Innovative Inelastic Neutron Scattering

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Exploring the phase diagram of the Shastry-Sutherland compound, SrCu2(BO3)2

Chasing new states of quantum matter is a central element in condensed matter physics, motivated both by fundamental curiosity but also by the need for a better understanding of many-body quantum effects for future technologies. Of particular interest are frustrated magnets where competing interactions may lead to exotic magnetic states and an external parameter such as magnetic field or pressure can be used to tune the system from one quantum state to another. The Shastry-Sutherland (SS) lattice is such a frustrated system. It consists of spin pairs (dimers) embedded in a square lattice and with inter-dimer coupling, J, and intra-dimer coupling J'. It has an exact dimer product ground state for $J'/J \leq 0.675$ [1]. Upon increasing the ratio of J'/J, the system goes through a quantum phase transition to a plaquette singlet state followed by a Néel phase [2]. SrCu2(BO3)2 (SCBO) is a unique material since it is topologically equivalent to the SS lattice [3]. With $J'/J \sim$ 0.6 close to the critical point, SCBO presents remarkable experimental testing grounds for the SS model. The ratio J'/J may be altered by applying pressure and the resulting phase diagram resembles that theoretically predicted for the SS model [4,5]. As a frustrated magnetic system, SCBO exhibits a series of phase transitions upon applying a magnetic field [6,7]. However, with the first transition to the 1/8 magnetization plateau occurring at 27T, these phases are beyond reach for standard neutron scattering experiments and hence direct evidence as to the static and dynamic magnetic behavior is lacking. One way of tuning these magnetic-field-induced transitions to a reachable regime is by applying pressure [8,9]. We demonstrate how to carry out such high-pressure, high-magnetic-field and low-temperature neutron scattering experiment and also discuss the associated challenges with regards to the data analysis.

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