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How does a Kondo impurity respond to its local environment?[1]

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The interplay between localized electrons on a magnetic atom and the conducting electrons in a metal can lead to intriguing many-body ground states such as the Kondo effect. When a spin is Kondo screened by conduction electrons the entire spin system performs a complicated dance that results in the formation of a spin singlet at sufficiently low temperature. For simplicity, most theoretical considerations of Kondo screening focus on magnetic impurities with the lowest possible spin S = 1/2. Such systems can be studied experimentally in exquisite detail and with great control using quantum dots in semiconductor heterostructures or carbon nanotubes. However, in Kondo systems consisting of localized magnetic atoms, the spin is often larger, making the Kondo effect richer and more complex. Here we use the imaging and spectroscopy capabilities of a scanning tunnelling microscope to study how the Kondo screening of a known high-spin atom is determined by its local environment. Co and Ti atoms were deposited on a thin insulating layer (Cu_2N) on a copper substrate. We study the influence of external magnetic fields, crystalline magnetic anisotropy, as well as spin-coupling to surrounding atomic spins on the Kondo effect that forms on the Co or Ti atoms. We find that the anisotropy of the crystalline field quenches the high-spin system of Co (S = 3/2) into an effective S = 1/2 Kramers doublet. Surprisingly, much of the impact of these environmental factors on the complex many-body ground state can be understood simply through their effects on the energy levels of the unscreened spin.

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