1

SUPPLEMENT TO THE ARTICLE BY S. DEVONS, "SEARCH FOR THE MAGNETIC MONOPOLE"

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Usp. Fiz. Nauk 85, 761-762 (April, 1965)

THE article by Devons[1] gives an introduction to one of the problems of contemporary physics that has so far not been definitely solved.

If Dirac's prediction is correct—that there exists an elementary magnetic charge, whose magnitude is about seventy times the magnitude of the elementary electric charge—then that should be a very "observable" particle. The ionization losses of a magnetic charge of such a large magnitude should be three orders of magnitude larger than for an electric charge. If a magnetic charge were to fall upon the emulsion of a nuclear photoplate, its track would be impossible to overlook. The energy losses of a magnetic charge by Vavilov-Cerenkov radiation, as was shown by A. A. Kolomenskiĭ,[7] should also be several orders larger than the energy losses of an elementary electric charge. It would therefore be difficult not to register a magnetic charge if it fell into a Cerenkov counter. O. S. Mergelyan[2] studied still another purely classical radiation effect—translational radiation of a magnetic charge incident upon the boundary of a refracting medium. In this case the energy of the radiation is also proportional to the square of the magnetic charge, i.e. the radiation should be large. We add that in the last two cases (Vavilov-Cerenkov and transitional radiation), the polarization of the wave being studied differs sharply from that produced by an electric charge. Thus the large predicted magnitude of the magnetic charge makes it possible to suggest a number of effects by which this charge can be distinguished from an electric charge and registered. Nevertheless a magnetic charge has up to the present not been discovered, despite a series of experiments conducted very recently, with use of the whole arsenal of resources of modern physics. One interpretation of this fact can be that no magnetic charge exists in nature. But so long as such an assertion has not been formulated in the form of a prohibition that flows out of physical laws, it cannot be taken for granted; in any case it seems no more convincing than does the contrary assertion of the existence of the magnetic charge. No prohibition of the existence of a magnetic charge has so far been formulated, although many physicists consider that a magnetic charge does not exist. Another interpretation of the unsuccessful experiments for discovery of a magnetic charge can be that, because of these or those reasons, magnetic charges are very rare in nature.

These two explanations, however—either magnetic charges do not exist, or there are very few of them—do not exhaust all possibilities. It may turn out that the theoretical ideas about magnetic charge that exist at present are themselves far from complete. In such a case, the negative result of the experiments for discovery of magnetic charge finds its natural explanation in the fact that physicists are not looking where it is necessary to look and are not looking for what actually exists. For example, it is still not clear what properties should be possessed by the four-dimensional current J_μ connected with a magnetic charge. Such a current may be either a vector or a pseudovector. If J_μ is a pseudovector, then the parity of the field of a magnetic charge will be the same as the parity of the field of an electric charge. If J_μ is a vector, then the parity of the fields of electric and magnetic charges is opposite. Obviously if J_μ is a pseudovector, then the parity of the electromagnetic field is conserved, and in the contrary case parity is not conserved. As was shown by L. M. Tomil'chik[3], the last possibility can explain naturally the experimental fact of the nonexistence of magnetic charges, if we suppose that parity is conserved in electromagnetic interactions. The conservation of parity in electromagnetic interactions is not absolute; therefore from the supposition of a vector character of magnetic current there follows no absolute prohibition of the existence of magnetic charges. The degree of nonconservation of parity in electromagnetic interactions can be estimated by an independent method, as was done, for example, by M. Sachs[4]. This permits setting an upper limit to the cross sections for processes due to interaction of magnetic charges with an electromagnetic field. The estimate shows that the constant of coupling of a magnetic charge with the electromagnetic field should be smaller by a factor no less than 10^{14} by comparison with the Dirac value g (if J_μ is a vector and if the estimates of M. Sachs are right). Thus, though the supposition of vector character for J_μ does not impose an absolute prohibition against the existence of a magnetic charge, it easily explains the negative results of all the attempts to detect a monopole experimentally.

We mention also the problem of the symmetry of Maxwell's equations with respect to electric and magnetic charges. The very fact of the existence of this symmetry has served for a long time as an argument in support of the existence of magnetic charges. This symmetry, however, can not be successfully preserved in the formulation of a variational principle, from which would be obtained, simultaneously, the field equations and the equations of motion of the particles, with simultaneous "coexistence" of electric and magnetic charges. P. A. M. Dirac, in formulating a variational principle, introduced for the description of a magnetic charge a certain nonphysical quantity, of which there is no necessity if it is an electric charge that is involved. A variational principle in which electric and magnetic charges would be on a par has so far not been formulated. Certain attempts to formulate such a principle[6] served rather to emphasize the difficulty of the problem than to contribute to its solution. This difficulty, also, may point to the incompleteness of our notions about magnetic charge. It is possible that from this there also follows some prohibition against the existence of monopoles.

[1] S. Devons, Sci. Progr. 51, 601 (1963); Russian translation, UFN 85, 755 (1965). References 13*—16* were added by the translator.
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[7] A. A. Kolomenskiĭ, Vestn. MGU 3, No. 6 (1962).

Translated by W. F. Brown, Jr.