Temperature-dependent Pauli susceptibility of an altermagnet candidate RuO_2

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Altermagnets are a newly identified class of antiferromagnets characterized by symmetry-driven magnetic responses. Following pioneering studies in 2019 and the review by Šmejkal [1], RuO_2 has become a prominent altermagnet candidate, motivating extensive efforts since 2020 to establish its altermagnetic nature. It remains unclear whether the ground state is paramagnetic or altermagnetic. Over the last several years (2020–2025), investigations have primarily used crystals with RRR values ranging from 12 to 160. High-quality RuO_2 crystals are crucial to resolve its intrinsic magnetic ground state.

We present the growth of ultra-high-purity RuO_2 single crystals with residual resistivity ratios (RRR) exceeding 1200 [2]. The crystals exhibit distinct morphologies—bulk-like or needle-like—depending on growth conditions [2]. We describe a low-temperature upturn in the DC magnetic susceptibility, attributable to paramagnetic impurities at the level of a few tens of ppm [1,2]. Curie–Weiss fits give Curie constants of 1.8×10^{-5} (RRR = 400) and 7.7×10^{-6} emu K/mol (RRR = 1200), corresponding to paramagnetic impurity levels of 36 ppm and 15 ppm, respectively [3]. The exceptionally high RRR of our ultra-clean crystals allows us to conclude that bulk RuO_2 is intrinsically paramagnetic [2-5]. However, the temperature-dependent magnetic susceptibility is well fit, including a nonanalytic $T^2 \ln T$ term. Correspondingly, the field-dependent spin susceptibility follows an $H^2 \ln H$ scaling, consistent with Fermi-liquid behavior [3]. Electronic specific heat, magnetic susceptibility, and T^2 resistivity indicate that RuO_2 is a weakly correlated 3D Fermi liquid, in agreement with Wilson and Kadowaki–Woods ratios [3].

References:

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