Soft Constrianed Topological Transition

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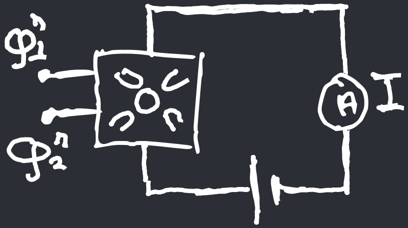
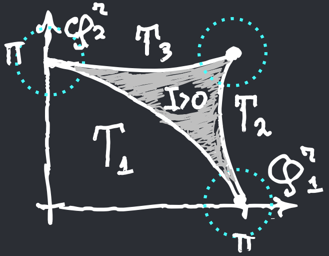
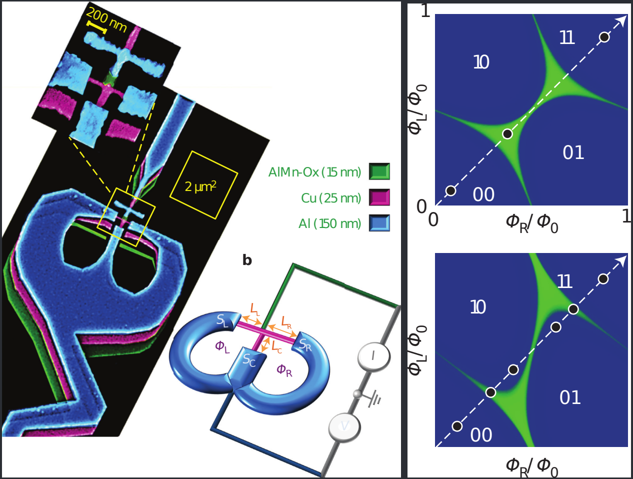
The setup





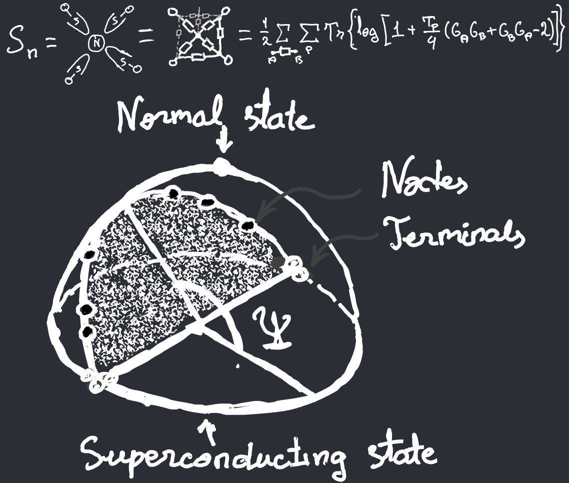
A similar experiment [3]



Strambini, E., D'Ambrosio, S., Vischi, F., Bergeret, F. S., Nazarov, Y. V., & Giazotto, F. (2016). The ω-SQUIPT as a tool to phase-engineer Josephson topological materials.

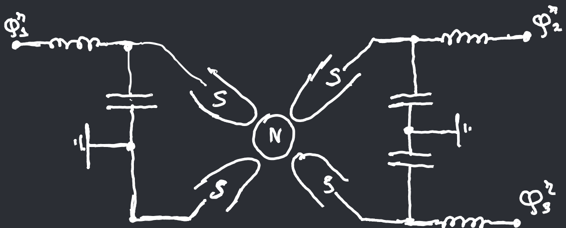
Why topological?

According to quantum circuit theory in a stationary case we can represent our nanostructure on the hemisphere $G = \vec{g} \cdot \vec{\sigma}$



What makes transition soft?

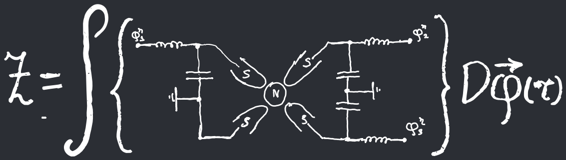
Due to external capacities and induktivities (which may rise due to bulk supercoductor geometry change) the superconductor order parameter (phase) can fluctuate around the equilibrium position given by external reservuar phases $\phi^r_{1,2,3}$:



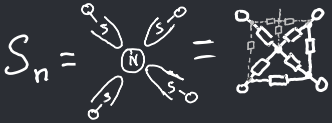
The question we ask: How would the softness of the constraint ($\langle \delta\hat{\phi}^2 \rangle \propto k_B T/E_J$) affect the topological phase diagram?

Our model

We write down the partition fucntion of our circuit:

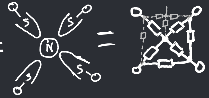


We use the quantum circuit theory to approximate the multiterminal superconducting junction:

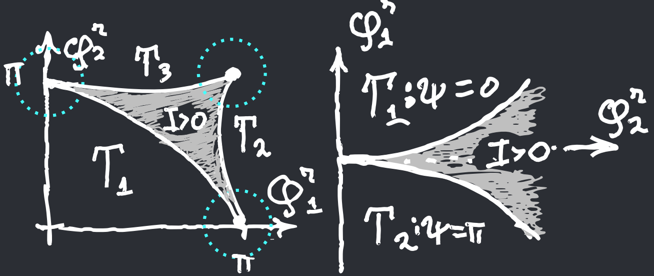


$$= \frac{1}{2}\sum_{A-B}\sum_{p} \mathrm{Tr}\left\{\log\left[1+\frac{T_p}{4}\left(G_A G_B + G_B G_A - 2\right)\right]\right\}$$

At the proximity of a special point



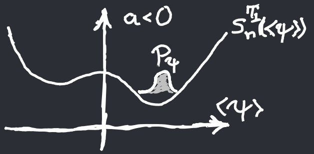
$$S_n = (\text{diagram}) = (\text{diagram}) = \frac{1}{2}\sum_{A-B}\sum_{P} \mathrm{Tr}\left\{\log\left[1 + \frac{T_P}{4}\left(G_A G_B + G_B G_A - 2\right)\right]\right\}$$

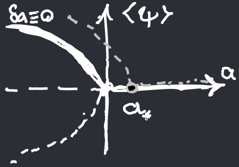


$$S_n^{T_1} \simeq \mathrm{Tr}\left[-2\varepsilon\Psi + \frac{1}{2}(a+\delta a)\Psi^2 + \frac{1}{4} b\Psi^4\right]$$

The renormalization

$$S_n^{T_1} \simeq \mathrm{Tr}\left[-2\varepsilon\Psi + \frac{1}{2}(a+\delta a)\Psi^2 + \frac{1}{4} b\Psi^4\right]$$





$$\langle S_n(a+\delta a,\Psi)\rangle \overset{?}{\doteq} S_n(a,\langle\Psi\rangle) + \langle S_n^{(2)}\rangle(a,\langle\Psi\rangle) \overset{?}{\doteq} S_n(a_*,\langle\Psi\rangle)$$

Second order P. T.

$$\langle \psi_2(\varepsilon) \rangle = \frac{3\psi_0(\varepsilon)\psi_0(\omega_{cut})}{4\pi(a + 3\psi_0^2(\varepsilon))} + f(a, \varepsilon)$$

The first term renormalizes *a*. The second term is logarithmic for a small negative *a*, which is expected as P. T. should break down at the transition point.

References

- Erdmanis, J., Lukács, Á., & Nazarov, Y. V. (2018). Weyl disks: Theoretical prediction. Physical Review B, 98(24)
- Huang, X. L. & Nazarov, Y. V. Topology protection-unprotection transition: an example from multi terminal superconducting nanostructures
- Strambini, E., D'Ambrosio, S., Vischi, F., Bergeret, F. S., Nazarov, Y. V., & Giazotto, F. (2016). The ω-SQUIPT as a tool to phase-engineer Josephson topological materials. Nature Nanotechnology, 11(12), 1055–1059