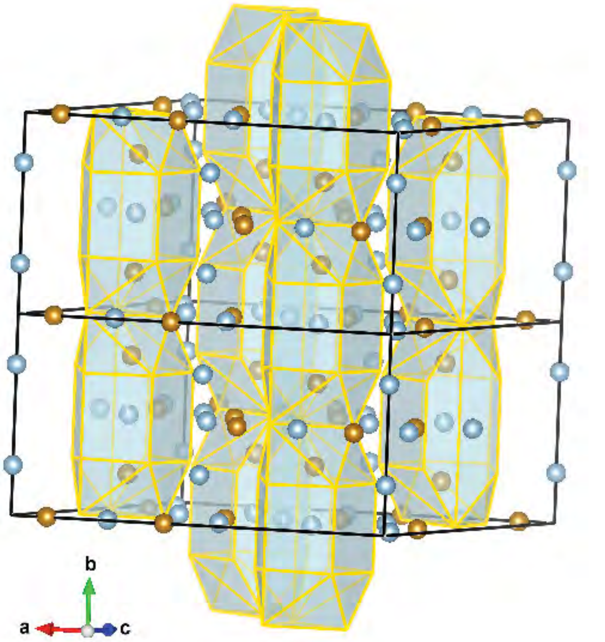

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MS27-O2

Anisotropic quantum critical point in the Ce_3Al intermetallic compound

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A quantum critical point (QCP) is a point in the phase diagram of a material where a continuous phase transition takes place at absolute zero temperature [1,2]. Quantum phase transitions at $T = 0$ are driven by zero–point quantum fluctuations associated with Heisenberg's uncertainty principle, in contrast to conventional (thermodynamic) phase transitions that occur at a nonzero temperature and are driven by thermal fluctuations. A QCP is typically achieved by a continuous suppression of a thermodynamic phase transition to zero temperature by the application of a magnetic field, pressure or through doping. Quantum phase transitions arise in quantum many–body systems as a result of competing interactions that foster different ground states. An example are the RKKY exchange interaction and the Zeeman interaction of spins with the external magnetic field, where a continuous increase of the field can induce a quantum phase transition from a magnetically ordered state to a paramagnetic state via tuning the degree of quantum tunneling between the "up" and "down" spin–polarized states.

Based on the magnetic susceptibility, magnetoresistance and specific heat measurements, we determined the anisotropic, magnetic field driven QCP in the magnetically anisotropic Ce_3Al compound that exhibits both antiferromagnetic (AFM) ordering and heavy fermion behavior. The QCP in the Ce_3Al results from competition of the RKKY exchange and the Zeeman interactions on the Ce–Al chains, where the Ce moments order AFM at $T_N =$ 2.6 K, whereas the moments on the Ce–Ce chains are Kondo–compensated and do not participate in the QCP formation. External magnetic field drives the AFM transition continuously toward zero temperature for the field applied in the monoclinic (a,b) easy plane, reaching the QCP at the critical field value $B_c =$ 4.2 T, where a transition from the AFM to a spin–flop state takes place. For the field applied along the perpendicular c direction, the QCP does not occur. The anisotropy of the QCP with regard to the direction of the magnetic field in the crystal lattice is a consequence of large, crystal–fields–induced magnetic anisotropy, which locks the magnetic moments into the easy plane and cannot be overcome by the two competing interactions. The QCP in systems with large magnetic anisotropy is generally anisotropic and the experiments to observe this anisotropy should necessarily be performed on monocrystalline samples.

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Keywords: quantum critical point, quasicrystals and approximants