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Scaling of the magnetic Grüneisen ratio near quantum critical point

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The magnetic Grüneisen ratio Γ_H =(1/T)dT/dH is the most sensitive probe of quantum criticality. Its divergence signals the underlying instability. We have studied quantum criticality in the frustrated Kondo lattice system YbAgGe and the heavy fermion superconductor $CeCoIn_5$ by high-precision magnetocaloric effect measurements. In the former, NFL behavior appears around a metamagnetic spin-flop transition between two symmetry broken phases. Previously, it was unclear how the two ordered phases are related to the NFL state. Here, we propose a novel quantum bicritical point (QBCP) scenario, which is distinct from either quantum critical end point or ordinary QCPs with single symmetry broken phase. The observed scaling behavior of Γ_H and its characteristic asymmetry across the critical field are consistent with a QBCP scenario. We also report a possible violation of Wiedemann-Franz law at the QBCP in YbAgGe. In $CeCoIn_5$ indications of a quantum critical field hidden inside the superconducting (SC) phase have been extensively debated. We show Γ_H data and scaling analysis in the normal state, which surprisingly suggests a zero-field QCP. Anomalous behaviors of Γ_H and specific heat within the SC state further support this conclusion.

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