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Discovery of Room-Temperature Charge Order, Hidden Magnetism, and a Dome-Shaped Superconducting Phase Diagram in the Kagome Superconductor LaRu3Si2

The interplay between superconductivity and charge or spin order is a key focus in condensed matter physics, with kagome lattice systems providing unique insights [1-9]. We recently discovered that the kagome superconductor $LaRu_3Si_2$ ($T_c \simeq 7$ K) exhibits a characteristic kagome band structure and a hierarchy of charge-order transitions at 400 K and 80 K, as well as an additional electronic and magnetic transition at 35 K [7,8]. Furtermore, using magnetotransport and X-ray diffraction under pressures up to 40 GPa, we find Tc peaks at 9 K (2 GPa), remains stable up to 12 GPa, and decreases to 2 K at 40 GPa, forming a dome-shaped phase diagram [9]. Similarly, both the resistivity anomaly at T^* and the magnetoresistance exhibit a dome-shaped pressure dependence. Moreover, above 12 GPa, the charge order evolves from long-range to short-range, coinciding with the suppression of T_c. These observations suggest that superconductivity is closely linked to the charge-ordered state and the electronic responses associated with $T_{co,II}$ and T^*. Notably, T_c reaches its maximum when the charge order remains long-range and the normal-state electronic properties are optimized. These results offer fresh insights into the relationship between superconductivity and charge order, paving the way for theoretical advancements and experimental strategies, such as uniaxial stress, to amplify lattice distortions and electronic responses in the charge-ordered state, with the potential to further enhance T_c.

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