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Discovery of Charge Order and Time-Reversal Symmetry-Breaking in the Kagome Superconductor YRu_3Si_2

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We report the discovery of a remarkably rich phase diagram in the kagome superconductor YRu_3Si_2, uncovered through a unique combination of muon spin rotation, magnetotransport, X-ray diffraction, and density functional theory calculations. Our study reveals the emergence of a charge-ordered state with a propagation vector of (1/2, 0, 0), setting a record onset temperature of 800 K for such order in a kagome system and for quantum materials more broadly. In addition, we observe time-reversal symmetry breaking below $T_2^* \simeq 30$ K and field-induced magnetism below $T_1^* \simeq 80$ K, indicating the presence of a hidden magnetic state. These transitions are mirrored in the magnetoresistance data, which show a clear onset at 100 K and a pronounced increase below 30 K, ultimately reaching a maximum magnetoresistance of 45%. Band structure calculations identify two van Hove singularities near the Fermi level, one of which resides within a flat band, suggesting a strong interplay between electronic correlations and emergent orders. At low temperatures, we find bulk superconductivity below T_c = 3.4 K, characterized by a two-gap (s+s)-wave or anisotropic s-wave pairing symmetry. Together, our findings point to a coexistence of high-temperature charge order, tunable magnetism, and multigap superconductivity in YRu_3Si_2, positioning it as a compelling platform for exploring strongly correlated kagome physics.

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