Quantum spin liquids in layered transition metal dichalcogenides

Denis Arčon[1,2]

[1]Department of Solid State Physics, Institute Jozef Stefan, Ljubljana, Slovenia
[2]Department of Physics, Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia

The original Anderson's proposal of a resonating valence bond state [1] was put forward to account for the unusual magnetic properties of a triangular atomic lattice of Ta atoms in the layered transition metal dichalcogenide 1T-TaS_2. Compared to some recent candidates for quantum spin liquids (QSL) on triangular lattice, e.g., $YbMgGaO_4$ [2] or κ-$(ET)_2Cu_2(CN)_3$ [3], layered dichalcogenides close to the Mott transition have a perfect triangular lattice geometry and a weaker effective spin-orbit coupling, offering a possibility for obtaining a unique insight into the competition between antagonistic QSL and Néel states. Here we report on QSL that appears to be realized by atomic-cluster polaron spins on the triangular lattice of a charge-density wave (CDW) state of 1T-TaS_2 [4]. In this system, nuclear quadrupole resonance and muon spin relaxation experiments reveal that polaron spins show gapless quantum spin liquid dynamics and no long range magnetic order down to 70 mK. Power-law temperature dependence of the spin-lattice relaxation dynamics is taken as a hallmark of a gapless QSL with a spinon Fermi surface. This state has itinerant spinon excitations and is connected to a high degree of intrinsic disorder probably reflecting the orbital texturing within the TaS_2 layers. The observed QSL is at first robust against applying chemical pressure in Se-doped samples before giving a way to a correlated metal and the low-temperature superconducting state [5]. The superconducting gap-to-T_c ratio $2D/k_B T_c \approx 7$ puts the Se-doped 1T-TaS_2 superconductor into a strong coupling regime. Results clearly underline the important role of antiferromagnetic fluctuations as well as electron correlations and disorder across the entire phase diagram of 1T-$Ta(Se,S)_2$. Finally, we'll show that 1T-TaS_2 may not be the only QSL candidate among the layered transition-metal dichalcogenides [6].

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