MAR10-2009-004399

Abstract for an Invited Paper
for the MAR10 Meeting of
the American Physical Society

Measurement of the charge and current of magnetic monopoles in spin ice

SEAN GIBLIN, ISIS Facility, Rutherford Appleton Laboratory, Chilton, Oxfordshire OX11 0QX, U.K.

The transport of electrically charged quasiparticles (based on electrons, holes or ions) plays a pivotal role in modern technology as well as determining the essential function of biological organisms. In contrast, the transport of magnetic charges has barely been explored experimentally, mainly because magnetic charges are generally considered to be, at most, convenient macroscopic parameters rather than sharply defined quasiparticles. However, the recent proposition of emergent magnetic monopoles in certain materials may change this point of view. Here we address the question of whether these magnetic charges and their associated currents ('magnetricity') can be directly measured in experiment, without recourse to any material-specific theory. By mapping the problem onto Onsager's theory of electrolytes, we show that this is possible, and devise an appropriate method. Then, using muon spin rotation as a convenient local probe, we apply the method to a real material: the spin ice $Dy_2Ti_2O_7$. Our experimental measurements prove that magnetic charges exist in this material, interact via a Coulomb interaction, and have measurable currents. We further characterise deviations from Ohm's Law, and determine the elementary unit of magnetic charge to be 5 $\mu_B Å^{-1}$. We show further results from magnetic susceptibility confirming the Wein effect and that the surface of the crystal behaves like a capacitor, storing charge, with the resultant relaxation described by the dissociation and recombination of charge carriers. The measurement of magnetic charge and observation of magnetic current emphasises the reality of these quantities and establishes an instance of a perfect symmetry between electricity and magnetism.