Department of Physics
Condensed Matter Physics
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UNIVERSITY OF OXFORD

CONDENSED MATTER SEMINAR

Thursday 14 February at 2.15pm

"Magnetic Monopole Noise"

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Magnetic monopoles are hypothetical elementary particles exhibiting quantized magnetic charge $m_0 = \pm(\mathrm{h}/\mu_0\mathrm{e})$ and quantized magnetic flux $\Phi_0 = \pm\mathrm{h}/\mathrm{e}$. A classic proposal for detecting such magnetic charges is to measure the quantized jump in magnetic flux Φ threading the loop of a superconducting quantum interference device (SQUID) when a monopole passes through it. Naturally, with the theoretical discovery that a plasma of emergent magnetic charges should exist in several lanthanide-pyrochlore magnetic insulators including $Dy_2Ti_2O_7$, this SQUID technique was proposed for their direct detection (*Nature 451*, 42 (2008)). Experimentally, this has proven extremely challenging because of the high number density, and the generation-recombination (GR) fluctuations, of the monopole plasma. Recently, however, theoretical advances at Oxford have allowed the spectral density of magnetic-flux noise $S_\Phi(\omega, T)$ due to GR fluctuations of $\pm m_*$ magnetic charge pairs to be determined. These theories present a sequence of strikingly clear predictions for the magnetic-flux noise signature of emergent magnetic monopoles. In response, we developed a high-sensitivity, SQUID based flux-noise spectrometer, and used this new instrument to measure the frequency and temperature dependence of $S_\Phi(\omega, T)$ for $Dy_2Ti_2O_7$ samples. Virtually all the elements of $S_\Phi(\omega, T)$ predicted for a magnetic monopole plasma, including the existence of intense magnetization noise and its characteristic frequency and temperature dependence, are detected directly. Moreover, comparison of simulated and measured correlation functions $C_\Phi(t)$ of the magnetic-flux noise $\Phi(t)$ reveals that the motion of magnetic charges is strongly correlated. A final striking observation is that, since the monopole GR time constants $\tau(T)$ are in the millisecond range for $Dy_2Ti_2O_7$, magnetic monopole flux noise amplified by the SQUID is audible to human perception.

Host: Siddharth Parameswaran

Simpkins Lee Room, Beecroft Building