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Quantized spin-momentum transfer in atom-sized magnetic systems[1]

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Our ability to quickly access the vast amounts of information linked in the internet is owed to the miniaturization of magnetic data storage. In modern disk drives the tunnel magnetoresistance effect (TMR) serves as sensitive reading mechanism for the nanoscopic magnetic bits [1]. At its core lies the ability to control the flow of electrons with a material's magnetization. The inverse effect, spin transfer torque (STT), allows one to influence a magnetic layer by high current densities of spin-polarized electrons and carries high hopes for applications in non-volatile magnetic memory [2]. We show that equivalent processes are active in quantum spin systems. We use a scanning tunneling microscope (STM) operating at low temperature and high magnetic field to address individual magnetic structures and probe their spin excitations by inelastic electron tunneling [3]. As model system we investigate transition metal atoms adsorbed to a copper nitride layer grown on a Cu crystal. The magnetic atoms on the surface possess well-defined spin states [4]. Transfer of one magnetic atom to the STM tip's apex creates spin-polarization in the probe tip. The combination of functionalized tip and surface adsorbed atom resembles a TMR structure where the magnetic layers now consist of one magnetic atom each. Spin-polarized current emitted from the probe tip not only senses the magnetic orientation of the atomic spin system, it efficiently transfers spin angular momentum and pumps the quantum spin system between the different spin states. This enables further exploration of the microscopic mechanisms for spin-relaxation and stability of quantum spin systems.

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[4] Hirjibehedin et al., Science 317, 1199 (2007).

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