Unconventional phases in frustrated ferromagnetic spin chains

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The search for exotic orders in (low-dimensional) quantum spin systems with geometric frustration has been a very active field of both theoretical and experimental studies. I will discuss some unconventional spin orders, such as vector chiral order, spin nematic and other multipolar spin orders, which appear in the one-dimensional spin-1/2 Heisenberg model with competing nearest-neighbor J_1 and antiferromagnetic next-nearest-neighbor J_2 exchange couplings in the presence of either magnetic field or easy-plane anisotropy, eigher one of which breaks the SU(2) spin symmetry down to U(1). The J_1-J_2 model, or the zigzag spin chain, is a minimal model of frustrated quantum magnets and is a host of various types of exotic spin orders. With a ferromagnetic nearest-neighbor coupling J_1, the model is considered to describe magnetic properties of quasi-one-dimensional edge-sharing cuprates such as $Rb_2Cu_2Mo_3O_{12}$ and $LiCuVO_4$.

In the recent publications listed below we obtained the ground-state phase diagram of the J_1-J_2 spin chain which contains various types of unconventional phases including a vector chiral ordered phase, a spin nematic phase, etc. For example, the vector chiral ordered phase is a quantum analogue of classical helical spin ordered phase, and the spin nematic phase can be regarded as a superfluid of two-magnon bound states. The spin nematic and higher-order multipolar phases appear near saturation field. In the presence of easy-plane exchange anisotropy (but without magnetic field), we find a series of quantum phase transtions between a dimer phase and an antiferromagnetically ordered (Neel) phase near the degeneracy point $J_1/J_2 = -4$. If time allows, I will briefly discuss the case of antiferromagnetic J_1 as well.

References:

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