MAR14-2013-004692

Abstract for an Invited Paper
for the MAR14 Meeting of
the American Physical Society

Slicing a Kondo lattice: the quest for exotic superconductivity in artificially engineered Ce-based superlattices

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Condensed matter systems that are both low-dimensional and strongly interacting often exhibit unusual electronic properties, with the high-T_c superconductivity in cuprates and iron pnictides as the most prominent example. A metallic state with the strongest electron correlation is realized in heavy fermion compounds, whose electronic structure is essentially 3D. Recently, by fabricating epitaxial superlattices built of alternating layers of Ce-based heavy-fermion and La- or Yb-based conventional nonmagnetic metals, we have succeeded in confining heavy fermions to two dimensions, resulting in slices of 2D Kondo lattice. In $CeIn_3/LaIn_3$ superlattices, 2D heavy fermions display striking deviations from the standard Fermi liquid properties, and these are associated with the dimensional tuning of quantum criticality [1]. Moreover, superconductivity is observed in $CeCoIn_5/YbCoIn_5$ superlatttices even in the superlattice with only one-unit-cell-thick $CeCoIn_5$ layers [2]. These superconducting superlattices with atomic layer thickness exhibit highly unusual behaviors, including striking enhancement and highly unusual angular dependence of H_{c2} [3]. We discuss these phenomena in terms of extremely strong coupling superconducting nature as a result of two-dimensionalization, and the entanglement of Pauli paramagnetism and Rashba interaction associated with the local inversion symmetry breaking at the heavy fermion interface. The heavy fermion superlattices offer a new playground for exploring exotic superconducting phases.

In collaboration with M. Shimozawa, S.K. Goh, H. Shishido, Y. Mizukami, T. Watashige, R. Endo, R. Kobayashi, T. Shibauchi and T. Terashima (Kyoto).

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