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Making magnetic monopole out of ordinary fields

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Since the ancient times, people have been wondering why there is no such thing as a magnetic pole, why every magnet, including the Earth itself, is a dipole with two poles, and why nobody succeeded to cut a magnetic dipole into two halves, carrying only one type of magnetic charge each, northern or southern. This fact becomes more interesting after one inspects the basic Maxwell equations of electrodynamics that readily admit inclusion of magnetic charges on the same ground as the well-known electric charges. However, Paul Dirac established that a magnetic monopole cannot exist alone: it must be supplemented by what is now called the Dirac string–an infinitely thin solenoid, which canalizes all the magnetic lines of force diverging to the monopole outwards. Later he established that quantum mechanics states that if at least one magnetic monopole exists in the whole world, all electric charges would have discrete values. If we accept the charge of the quark, the smallest constituent of matter, to present the necessary quantum of charge, the corresponding value of the magnetic charge would be tremendous. However, up to now no magnetic charge has been discovered anywhere in nature. The reason may be that the magnetic charge is a very special object, called a pseudo-scalar, the scalar that changes its sign under reflection in a mirror. No fundamental object of this sort is known, but it can be readily constructed as the scalar product of a magnetic and electric fields. Therefore, to build a magnetic monopole one might try to combine multiplicatively an electric monopole with these two fields. However, the classical electrodynamics of Maxwell and Faraday admits only linear combinations of fields, the fields are independent and they do not influence each other. The situation becomes different when quantum electrodynamics by Feynman and Schwinger comes into play. In that theory the quantum of electromagnetic field, photon, creates virtually a pair of electrically charged particles, electron and positron, that later annihilate back to a photon. But, while existing in the state of the charged particles, the photon might interact with other electromagnetic fields and with itself. This is how, in quantum theory, electromagnetic fields interact between themselves. Correspondingly, the modified Maxwell equations become non-linear already in the vacuum. If we place a point-like electric charge into a combination of constant electric and magnetic fields with non-zero scalar product between them, the non-linear Maxwell equations produce the magnetic response, which carries a single point-like magnetic charge. Unlike the Dirac monopole proper, this one, cooked of ordinary fields, is not spherically symmetrical. It has two Dirac strings stretched along the above electric and magnetic fields, which merge to one if these fields are parallel. However, this modified monopole cannot serve to establish the discreetness of electric charges in Dirac's way. Hence the problem raised by his consideration remains unsolved, although a magnetic monopole has been made.

Biography

Anatoly Shabad is educated from Moscow State University (1956-1962). He acquired his Candidate of Science (1968) and Doctor of Science (1986) degrees in P N Lebedev Phys. Inst., Russian Academy of Sciences. He is affiliated with this institute since 1965, now as Principal Researcher of I E Tamm Dept. of Theor Phys. He served two terms as a Deputy to the Parliament of the Russian Federation, 1990-1996, was a supporter of the Yeltsin-Gaidar reforms. His works are in the fields of quantum mechanics, optics, quantum theory of gauge fields and quantum plasma theory. His main achievements relate to nonlinear effects associated with quantum electrodynamics with strong external fields. Among these are the photon capture by magnetic field of a pulsar, accompanied by formation of a mixed state between the photon and the positronium atom, renormalization of the magnetic and electric dipoles of elementary particles due to the self-interaction of their electromagnetic fields, presence of a magnetic response to an electric source in external fields, especially in the form of a magnetic monopole. Also an upper bound possible value of the magnetic field is found to be supplied by the phenomenon of collapse of positronium in a strong magnetic field.

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