Spin-excitations in a 4*f*-3*d* heterodimer on MgO

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Rare-earths (RE), especially, the late lanthanides have engaged a lot of attention in atomic and molecular magnets in recent years [1-4]. Most of the scientific interests in this field are largely driven by the search of magnetic stability down to the scale of single RE atoms at technically relevant temperatures. As the very first step towards achieving this goal, it is crucial to understand the atomic scale interactions, which govern fundamental magnetic properties in surface-supported, low-coordinated systems.

Here we explore such interactions in an atomic scale cluster, namely, heterodimer made of RE and transition metal (TM) atom. These heterodimers are the basic building blocks of RE-TM alloys, which are quite successfully used in permanent magnet industry. The prototypical heterodimer is HoCo adsorbed on MgO. The properties of Ho and Co on this surface are particularly intriguing: Ho is the first discovered stable single atom magnet [2], while Co exhibits the highest magnetic anisotropy energy among all surface-supported transition metal atoms [5]. We observe two pairs of spin-excitations in this heterodimer, at ± 8 and ± 20 meV. Using an effective spin Hamiltonian model we reproduce their magnetic field dependence and identify the low energy spectrum of the magnetic levels. Combining these with density functional theory calculations, we infer a ferromagnetic coupling between Ho and Co, unlike the case of conventional 4*f*-3*d* compounds. The novelty of detecting magnetic transitions in RE based nanostructures enables to unravel their magnetic level spectrum as well as their internal magnetic coupling.

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