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Deciphering Electron Matter in Novel Superconductors

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Superconductors may be grouped into two major classes. The first is conventional metallic, whose pairing mechanism is explained by the BCS theory and electron-phonon coupling. The pairing mechanism of the second class, driven by electron correlations, is still to be completely worked out. These superconductors have electronic properties that are highly tunable, either by doping or pressure, from a non-superconducting ground state to a superconducting one, thus defining a superconducting "dome" in the phase diagram. More than 40 families of such superconductors, including high-temperature cuprate and iron-based, heavy fermion, organic, and transition-metal di-chalcogenide superconductors exhibit this ubiquitous phase diagram. All of these materials show intriguing correlated electron states above the dome, and researches agree that the understanding of this electron matter holds the key to the pairing mechanism, and ultimately predicative design of new superconductors, which hold great promise of revolutionary applications, including energy, information technology, and medicine.