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Pseudogap and Critical Spin Fluctuations in the Kondo Condensate of P-Doped Silicon

Si:P offers a versatile setting for exploring quantum many-body effects. At intermediate impurity concentrations, Si:P hosts a Kondo condensate—a quantum state featuring an energy gap in the electronic density of states. In this regime, overlapping Kondo clouds interact via RKKY exchanges, though the nature of the magnetic ground state has remained unclear.
In this presentation, we combine ESR and μSR to address the magnetic ground state and spin dynamics in Si:P. The ESR data reveal a crossover from a Korringa-like metallic regime to one dominated by spin fluctuations in the temperature range between 150 K and 22 K. Below 22 K, signatures of dynamic Kondo-singlet formation emerge, developing static Kondo singlets below 6 K. Complementary μSR results reveal the emergence of Kondo singlets with a well-defined singlet gap ΔZF = 0.8(4) K, forming below the Kondo temperature, TK = 2.4 K. On further cooling, we observe the onset of a correlated Kondo ground state below a characteristic temperature T* = 0.6 K. This state is marked by a power-law dependence of the muon Knight shift, $-K\mu T \sim T\xi$, indicative of critical spin fluctuations.
This Kondo condensate state exhibits a coexistence of a Bardeen-Cooper-Schrieffer-like charge gap and critical magnetic fluctuations, drawing striking parallels to the pseudogap phases observed in doped Mott insulators. These findings extend the scope of pseudogap phenomena, highlighting their relevance in the domain of doped semiconductors.

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