Observation of pressure effect on excitation spectra in the triangular-lattice antiferromagnet Cs_2CuCl_4

The effect of pressure on the spin dynamics in Cs_2CuCl_4, a spin-1/2 Heisenberg antiferromagnet on a triangular lattice, was studied by means of high-field electron spin resonance spectroscopy. A pronounced shift of the exchange mode under applied pressure was observed in the fully spin-polarized phase. Our finding clearly suggests that pressure can be used as a tuning parameter, controlling spin-Hamiltonian parameters in Cs_2CuCl_4.

Spin-1/2 Heisenberg antiferromagnets on triangular lattices form an important class of low-dimensional spin systems, allowing to probe effects of quantum fluctuations, magnetic order, and frustrations. Among other frustrated spin systems, Cs_2CuCl_4 and Cs_2CuBr_4 are two the most prominent members of the this family. Although magnetic properties of these two materials are very well studies, a lot of important questions still remain open. One of the main problem to solve is the presence of 1/3 and 2/3 saturation magnetization plateaus, which were revealed in Cs_2CuBr_4, but not the in isostructural material Cs_2CuCl_4[1]. The reason of such striking difference (and some other very important peculiarities) remains unclear.

Systematic electron spin resonance measurements of Cs_2CuCl_4 and Cs_2CuBr_4 have been performed by us. Studying the magnetic excitations spectrum in the magnetically saturated phase allowed us to accurately describe the magnetic excitation spectra in both materials and, using the harmonic spin-wave theory, to determine their exchange parameters [2]. Apart from that, in Cs_2CuBr_4 we observed the presence of a substantial zero-field energy gap, ~10 K. The experimental data are compared with results of model spin-wave-theory calculations for spin-1/2 triangle-lattice antiferromagnet, revealing very good agreement [3].

In the present research, the pressure is served as a tuning parameter, a critical behavior between 1D and 2D spin dynamics can be expected. Such experiment will allow us to obtain better understanding of effects of geometrical frustration in these materials, and to study the pressure-tuned quantum critical properties of these and related materials. It is also important to mention that this kind of tunable-frequency high-field and high-pressure ESR experiments is unique, and have never been performed before. We are very much confident that our high-field and high-pressure ESR measurements will stimulate further interest of the high-field research community worldwide to use this unique facilities at IMR.

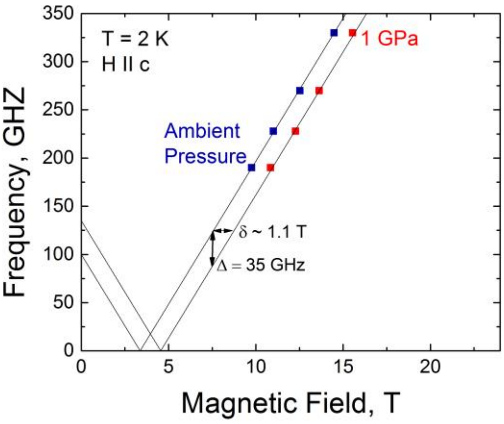

Fig.1 The frequency-field diagram of magnetic excitations in Cs_2CuCl_4 with magnetic field, applied along the c-axis at ambient pressure (blue symbols) and 1 GPa (red symbols).

The effect of pressure was observed in Cs_2CuCl_4 for magnetic field applied above the saturation field (H_{sat} =8 T) along the c-axis. We found that the application of a pressure of 1 GPa shifts the resonance field of exchange mode (whose position is determined mainly by the zigzag interchain coupling, J' [2]) by more than 1 T (see Fig. 1). In the 2018, we continued the investigation and obtained the systematic high-field ESR data up to 2 GPa. We found a considerable change of exchange parameters leading to the pressure induced quantum phase transition.

References

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