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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$_5$ superlattices 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.
