Field-Induced Quantum Phase Transitions in Low-Dimensional Magnetic Insulators

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Quantum magnetic systems have in recent years offered diverse opportunities for the study of a broad range of novel physical phenomena including field-induced BEC of magnons. Dimer-based magnetic insulators and their experimental and theoretical investigation have hereby played a prominent role. A short summary of the progress in the field will be presented, covering mainly inorganic compounds like the 3D copper-halide family $ACuCl_3$ (A=K, Tl, NH_4) [1]. Low-dimensional systems, like quasi-2D $BaCuSi_2O_6$ with dimers on a square-lattice, have recently attracted considerable attention due to novel observations in their field-induced phase diagram, which are directly related to the dimensionality and geometry of the magnetic interactions [2]. We have studied this material by inelastic neutron scattering in zero and finite magnetic field [3]. The spin Hamiltonian describing $BaCuSi_2O_6$ is more complex than previously thought and defines a new class of quantum magnets. Implications for both the phase diagram and the uniform magnetization will be discussed. We further identify a new mechanism, which can lead to effective low-dimensional physics in presence of 3D-interactions. Regarding low-dimensional dimer materials, the quantum spin ladder so far escaped a detailed study of its field-tuned phase diagram. Organic chemistry offers the unique opportunity to isolate magnetic units from each other by using large organic molecules as spacers inside the crystal structure. We recently succeeded to characterize such an organic spin system. Field-induced quantum critical phenomena can now be investigated in the fascinating quasi-1D ladder limit, which promotes characteristic quantum phases like the Luttinger-liquid regime.

References:

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