Molecular Magnets: From the single molecule to the 3D self-assembly

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Abstract

Real materials are not pure. Impurities can bring to light beautiful physics: they are crucial, for instance, in achieving the functionality of doped semiconductors. Indeed, sensitivity of a physical system to disorder can lead to elucidating details of electronic correlations and producing electronic states that are impossible in clean systems.

In particular, magnetic impurities in superconductors are able to reduce the superconducting BCS gap and may ultimately destroy the superconducting state. A single classical spin of a magnetic atom is able to create a localized bound state within the BCS gap (Shiba state). Consequently, a finite concentration of magnetic impurities can form an impurity band within the superconducting gap. The spatial decay of these bound states critically depends on the dimensionality of the system, i.e. it is increased by reducing the dimensionality [1].

The Pb/Si(111) system is one of the most remarkable examples of a 2D superconductor in which superconductivity arises in a single atomic plane of Pb [2,3]. I will present preliminary results of the in-situ preparation (UHV conditions) of this system at room temperature and I will show its complex phases diagram. I will also illustrate the possibility to use Differential Reflectance Spectroscopy (DRS) in order to optically follow in real-time the temporal evolution of the thickness of Pb during its growth on the Si substrate.

The use of magnetic phthalocyanines as magnetic impurities by evaporating them on the Pb monolayer might lead to some advantages. For instance, playing with both self-assembly properties of these molecules and substrate anisotropy allows to tailor robust arrays of magnetic centers in 1D and 2D [4]. For this reason, is very intriguing to investigate the superconducting substrate-mediated interaction [5] between two Shiba States which could be used as building blocks for coupling coherently distant magnetic molecules. Such long-range coupling of magnetic impurities through a 2D superconductor could be an efficient way to create new topological phases exhibiting Majorana edge states.

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