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Evolution of Kondo Resonance from a Single Impurity Molecule to the Two-Dimensional Kondo Lattice

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We investigated the Kondo resonance formed by the adsorption of magnetic molecule, iron(II) phthalocyanine (denoted as FePc), on Au(111) from a single impurity regime to the two-dimensional Kondo lattice by using scanning tunneling microscopy, the density functional theory (DFT) and numerical renormalization group (NRG). In the single molecule regime, FePc takes ontop and bridge configurations. These species show characteristic Kondo signatures in their one-particle energy spectra depending on the adsorption site. The ontop species shows a broad peak accompanied by a sharp dip, while the bridge species only a broad peak. The origin of these features comes from the difference in the local symmetry around the Fe ion. The two-stage Kondo screening occurs for two localized electrons in the different 3d orbitals characterized by low and high Kondo temperatures, reflecting the different coupling strength of these orbitals with Au(111). For the ontop species, highly-symmetric SU(4) Kondo effect is realized, leading to the sharp dip. The dip observed for the ontop species is also evolved from the single impurity regime to the two-dimensional lattice. The spectral evolution and the quantum phase of the lattice are discussed by the competition of the Kondo effect with antiferromagnetic RKKY coupling between the molecular spins.