Generating Heavy Electrons Without Problematic Elements

A new strategy allows scientists to find and make materials that host so-called heavy electrons without requiring rare-earth or actinide elements.

By **Ryan Wilkinson**

Fifty years ago, physicists discovered that certain metallic compounds contain electrons that behave as if they are much heavier than regular electrons. Such heavy-fermion materials are used to explore strongly correlated electron systems and unconventional superconductivity, and they could have applications in various quantum technologies. However, they typically need rare-earth or actinide elements, which can be scarce, radioactive, and hard to extract. Now Luca de' Medici at the Laboratory of Physics and Material Studies (LPEM), France, and his colleagues have proposed and tested a way to systematically produce heavy-fermion materials that lack these problematic elements [**1**].

The first step in the researchers' approach is to select a metallic compound classified as a Hund metal, a material whose properties are strongly influenced by interactions between electrons in partially filled atomic orbitals. The second step is to replace atoms of one metallic element with atoms of a different one until the material's conduction bands are almost half-filled with electrons. At that point, electrons in certain atomic orbitals strongly interact with one another, causing them to move slowly and thus seem heavy. This behavior mimics that of electrons in heavy-fermion materials containing rare earths or actinides.

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De' Medici and his colleagues demonstrated their technique experimentally by selecting a Hund metal made of cesium, iron, and arsenic and then replacing some of the iron atoms with chromium ones. The researchers found evidence for pronounced heavy-fermion behavior through measurements of the material's resistivity, magnetic susceptibility, and thermal expansion. The team says that the next step is to use this strategy to create other heavy-fermion materials and explore their potentially advantageous properties.

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REFERENCES

1. M. Crispino *et al.*, "Paradigm for finding *d*-electron heavy fermions: The case of Cr-doped $CsFe_2As_2$," **Phys. Rev. Lett. 134, 076504 (2025).**