

Seminář odd. 26

Tenkých vrstev a nanostruktur

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TÉMA

Real-space observation of surface orbital order by scanning tunneling microscopy

Yukio Hasegawa

The Institute for Solid State Physics, Univ. Tokyo, Kashiwa, 277-8581 Japan

Using low-temperature ultrahigh vacuum scanning tunneling microscopy (STM) we have obtained real-space images showing orbital order on a Co-terminated surface of CeCoIn₅, which is a heavy-fermion superconducting material. Because of the 4-fold symmetry, 3d_{xz} and 3d_{yz} orbitals of the Co atoms are energetically degenerated. However, on the surface, because of the reduced coordination number and resulting enhanced electron correlation, the capability of the electron screening is suppressed. As a result, in order to reduce the Coulomb repulsive energy alternating unoccupation of the two 3d orbitals in an antiferromagnetic manner becomes favorable. We observed alternately-arranged dumbbells whose shape is quite similar with that of d_{xz} and d_{yz} orbitals looking from the z direction, proving the existence of the orbital order.

In a technical point of view of STM, observing d orbitals is not an easy task because of their localized nature near the core. Since STM detects wave functions of sample surface by the probe tip, states that decay long from the surface are probed more efficiently than quickly decaying states. In fact, on the Co-terminated surface we observed round-shaped Co atoms arranged in a square lattice by STM in standard tunneling conditions, which obviously originate from Co s-derived states. In order to observe the d orbitals, we intentionally locate the tip close to the surface; almost touching but still in the tunneling regime, and successfully observed their ordering.

Reference

[1] H. Kim, Y. Yoshida, C.-C. Lee, et al., *Sci. Adv.* 3, eaao0362 (2017).

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