Department of Physics Colloquium

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Atomic spins in highly excited states

Friday, Oct. 30
2:30 P.M.
210 Robeson Hall

Our ability to quickly access the vast amounts of information linked in the internet and everywhere else is owed to the miniaturization of magnetic data storage. From the invention of the hard disk drive in 1956 to our present day life, magnetic bits have shrunk from millimeter size to a few tens of nanometers. If magnets shrink further, down to a point where only a few atoms comprise the magnetic structure, they undergo a dramatic shift in their behavior. While classical magnets allow for a continuous rotation of their magnetization direction, small spin systems behave quantum mechanical – their magnetic orientation becomes quantized. Studying the energetically discrete excitations of these nanomagnets and their response to external influences allows insight into basic principles of quantum mechanics.

Here we show how the magnetic properties of individual atoms and artificially created nanostructures can be probed with a low-temperature, high-field scanning tunneling microscope (STM) when the atoms are placed on a thin insulator (see Fig. 1). We find clear evidence of large magnetic anisotropy, a prerequisite for building stable magnetic bits, for individual d-metal atoms embedded in a monatomic layer of Cu2N on copper [1]. The STM allows the determination of all parameters in the corresponding Spin Hamiltonian which describes the quantized energy levels of the spin system in real-space and under application of external magnetic fields. The spin excitations proof to be strongly dependent on the spin orientation of the tunneling electrons. At high current densities, a spin-polarized current can transfer a significant amount of spin angular momentum to the magnetic atoms and nanostructures [2]. The current pumps the atomic spin into highly excited states culminating in the reversal of the spin’s magnetic orientation. This enables exploration of the microscopic mechanisms for spin-relaxation and stability of nanomagnets.