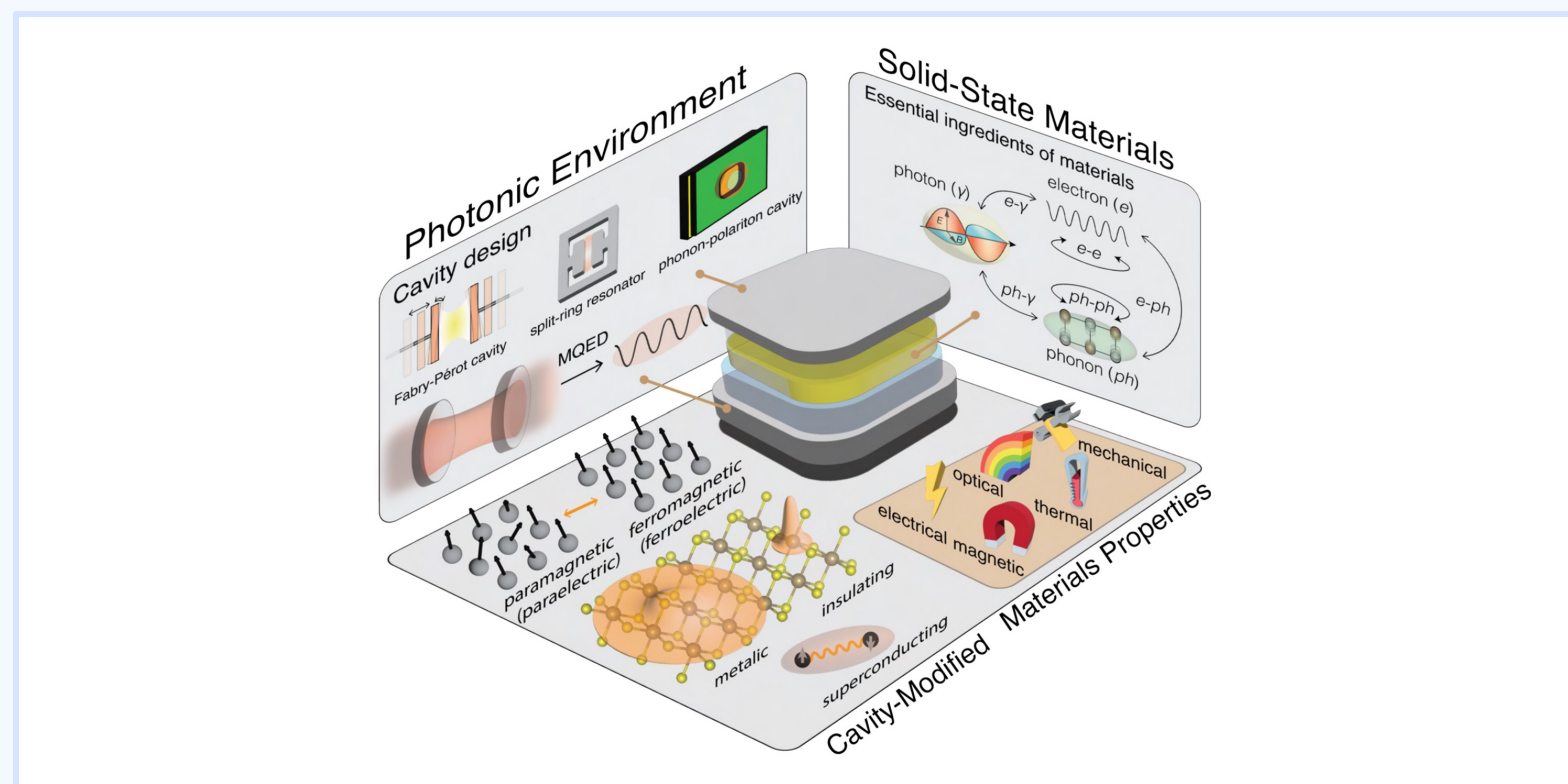


Cavity Control of Material Properties



I.-T. Lu, et al., Adv. Opt. Photon. 17, 441 (2025).

dark-cavity control: photons, phonons, electrons, and phases

Superconducting Properties

Existing Results

Theory

phonon-polariton enhancement route

polaritonically enhanced e-ph coupling

cavity-mediated e-e interaction

effective interaction routes

band reconstruction raises Tc

cavity-enhanced / band-engineered superconductivity

Experiment

dark-cavity Tc shift

transition-temperature shifts

superfluid-density modification

cavity-altered superconductivity

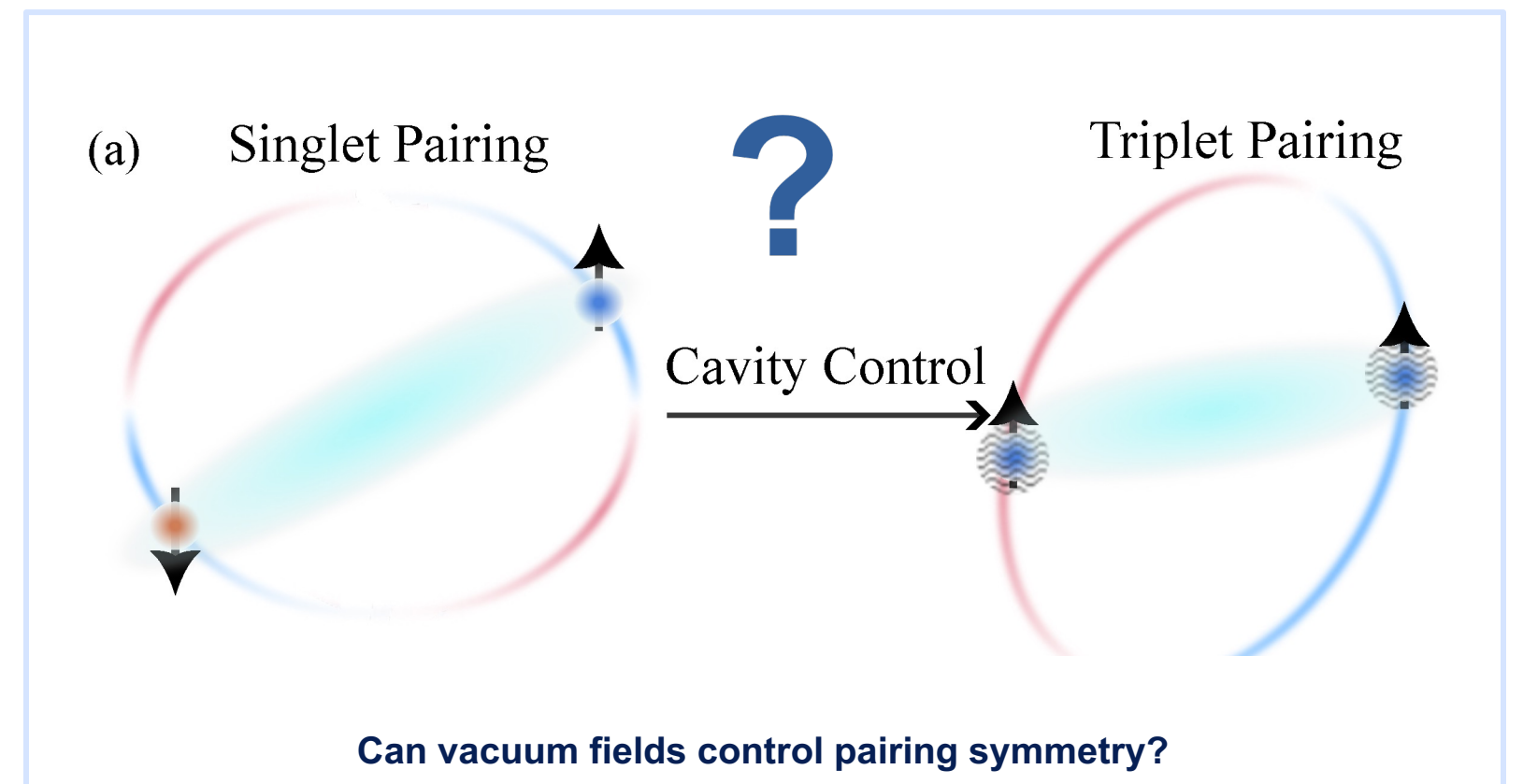
I.-T. Lu, et al., PNAS 121, e2415061121 (2024).

V. K. Kozin, et al., PRB 111,035410(2025). M. A. Stentef, et al., Sci. Adv. 4, eaau6969(2018).

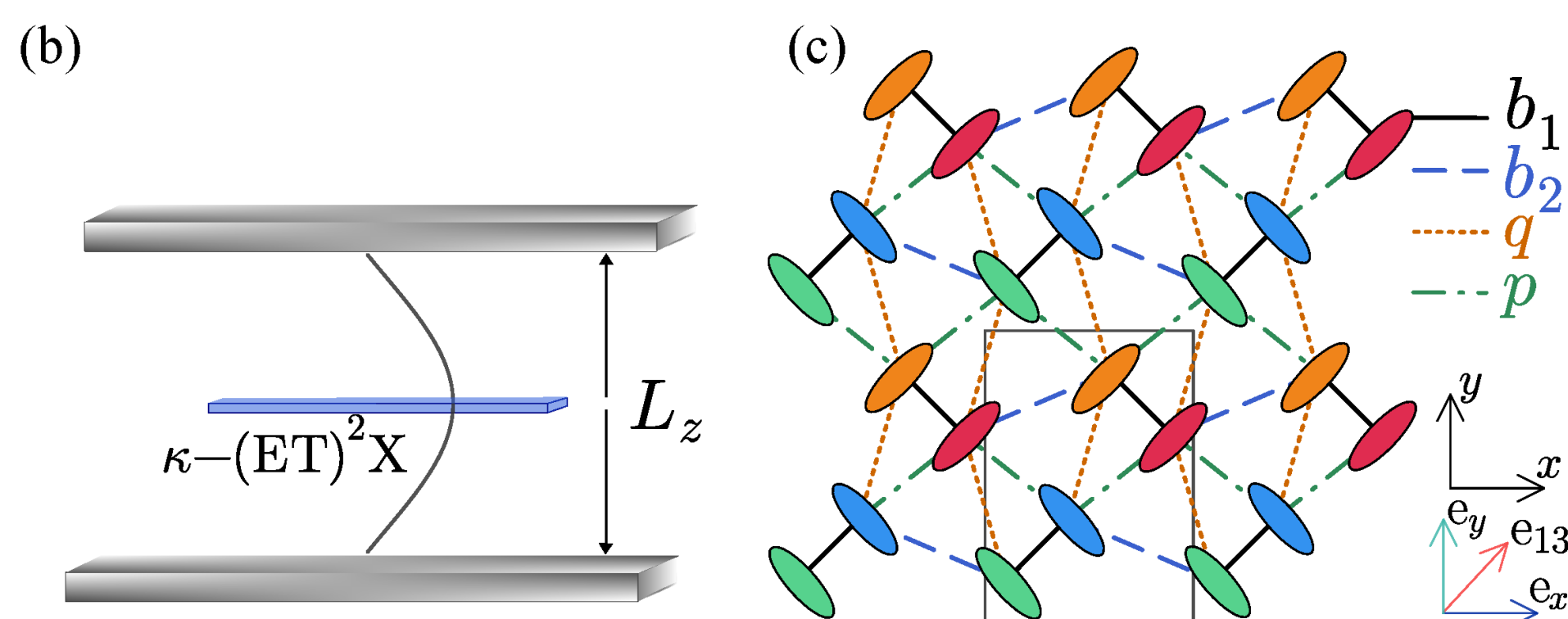
I. Keren, et al., Nature 650,864(2026). F. Schlawin, et al., PRL 122, 133602(2019)

J. Li, et al., PRB 105,165121. A. Thomas, et al., Nano Lett. 21,4365 (2021), J. Chem. Phys. 162, 134701 (2025).

This work



Model + Symmetry Channels



Cavity dressing enters through bond-selective hopping

$$H_0^{eff} = -\sum_{ij,\sigma} \tilde{t}_{ij} (c_{i\sigma}^\dagger c_{j\sigma} + H.c.)$$

$$\tilde{t}_{ij}^0 = t_{ij} \exp[-2\lambda |z_{ij}|^2 g_{eff}^2]$$

Symmetry-adapted gap channels

$$\Phi_{G,\beta}^{(s/t)}(k) = f_{G,\beta}^{(s/t)}(k) M_{G_{sub},\tau}(k)$$

$$M_{G_{sub},\tau} = \sum_{g \in C_{2v}} \chi_g^*(g) \hat{g} [M_{seed}]$$

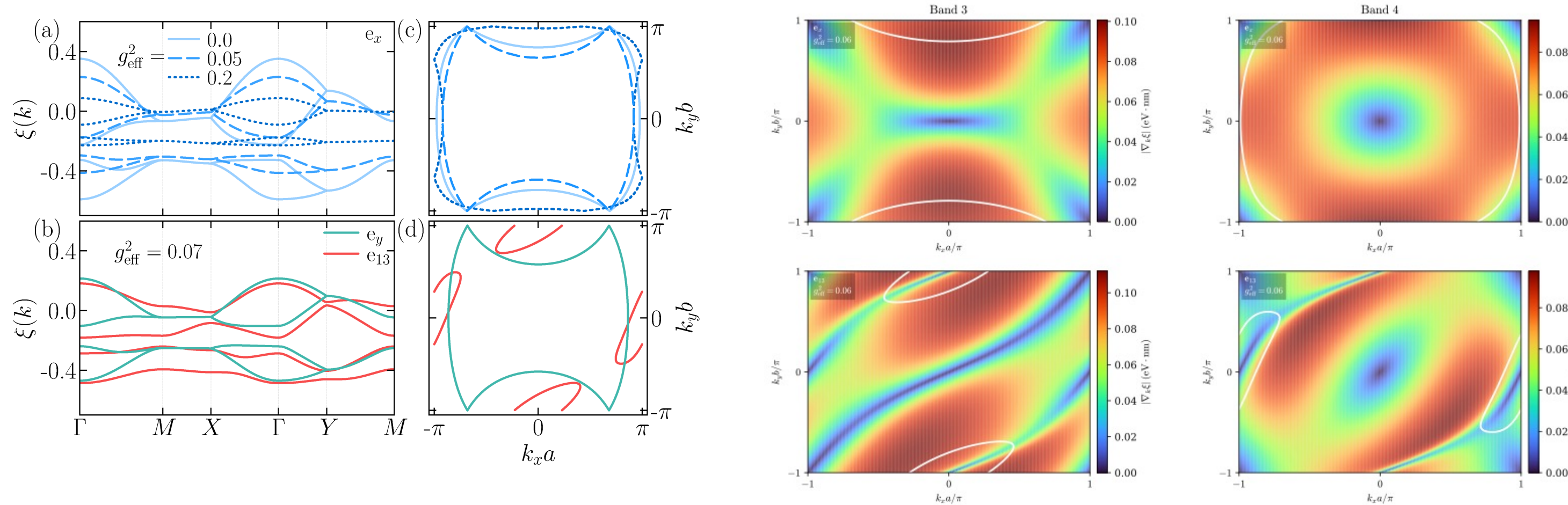
$$\Delta^{(s/t)}(k) = \sum_{G,\beta} \eta_{G,\beta}^{(s/t)} \Phi_{G,\beta}^{(s/t)}(k), \quad n = (G,\beta)$$

C _s	E	C ₂	g _z	g _x
A ₁	1	1	1	1
A ₂	1	1	-1	-1
B ₁	1	-1	1	-1
B ₂	1	-1	-1	1

$$\Delta_{ul}^{(s)}(k) = \Delta_{ul}^{(s)}(-k)$$

$$\Delta_{ul}^{(t)}(k) = -\Delta_{ul}^{(t)}(-k)$$

Mechanism: Band Flattening Reweights the Cooper Kernel



$$\hat{\Delta}_n^\dagger = \frac{1}{N_k^{1/2}} \sum_k \hat{c}_k^\dagger \Phi_n(k) \hat{c}_{-k}^\dagger$$

$$H_{int}^{(pair)} = \frac{1}{2} \sum_{nm} V_{nm} \hat{\Delta}_n^\dagger \hat{\Delta}_m, \quad K_{n\ell} = \sum_m V_{nm} C_{m\ell}$$

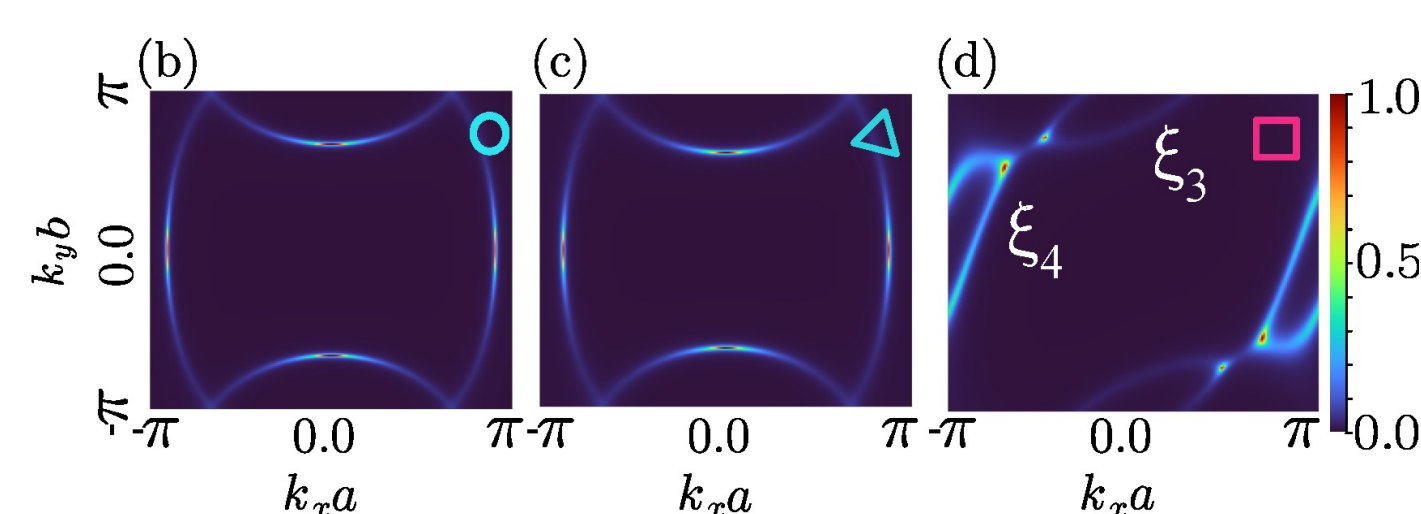
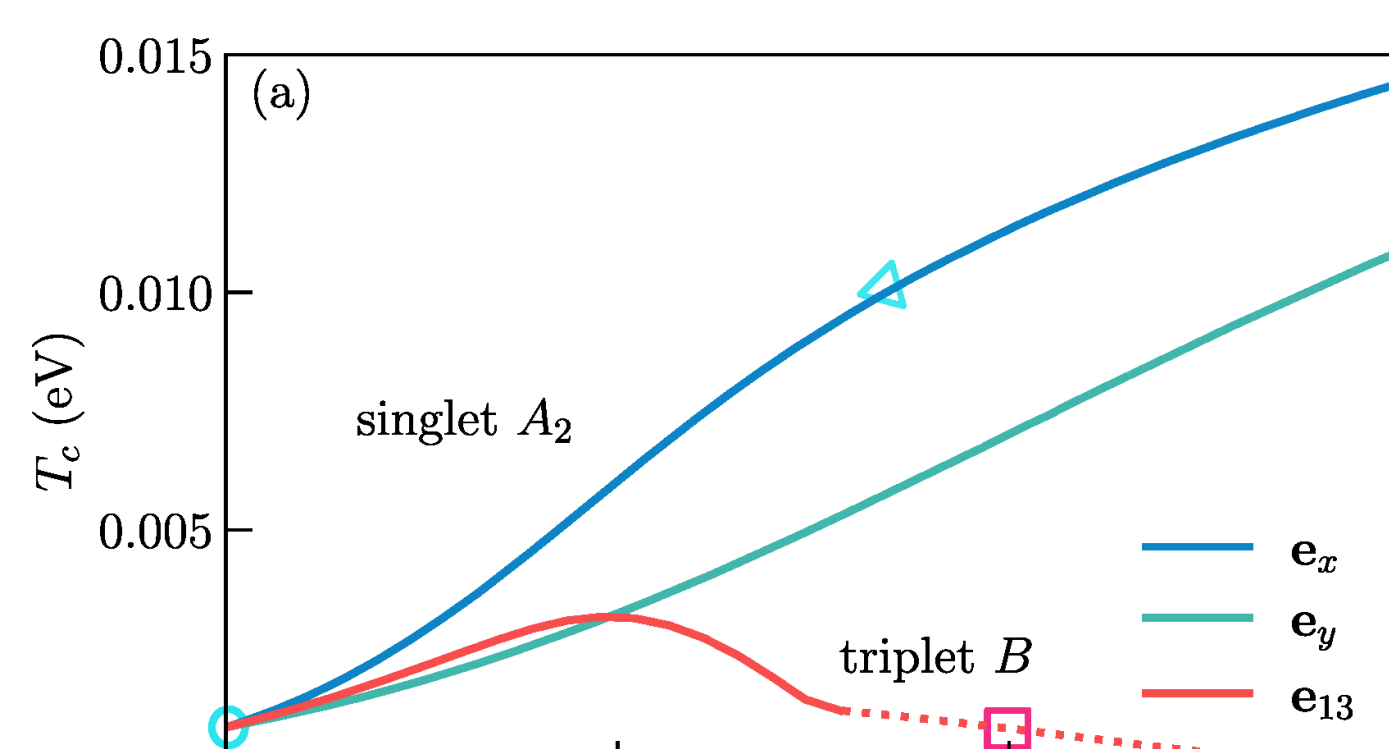
polarization
band dressing

FS weight
kernel reweighting

channel
eigenvalue switch

e13 polarization breaks both glides and gives the strongest symmetry-selective reweighting.

Result: Singlet-to-Triplet Switching



Conclusion

Dark-cavity vacuum dressing reshapes the Fermi surface and Cooper kernel. e13 polarization breaks glides, reweights Fermi velocity, suppresses the singlet channel, and stabilizes a triplet channel.

$$n_{lead} = \operatorname{argmax}_{n,s/t} \lambda_n^{(s/t)}$$

$$\lambda_{\max}(T_c) = 1$$

Outlook: cavity vacuum engineering offers a controllable route toward unconventional and potentially topological superconductivity.