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ARPES Clues to the Hidden Order in URu$_2$Si$_2$

JONATHAN DENLINGER$^2$, Lawrence Berkeley National Laboratory

The three-dimensional electronic structure of UHV-cleaved URu$_2$Si$_2$ is investigated using photon-dependent angle-resolved photoemission (ARPES). Wide angle Fermi-surface (FS) maps as well as high-resolution spectroscopy focused on key high symmetry points reveal high U 5$f$ spectral weight at the hole-like regions of the Γ and Z-points. The small hole-surface FS topologies have good size correspondence to dHvA FS orbit frequencies, but do not agree well with LDA band structure calculations. More favorable correspondence of the URu$_2$Si$_2$ ARPES is made to LDA+DMFT calculations as well as to detailed ARPES measurements of 5$f^0$ ThRu$_2$Si$_2$. Special attention was given to spatial-dependent characterization of the cleave surface in order to understand the possible cleave terminations and to avoid surface effects related to disorder or non-bulk coordinated U-termination. Theoretical surface slab calculations assist in identifying surface-termination related features at the X-point. In addition, we propose a model for the incommensurate nesting vectors, 0.6$a^*$ and 1.4$a^*$, observed by inelastic neutron scattering$^3$ to be characteristic of the hidden order phase of URu$_2$Si$_2$. Finally, preliminary ARPES results for URu$_{2-x}$Re$_x$Si$_2$ give a clue as to the mechanism by which Re doping suppresses the hidden order phase in favor of ferromagnetism.

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