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Probing magnetic exchange interactions using magneto-Raman spectroscopy

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Abstract

We present recent studies on the nature of magnetic exchange interactions in different classes of magnetic materials using magneto-Raman spectroscopy. The first compound that will be discussed is $SrCu_2(BO_3)_2$. It is a quasi-2D orthogonal spin dimer system with a spin singlet ground state and considered as typical example for the realization of the Shastry-Sutherland model and exhibits a sequence of magnetization plateau at magnetic fields higher than 20 T, i.e., high enough to close the low temperature spin gap. The unique behavior of this quantum spin liquid results from the interplay between geometrical frustration and strong quantum fluctuations. The origin and characteristics of the strong spin-lattice coupling in $SrCu_2(BO_3)_2$ revealed by Raman scattering studies at high magnetic fields up to 45T will be presented. The interpretation of experimental results is supported by a theoretical analysis and prediction of active Raman modes that include the so-called pantograph mode. The second compound is $[(CH_3)_2NH_2]Co(HCOO)_3$ belonging to the family of multiferroic metal organic frameworks (MOF). In the infrared studies under applied magnetic fields upto 35T, it was concluded that Co MOF adopts a different mechanism for facilitating saturation of magnetic states by involving formate stretching distortions unlike other complexes in the family that use the formate bending mode. We performed Raman spectroscopy on $[(CH_3)_2NH_2]Co(HCOO)_3$ at magnetic fields up to 31T to probe the magneto-elastic coupling. It was found that a weak Raman active vibrational mode at about 798 cm^{-1} corresponding to symmetric bending of the formate ion does exhibit magnetic-field-induced frequency shifts. Lastly, we will present $Co^{II}(acac)_2(H2O)_2$ (acac = acetylacetonate) which is a molecular magnet. We were able to show for the first time distinct couplings of g phonons of and its deuterated analogs with zero-field-split, excited magnetic/spin levels (Kramers doublet (KD)) of the $S = 3/2$ electronic ground state. The couplings are observed as avoided crossings in magnetic-field-dependent Raman spectra with coupling constants of 1–2 cm^{-1}. The results of our investigations and its implications will be discussed in detail in this presentation.