Measuring magnetic anisotropy in a single-molecule spin transistor

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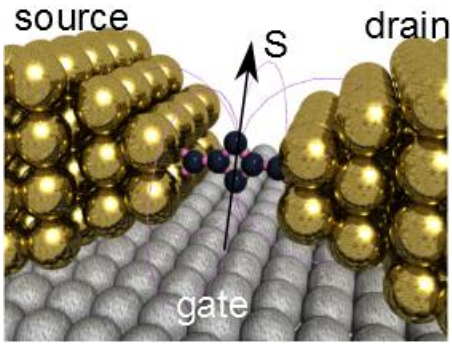
Spintronics, which aims to use the spin state of the electrons to process information, is a promising technology to supplement conventional electronics based on the control of the electrical charge of the electrons. The field is rapidly evolving into molecular spintronics where transport takes place through individual molecules advancing in miniaturization and spin-state preservation. The versatility of molecular synthesis allows to introduce built-in properties such as magnetism in molecules. As a result, the molecule possess intrinsic spin and therefore a spin polarized current is no longer needed. But, under what conditions this molecular spin-state can be read, controlled or written? The viability of molecular spintronics rest in the ability to discern and control the spin state of this magnetic molecule.

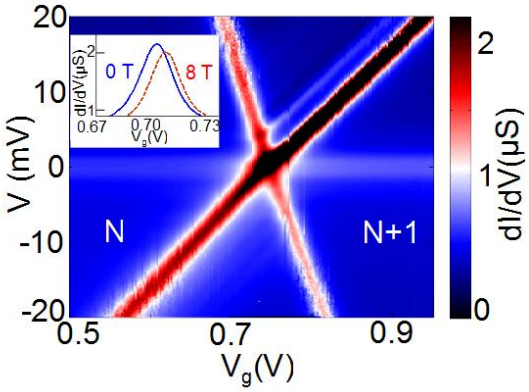


We study three-terminal charge transport through individual Fe_4 single-molecule magnets [1]. The Fe_4 molecule is linked to two gold electrodes fabricated by self-breaking electromigration of a gold nanowire [2,3]. A third gate electrode is used to access different redox states of the molecule.

We directly observe for the first time [4] the magnetic anisotropy of the single molecule by introducing a spectroscopy technique based on measuring the position of the zero-bias degeneracy-point (see figure) as a function of gate voltage and applied magnetic field.

Our measurements reveal an increase of the magnetic anisotropy and a decrease of the ground state spin upon reduction of the molecule. Moreover, the sensitivity of this method allows to detect small changes in the orientation and magnitude of the anisotropy in different charge states. We find that the easy axes of the molecule in adjacent charge states are (almost) collinear.

The sensitivity of the technique will allow to study quantum properties of the Fe_4 such as the quantum tunneling of the magnetization at the single-molecule scale.



Differential conductance map of a single Fe_4 SMM showing two different charge states.

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References

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