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Supplementary Materials for

Nonreciprocal charge transport in noncentrosymmetric superconductors

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Effect of the Rashba term

We discuss the effect of the Rashba term in the nonreciprocal current. The Rashba term creates the term linear in momentum in the GL free energy (*16*). Therefore, the Eqs. 28, 30, and 31 in the main text are modified to

$$F = \sum_{\boldsymbol{q}} \left[a + \frac{\hbar^2 \boldsymbol{q}^2}{4m} + \alpha_R \hat{\boldsymbol{z}} \cdot (\boldsymbol{B} \times \boldsymbol{q}) + \Lambda B q_x (q_x^2 - 3q_y^2) \right] \left| \Psi_{\boldsymbol{q}} \right|^2 + \frac{b}{2} \left| \Psi_{\boldsymbol{q}} \right|^4 \quad \text{(S1)}$$

$$\eta_{\boldsymbol{q}}(t) = a + \frac{\hbar^2}{4m}\left(\boldsymbol{q} - \frac{2e}{\hbar}\boldsymbol{E}t\right)^2 + \alpha_R \hat{\boldsymbol{z}} \cdot \left[\boldsymbol{B} \times \left(\boldsymbol{q} - \frac{2e}{\hbar}\boldsymbol{E}t\right)\right] + \Lambda B \left(q_x - \frac{2e}{\hbar}E_x t\right) \times \left[\left(q_x - \frac{2e}{\hbar}E_x t\right)^2 - 3\left(q_y - \frac{2e}{\hbar}E_y t\right)^2\right] \quad \text{(S2)}$$

$$j_{\boldsymbol{q}}(t) = -\frac{e\hbar}{m}\left(\boldsymbol{q} - \frac{2e}{\hbar}\boldsymbol{E}t\right) - \frac{2e}{\hbar}\alpha_R(\hat{\boldsymbol{z}} \times \boldsymbol{B}) - \frac{6e\Lambda B}{\hbar} F\left(\boldsymbol{q} - \frac{2e}{\hbar}\boldsymbol{E}t\right) \quad \text{(S3)}$$

where $\hat{\boldsymbol{z}}$ is the unit vector along the z direction and α_R represents the strength of the Rashba spin-orbit interaction. By substituting these equation into Eq. 18 in the main text and performing the integration in the exponential function and over the momentum, we obtain

$$\boldsymbol{j} = \int_{-\infty}^{0} du \frac{e^2 k_B T_c}{\pi \hbar^2} \left[\boldsymbol{E} + \frac{4em\Lambda B}{\hbar^3} u \boldsymbol{F}(\boldsymbol{E})\right] \exp\left[\frac{12amu + e^2 \boldsymbol{E}^2 u^3}{6\hbar m \Gamma}\right] \quad \text{(S4)}$$

which does not contain α_R in the lowest order. Therefore, we reach to Eq. 32 in the main text.