[QMS2020 invited talk]

Spin liquid-like state in 2D/3D frustrated magnets - a tale of emergence of exchange-frustration, randomness, and dimensionality

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Recently, exchange randomness or quenched disorders have been proposed as an efficient route to achieve quantum spin liquids (QSLs), valence-bond-glass, and random-singlet states. The randomness-induced QSLs become stabilized as long as the moderate randomness is introduced to frustrated magnets irrespective of their spatial dimensionality, type of exchange interactions (Heisenberg and Kitaev), and lattice geometry (triangular, Kagome, honeycomb, and square lattices).

In this talk, I first address this issue in the s=1/2 J_1- J_2 square-lattice Heisenberg antiferromagnets $Sr_2Cu(Te_{1-x}W_x)O_6$ (x = 0.05 - 0.1). Chemical substitution of W^{6+} for Te^{6+} ions enables controlling the ratio J_2/J_1, while generating exchange randomness due to their random occupation. $Sr_2Cu(Te_{1-x}W_x)O_6$ exhibit the Néel order at x = 0, columnar antiferromagnetic order at x = 1, and quantum spin liquid at x = 0.5 [1]. We focus on the ground state and spin dynamics near the phase boundary (x = 0.05 - 0.1) that separates the Néel ordered and quantum disordered states. The magnetic susceptibilities $\chi(T)$ of x = 0.05 - 0.1 exhibit a broad hump around 70 K and the magnetization curves show a gradual, nonlinear increase without saturation up to 55 T. These features are typical for short-range magnetic correlations. The μSR, ESR, and specific data of the x = 0.1 compound show many of QSL phenomenology, namely, persistent spin dynamics and abundant low-energy excitations. The drastic suppression of the magnetic order is boosted by the random Te-for-W substitution, signifying a pivotal role of exchange randomness.

Second, we discuss $Re_3Sb_3Mn_2O_{14}$ (Re = La, Lu), where the Mn^{2+} magnetic ions (S=5/2) constitute a rhombohedral lattice. Our DFT calculations unveil that $Re_3Sb_3Mn_2O_{14}$ is a close realization of a 3D Shastry-Sutherland model, yet to be discovered. The thermodynamic quantities display a power-law dependence and the ESR and μSR data show a dynamically fluctuating state down to 20 mK. All these results give evidence for a random singlet state. Given the 3D classical frustrated spin topology of $Re_3Sb_3Mn_2O_{14}$, this comes as a surprise. Our work stimulates future theoretical studies of a s=5/2 3D Shastry-Sutherland system.

[1] O. Mustonen *et al*., Nat. Commun. **9**, 1085 (2018).