COUPLED YU-SHIBA-RUSINOV STATES IN MOLECULAR DIMERS ON NBSE$_2$

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Magnetic impurities have a dramatic effect on superconductivity by breaking the time-reversal symmetry and inducing so-called Yu-Shiba-Rusinov (YSR) low energy bound states within the superconducting gap [1–3]. These types of systems have attracted renewed interest after the recent observation of Majorana modes in a linear chain of magnetic atoms on an s-wave superconductor [4, 5]. In general, controlled coupling of YSR states should enable realizing designer quantum materials with novel topological phases [6]. The spatial extent of YSR states depends crucially on the dimensionality of the underlying superconductor and is greatly enhanced in 2D systems [9], which should facilitate the formation of coupled states. However, coupling between YSR states on 2D superconductors has not yet been demonstrated. Here, we observe YSR states on single cobalt phthalocyanine (CoPC) molecules on a 2D superconductor NbSe2 and confirm their slow spatial decay using low-temperature scanning tunneling microscopy (STM) and spectroscopy (STS). We use STM lateral manipulation to create controlled CoPc dimers and demonstrate the formation of coupled YSR states. The experimental results are corroborated by theoretical analysis of the coupled states in lattice and continuum models. Our work forms an important step towards the realization of exotic topological states in designer magnetic lattices [6, 7]

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