# Control of Majorana zero modes hybridization via a single magnetic adatom

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Advances in controlling impurity spins of magnetic impurities deposited on superconductors have enabled observations of promising signatures of Majorana zero modes. However, detecting their fusion rules, that reflect their non-Abelian character, requires control of their hybridization which still remains an unresolved problem. We take the first step in this direction and propose a protocol using a Yu-Shiba-Rusinov state induced by a magnetic adatom deposited on the superconductor. Considering two chains of magnetic impurities on an s-wave superconductor in the topological regime with a single magnetic atom in between, we observe that the overlap of the Yu-Shiba-Rusinov state with Majorana zero modes modulates their bare hybridization energy. We show that the parameters associated with this single adatom, namely, its orientation, distance from the chains and exchange coupling to the SC, can act as control knobs for tuning the hybridization of the Majorana zero modes within a wide range of values starting from zero. Using multiple experimentally relevant models we demonstrate that our proposal is general and model independent. We also discuss the possible experimental realization using the scanning tunneling microscopy-electron spin resonance techniques. Our results pave way for the possibility of controlled fusion and braiding experiment on magnetic impurity-superconductor experimental setups.

Figures

**Figure 1:** Sketch of the system: Two chains of magnetic adatoms separated by distance R with a single magnetic impurity (blue) placed at between the two chains.

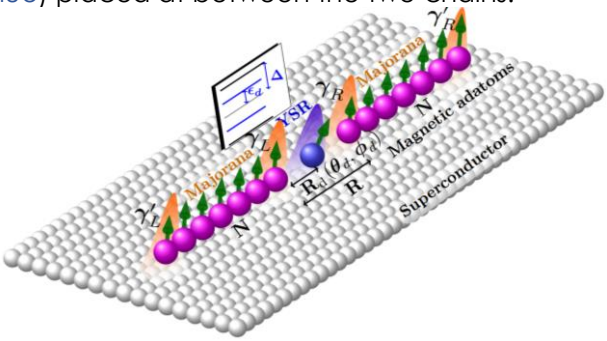


**Figure 2:** Analytical results for the effective Majorana-Majorana hybridization as a function of the orientation of the single magnetic adatom.