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Composition of magnetic interactions in the heavy-fermion system CeIn3

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We report high-resolution neutron spectroscopy on the archetypal heavy fermion material CeIn3 that exhibits an antiferromagnetic (AFM) order below TN= 10.1 K. Increasing pressure suppresses the AFM state to zero temperature resulting in a quantum critical point, the critical fluctuations of which are believed to mediate unconventional superconductivity. Previous neutron results with moderate resolution reported a substantial spin gap of about 1 meV, which suggest a substantial magnetic anisotropy, in contrast to the observed bulk properties. Our results unambiguously demonstrate that CeIn3 does not exhibit a spin gap. Instead, we find that the spin waves disperse quasi-vertically up to almost 1 meV. We show that via ab-initio band structure calculations fed into the multi-orbital periodic Anderson model can predict the magnetic excitation spectrum quantitatively. Our results show that this model can be renormalized to a simple Kondo lattice model decorated with short-range super exchange as well as long-range particle-particle interactions to account for the formation of magnetic order. This microscopically-derived modified Kondo lattice model quantitatively reproduces the low-energy magnetic soft modes in CeIn3, which are key to understanding unconventional superconductivity.

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