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Dirac Strings and Magnetic Monopoles in the Spin Ice, $Dy_2Ti_2O_7$

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Recent proposals in condensed matter physics that magnetic monopoles can appear as emergent quasiparticles have attracted wide levels of interest. Dirac's original picture of magnetic monopoles had them connected to strings through which magnetic flux flowed. Here we report studies into a system called Spin Ice. Spins on magnetic ions mimic the hydrogen bonds in water ice, obeying "ice rules" of 2 spins into and 2 spins out of their tetrahedron. In these materials it has been predicted that strings of spins form screening the applied magnetic field via a 3D Kasteleyn transition [1]. The geometry of spin-ice allows for net magnetic charge (magnetic monopoles) to form where "ice rules" are broken at the tips of the strings [2]. Here we present three experimental pieces of evidence for these strings and magnetic monopoles [3]. Magnetization data confirms the Kasteleyn transition leads to the formation of strings of spins. Neutron scattering then is used to measure the field dependent behavior of these strings, along which **B** flows towards the monopoles analogous to Dirac strings and therefore $\nabla \cdot \underline{B} = 0$ remains intact. Finally heat capacity results can be described by a gas of magnetic monopoles interacting via the magnetic Coulomb interaction.

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