Spin glass effects and nonexistence of a ferromagnetic quantum critical point in the compositionally tuned $FeGa_{3-x}Ge_x$ metallic quantum ferromagnets (x = 0.0-0.16)

M. Wencka[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*

A quantum critical point (QCP) is a point in the phase diagram of a material where a continuous (second-order) quantum phase transition (QPT) from a disordered to an ordered state takes place at absolute zero temperature, driven by a nonthermal control parameter such as pressure, magnetic. Searching for a ferromagnetic (FM) quantum critical point of a compositionally tuned system, we have investigated experimentally the quantum phase transition (QPT) in the $FeGa_{3-x}Ge_x$ (x = 0.0-0.16) metallic quantum ferromagnet, by using crystallographically oriented single-crystalline samples with the Ge contents x below and within the quantum critical regime. Performing the measurements of dc and ac magnetic susceptibility and M(H) curves down to the temperature of 0.4 K in low magnetic fields 0.01-25 mT, and the measurements of electrical resistivity and specific heat down to 0.35 K, we found that there is no direct, continuous transition from the paramagnetic to the FM state and consequently no FM quantum critical point in the compositional phase diagram, but the QPT involvesan intermediate canonical spin glass (SG) state at x $\approx$ 0.12-0.16. The compositional region of the SG state is narrow, it is formed at low temperatures (the spin freezing temperatures are in the range 1.1–1.8 K) and the coupling between the spins is weak, so that the SG ordering is fragile with respect to the external magnetic field. The analysis of the ac susceptibility via the Cole-Cole diagrams in the QPT region has revealed that the slowing-down spin dynamics of the SG state remains thermally activated down to the lowest investigated temperature of 0.4 K, so that the regime of quantum fluctuations is not yet entered. The employed experimental conditions have enabled us to follow the formation of fragile magnetic ordering in the $FeGa_{3-x}Ge_x$ compositionally tuned system in its infancy state [1].

References:

[1] S. Vrtnik, P. Koželj, M. Wencka, K. Bader, J. Petrović, J. Luzar, P. Mihor, A. Jelen, P. Gille, J. Dolinšek, Phys. Rev.B 112 (2025) 104420