Unconventional Magnetism Seminars

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Classical order by disorder: a theoretical study towards its detection in a real frustrated system of magnetic monopoles

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Both thermodynamics and common sense tend to associate temperature with disorder. Nonetheless, some frustrated systems contradict intuition: their disordered ground state develops long-range order thanks to thermal fluctuations. Although this mechanism --known as classical order by disorder (OBD)-- has been studied theoretically for more than thirty years, it has never been conclusively observed in the laboratory. Following a recent work [Phys. Rev. Lett. 117, 167203 (2016)], we address the possibility of its detection in a scenario that is as interesting as the phenomenon itself: a fluid of magnetic charges or monopoles.

A crucial question to ask when dealing with real systems is how to determine that the main cause of order is indeed the entropy term in the free energy, and not uncontrolled perturbations changing the internal energy of the massively degenerated manifold. In this talk we explore in detail this point, proposing antiferromagnetic Ising pyrochlores as promising materials to study this problem. While it is never possible to switch off every term affecting the unperturbed Hamiltonian in any real systems, the physics on these materials naturally suggest the reverse approach: the entropy-driven tendency towards magnetic charge order can be detuned by means of an easily-controllable parameter. In this way, we manipulate the magnetic field to change the type of excitations occurring at fixed temperature. This allows us to gauge the importance of the OBD mechanism by its effect on the staggered charge density (the order parameter). Using Monte Carlo simulations, we apply this method for the particular case of dipolar interactions which, aside from being expected to be present in real materials, allow understanding the perturbation as an attraction among Coulomb charges. In principle, the same ideas could be applied to any other perturbation terms. We also study the case of a misaligned magnetic field, which is special since the control parameter used to put in evidence the OBD mechanism is also a force driving the order. With the intention to bridge the gap between theory and experiment, we show how the ordering effect of thermal disorder could be observed in real materials using neutron scattering techniques.

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