Spectroscopic evidence for negative electronic compressibility in a quasi-three-dimensional spin-orbit correlated metal

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Negative compressibility is a sign of thermodynamic instability of open or non-equilibrium systems. In quantum materials consisting of multiple mutually coupled subsystems, the compressibility of one subsystem can be negative if it is countered by positive compressibility of the others. Manifestations of this effect have so far been limited to low-dimensional dilute electron systems. Here, we present evidence from angle-resolved photoemission spectroscopy (ARPES) for negative electronic compressibility (NEC) in the quasi-three-dimensional (3D) spin-orbit correlated metal $(Sr_{1-x}La_x)_3Ir_2O_7$. Increased electron filling accompanies an anomalous decrease of the chemical potential, as indicated by the overall movement of the deep valence bands. Such anomaly, suggestive of NEC, is shown to be primarily driven by the lowering in energy of the conduction band as the correlated bandgap reduces. Our finding points to a distinct pathway towards an uncharted territory of NEC featuring bulk correlated metals with unique potential for applications in low-power nanoelectronics and novel metamaterials.