Spin-Orbit Excitons in a Correlated Metal Sr_2RhO_4

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We have carried out inelastic photon scattering measurements to investigate the electronic structure of the correlated metal Sr_2RhO_4, where prior experiments had revealed sharp Fermi surfaces. Using polarization-resolved Raman spectroscopy, we observe unusual but well-defined excitations around 230 meV with A_{1g} and B_{1g} symmetries [1], analogous to those recently discovered in the well-studied spin-orbit Mott insulators Sr_2IrO_4 and α-$RuCl_3$. We identify them as excitonic transitions between the spin-orbit multiplets J = 1/2 and J = 3/2 of the Rh ions (also known as spin-orbit exciton), which is a direct signature of unquenched spin-orbit coupling of correlated electrons in Sr_2RhO_4. A quantitative analysis of Raman data further reveals that the tetragonal crystal field has a sign opposite to that in insulating Sr_2IrO_4, which suggests that c-axis compression of Sr_2RhO_4 may induce a metal-to-insulator transition. In addition, we performed resonant inelastic x-ray scattering at the O K-edge [2] and Rh L-edge [3] to confirm our Raman observations and study the dispersion of this spin-orbit entangled quasiparticle. The observed spectroscopic feature is complementary to prior ARPES experiments on the coherent fermionic quasiparticles near the Fermi level. Combining our datasets, we prove that atomiclike excitations and fermionic quasiparticles can coexist in multiorbital metals. The experiments we have presented on a disorder-free system with a relatively simple electronic structure thus open up a potentially rich source of information on electronic correlations in other multiband metals.

References

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