Exploring heavy-fermion quantum criticality in the extreme 3D limit

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Heavy-fermion compounds have in recent years emerged as prototypical quantum critical systems. Most investigations so far have focused on anisotropic heavy-fermion compounds, as for instance $CeCu_{6-x}Au_x$, $CePd_2Si_2$, $Ce(Co,Rh)In_5$, or $YbRh_2Si_2$. Different mechanisms have been evoked to explain the physical properties observed in the vicinity of the respective quantum critical points (QCPs). In particular, the Kondo breakdown scenario [1] was suggested to account for the experimentally observed abrupt change of Fermi surface across the field-induced antiferromagnetic to paramagnetic transition in $YbRh_2Si_2$ [2]. We now have identified a cubic heavy-fermion material, $Ce_3Pd_{20}Si_6$, as exhibiting a field-induced quantum phase transition accompanied by a very similar abrupt change of Fermi surface [3]. This finding is intriguing since the Kondo breakdown scenario explicitly evokes two-dimensional (2D) spin fluctuations that are unlikely to be relevant in a cubic material. However, there is an important difference between both cases. The suggested Kondo destruction QCP in $Ce_3Pd_{20}Si_6$ occurs as the lower of two consecutive phase transitions is suppressed to zero. Thus, this QCP separates two different ordered – presumably antiferromagnetically ordered – phases. Between these, Kondo breakdown could occur even in dimensions higher than 2D [4]. From these results we have proposed a materials-based global phase diagram [3] that points to the importance of dimensionality – and may serve as guide in the search for a unified theoretical description .

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