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Dimensionality and quantum criticality in heavy fermion metals[1]

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Heavy fermion compounds are at the forefront of research on quantum criticality. This is due to the fact that many of these materials can be tuned to a quantum critical point (QCP) by readily accessible values of the control parameters magnetic field, pressure or substitution/doping. In recent years efforts are being made to classify the different kinds of quantum critical behavior experimentally observed, to test the extent to which heavy fermion quantum criticality is universal. We have identified a cubic heavy fermion material, $Ce_3Pd_{20}Si_6$, as exhibiting a field-induced quantum phase transition as the lower of two consecutive phase transitions is suppressed to zero. This transition is accompanied by an abrupt change of Fermi surface [1], reminiscent of what happens across the field-induced antiferromagnetic to paramagnetic transition in tetragonal $YbRh_2Si_2$ [2]. In $Ce_3Pd_{20}Si_6$, the QCP separates two different ordered phases. In fact, a Kondo destruction QCP [3] has been theoretically predicted to exist in the ordered portion of a global phase diagram for quantum critical heavy fermion compounds [4]. We conclude that dimensionality is an effective way to tune through such a global phase diagram and that the cubic material studied here is situated in the barely explored three-dimensional portion of this phase diagram. We believe that this finding will guide the search for further experimental anchoring points in the global phase diagram, and for a unified theoretical description.

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