Discovery of higher charge superconductivity beyond charge-2e Cooper pairs

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Despite of the various forms of superconductivity, conventional or unconventional, topologically trivial or nontrivial, the condensation of charge-2*e* Cooper pairs with the quantized magnetic flux in units of *h*/2*e* has remained the origin and character of all superconductivity, as described by the BCS theory. We experimentally discovered charge-6*e* superconductivity in ultrathin ring devices fabricated using the kagome superconductor CsV_3Sb_5 [1]. These new phase coherent states were discovered by the observation of the quantized magnetic flux in units of *h*/6*e* in systematic magneto-transport measurements. More recently, we have fabricated new micron-sized CsV_3Sb_5 ring devices with relatively sharp superconducting transition (the onset transition temperature $\sim$ 3.76 K and the zero-resistance transition temperature $\sim$ 2.80 K), and strikingly clear charge-6e oscillations are observed in both the magnetoresistance and the superconducting transition temperature (T_c), highlighting the robustness of the exotic phase-coherent higher-charge states. Our observations provide direct experimental evidence for the existence of phase coherent paired quantum matter with the duality of fractional quantum vortex state beyond the charge-2*e* superconductors, and provide ground work for exploring the physical properties of the charge-6*e* superconductivity and 1/3 quantum vortex states as unprecedented phases of matter beyond the condensation of charge-2*e* Cooper pairs described by the BCS theory.

Reference

[1] Jun Ge *et al*. *Physical Review X* **14**, 021025 (2024) (arXiv: 2201.10352).

[2] Jun Ge *et al*. *in preparation* (2026)