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Communication

The Magnetic Monopole and the Aharonov-Bohm Effect

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Abstract - A very interesting comment by Nobel laureate Gerard't Hooft is the "discovery that unifying the forces of physics requires the existence of magnetic monopoles". We examine this proposal through the prism of the Aharonov–Bohm effect

Keywords - Quantum gravity; Magnetic monopole; Hemispherical power asymmetry; Cosmic microwave background; Aharonov-Bohm effect.

As a thought experiment, suppose that electricity and magnetism are exactly the same thing. This thought experiment will be backed up in the text underneath Fig. 1, by the scientific experiment conducted in 1986 by Akira Tonomura and his colleagues [1]. The only apparent difference between electricity and magnetism is the frame of reference.

While an observer stationary with respect to an electric charge will see it as a source of electric field only, a second observer moving relative to the first will see the same charge as a source of both electric and magnetic fields in a way dictated by special relativity [2].

Every particle of matter has a quantum spin of 1/2 which means it must be completely rotated twice (through 720 degrees) to resume the same quantum state. And a Mobius strip needs to be traveled around twice to reach the starting point. A possible result is that the Mobius is involved in the composition of particles. Instead of focusing on the mass of particles following the contours of the strip, we could imagine the electric charges of all the universe's particles - positive, negative, totally canceling and neutral, or partly canceling and reduced - obeying the undulations of the Mobius.

Recalling the frames of reference, this waviness can also represent magnetic polarity. A classical view could be adopted in which magnetic polarity is associated with positive / negative / neutral / reduced charges of individual particles. Then it would be natural to believe that, just as particles can have (overall) either positive or negative electric fields, they can also possess the single polarity of either a North or South magnetic field. Alternatively, a topological interpretation could be adopted. Since this involves Mobius strips as components of matter, it might be called a quantum-mechanical interpretation. In this, attention is not concentrated on individual and separate particles. Quantum Mechanics and General Relativity are combined to show how the topological and subatomic quantum world might be joined with the

cosmic world. In the cosmic, the collection of the universe's particles, electric fields, and magnetic fields are united by obeying one thing - the following of Mobius undulations. This quantum mechanical or unified field-view doesn't say individual particles include magnetic monopoles. It says the cosmos itself may be the monopole. If the universe only has either a North or South pole, this Super-Asymmetry of known temperature-magnetism interactivity might account for Hemispherical Power Asymmetry where the Cosmic Microwave Background (CMB) has very slight temperature differences in its celestial hemispheres.

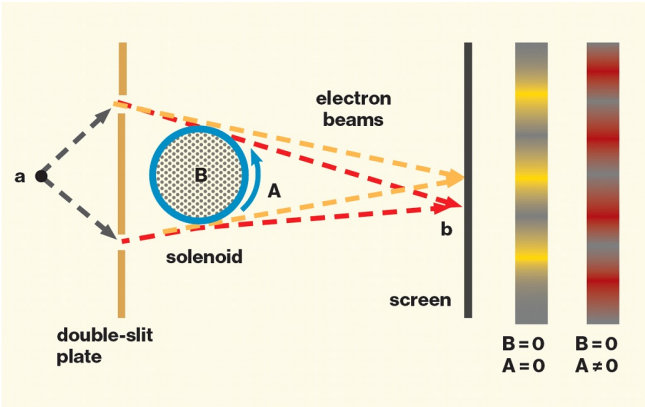

Figure 1: The Aharonov–Bohm effect: Electrons from 2 slits pass by a solenoid (an electromagnet) on its upper and lower side. The electrons form interference patterns on the screen. Without a magnetic field in the solenoid, the interference pattern is like the yellow palette. With a magnetic field inside the solenoid but not outside, the electrons form the interference pattern shown on the red palette. In quantum mechanics, the result is interpreted as being directly related to the vector potential which causes the shift of the interference pattern. The electromagnetic equations of 19^{th} century Scottish physicist James Clerk Maxwell had been written in terms of both the electric (**E**) and magnetic (**B**) fields and a concept called the "potentials." There are 2 electromagnetic potentials - an electric scalar one, often denoted by ϕ; and a magnetic vector potential, written as **A**. An electrically charged particle like an electron is affected by **A**, despite being confined to a region in which both the magnetic field and electric field are zero. The physical reality of electromagnetic potentials (**A** not equaling zero) was shown by the experiment of Dr. Tonomura et al. (Google search, public-domain image)

Referring to Fig. 1 - the vector potential causes the shift of the interference pattern but it could be said that magnetism affects the charged electrons by causing the shift since the vector potential is magnetic. If electric and magnetic fields are identical (except for the frame of reference), then the electric charges will also affect the solenoid's magnetic field. By extension, the combined charges of all the particles in the universe will affect cosmic magnetism. The magnetic Aharonov–Bohm effect is also closely related to Paul Dirac's argument that the existence of a magnetic monopole can be accommodated by Maxwell's equations if both electric and magnetic charges are quantized. If electric fields are made to pulsate, the pulses could correspond to binary digits' on-off sequences and an electron's charge would be quantized. Magnetism would also be quantized if an electric and magnetic fields are identical (apart from the reference frame). The universe's combined charges can thus shift cosmic magnetism away from the human- or astronomic- scale detection of magnetic fields of individual particles, objects, even galaxies. They would shift magnetism to a universal scale with the cosmos itself being the magnetic monopole and possibly accounting for the CMB's Hemispherical Power Asymmetry.

References

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