Parity-Violating Current-Voltage Curves in a Single Domain of Sr$_2$RuO$_4$ Superconductors

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We have found parity-violating current-voltage (I-V) curves in a single domain of spin-triplet Sr$_2$RuO$_4$ below the superconducting transition temperature $T_c$ [1]. In four-terminal measurements, the induced voltage $V$ is generally an odd function of bias current $I$ as observed for $T > T_c$ of Fig. 1(b), which is a result of parity conservation. However, at $T < T_c$, we find that $V$ is an even function of $I$. The anomalous I-V curve means that positive voltage is detected regardless of the current direction and suggests the violation of parity. To understand the nature of the parity-violating I-V curves, we consider a simple model of a vortex which has a helical internal structure characterized by a Hopf invariant (a topological invariant) [2]. We will also discuss that the hydrodynamics of such a helical vortex causes the parity violation to retain the topological invariant.

![Figure 1: (a): A micrograph of a microscale Sr$_2$RuO$_4$. (b): $V$ is plotted as a function of $I$ at 63 mK and 4.2 K in the absence of magnetic field.](image)