AHMF& Cadet Program Joint Lectures and seminar

先端強磁場科学研究センター＆カデットプログラム共催講義とセミナー

講師 (Speaker): Dr. Alexander Smirnov (P. L. Kapitza Institute for Physical Problems of the Russian Academy of Sciences, Russia)

場所 (Venue): 講義(Lectures) 2F Meeting room in the old KYOKUGEN center
極限科学研究棟２階会議室
セミナー(seminar) H601 meeting room (tentative)
理学研究科 H 棟 601 会議室

Lecture 1: Low frequency dynamics of spin-gap magnets. (November 20, 13:00-14:30)

Abstract: Magnetic dielectric crystals with antiferromagnetic exchange usually exhibit antiferromagnetic ordering at a temperature of the order of the exchange integral. Nevertheless, crystals with a special arrangement of antiferromagnetic exchange bonds (spin chains, dimer networks, frustrated lattices) demonstrate a strong delay of the magnetic ordering till very low temperatures, or do not order even at absolute zero. The ordered spin component in the ground state may be equal to zero (in this case we speak about spin-liquids) or is strongly reduced in comparison with the nominal value. Quantum fluctuations destroy the ordered state, proposed for these systems from the classical point of view. In this sense, quantum magnets are analogous to liquid helium, which does not crystallize or solidified at absolute zero. However, the spin-disordered ground state appears to be strongly correlated and its excitations are quantized modes of spin motion, which are drastically different from conventional magnons. Magnons in conventional magnets are oscillations of the order parameter, while ordering is absent in quantum magnets. We shall discuss quantum magnets demonstrating excitation spectra with a spin gap, which stabilizes a spin liquid state. In spin-gap quantum magnets the excitations are quantized and carry spin $S=1$, they may be excited by transmitting quantized energy and momentum from neutrons or photons, enabling the experimental study. This study resolves the general view of the spectrum, as well as the fine structure. We will discuss some of these experiments.

Lecture 2: Spin dynamics of gapless spin liquids (December4, 13:00-14:30)

Abstract. Solving the Heisenberg problem for $S=1/2$ antiferromagnetic spin chain resulted in a set of new concepts, challenging experimentalists to check the theoretical predictions. It was shown theoretically, that excitations of $S=1/2$ antiferromagnetic chain are fractionalized, i.e., carry spin S=1/2, in contrast to triplet excitations of Haldane (S=1) chains. The spin structure corresponding to fractionalized excitations (spinons) corresponds rather to a delocalized domain wall than to a flipped spin, as in a conventional antiferromagnet or in the spin gap magnet. The concept of unbound fermions within the one-dimensional chain has resulted in several unexpected

predictions in spin dynamics. At first, for neutron scattering or photon absorption, these excitations provide a continuum of the transmitted energy for a fixed wavevector, since fermions are excited by pairs, having the total spin S=1. Further, the fermion character of excitations presumes incommensurate soft modes at distinct field-dependent momentum values. The presence of well defined quasiparticles implies high heat conductivity along the chains. And finally, uniform Dzyaloshinsky-Moriya interaction was predicted to provide a fine structure of the energy spectrum in the middle of the Brillouin zone due to a modification of the continuum. We shall discuss the experimental proofs of these predictions.

Seminar: Thermodynamics and spin dynamics of selected triangular lattice antiferromagnets. (December18, 13:00-14:30)

Abstract. Triangular antiferromagnets provide one of the simplest models of frustration of the exchange interaction. One of the features of frustration is the impossibility of the minimization of the energy of interaction for pairs of magnetic ions in the ground state of the whole multi-spin system. Besides, frustrated systems demonstrate a strong degeneration of the states, which minimize the molecular-field energy. In case of 2D triangular lattice antiferromagnet this degeneracy is lifted by the so-called order-by disorder mechanism, where ground state is selected due to fluctuations, which give different contributions to the free energy for different degenerate configurations. We shall discuss a quasiclassical S=5/2 triangular lattice antiferromagnet $RbFe(MoO_4)_2$ with the ideal triangular lattice and S=1/2 antiferromagnet Cs_2CuCl_4 with a distorted triangular lattice. First we will consider experiments with the first compound, which demonstrate a “1/3”- plateau of magnetization in the correspondence with the scenario of the selection between the degenerate states by means of the fluctuations. Further, we shall analyze the quasi 2D S=1/2 model with distorted triangular lattice, which demonstrates completely different behavior. This behavior includes continuum of fractionalized excitations, cycloid–type ordering and magnetic phases controlled by tiny residual interactions. Experiments testing these features will be described. In particular, experiments uncover an exotic coexistence of magnon and spinon modes.