The dual nature of 4*f* electrons in rare-earth intermetallics: ARPES view

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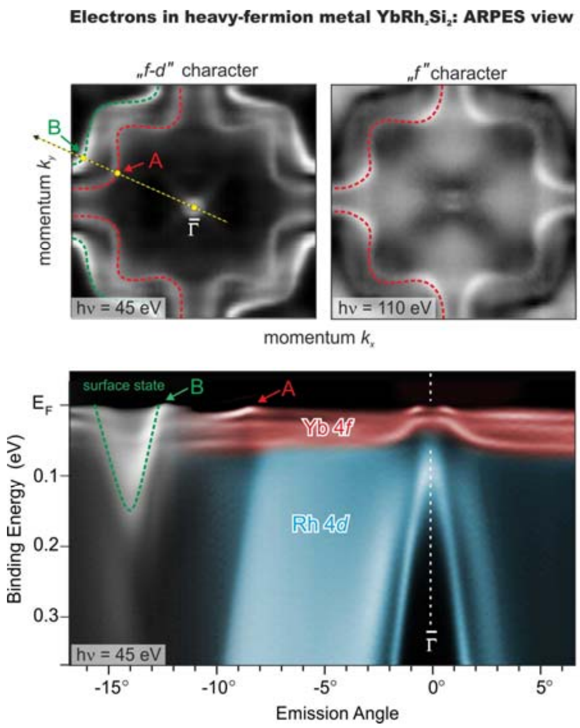
Rare-earth intermetallic compounds have taken a central place in condensed matter physics over the past three decades. Different types of magnetic order, unconventional superconductivity, magnetic heavy-fermion behavior and break-down of the Fermi-liquid properties are prominent examples of the astonishing low-temperature physics of these systems. Investigation of these phenomena is an intriguing task since a profound understanding of the underlying mechanisms might enable to control these effects and to create new materials with tailored properties. Most of these properties are related to a delicate interplay between the partially filled 4*f*-shell and conduction electrons.



Our last experiments provide an important insight into the fine electronic structure near the Fermi level (E_F) and the Fermi surface (FS) of $YbRh_2Si_2$. This compound has been in the focus of recent research for its unusual magnetic and Kondo properties and its close proximity to a quantum critical point. Here, we made the observation of crystal-electric field (CEF) splittings of a 4*f* state by means of ***k***-resolved photoemission. This allowed us to disclose that interaction with extended valence bands can force the localized CEF-split 4*f* states to become dispersive and thus induce formation of hybridization gaps and E_F crossings in specific parts of the ***k***-space. This can change the ground-state symmetry as well as the occupancy, number, energy separation, energy order and degeneration of the CEF-split magnetic 4*f* states ***k***-dependently, i.e. very different from the widely believed scenario based on non-interacting atomic-like 4*f* orbitals.

Finally, we got direct access to the FS of this system and: (i) detected its strong *f*-character, (ii) disentangled its topology and features reflecting *f-d* coupling at the surface and bulk of the material, (iii) explored evolution of the iso-energy surfaces closely below the Fermi energy that indeed change dramatically at the meV range. These results create a solid platform to further attack on the outstanding low-temperature properties of rare-earth intermetallics including the Kondo phenomenon, heavy-fermion behavior and quantum-criticality.

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[3]. D. V. Vyalikh, et al., Phys. Rev. Lett. **105** 237601 (2010).