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Scanning Probe Microscopy for Spin Mapping and Spin Manipulation on the Atomic Scale

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A fundamental understanding of magnetic and spin-dependent phenomena requires the determination of spin structures and spin excitations down to the atomic scale. The direct visualization of atomic-scale spin structures [1-4] has first been accomplished for magnetic metals by combining the atomic resolution capability of Scanning Tunnelling Microscopy (STM) with spin sensitivity, based on vacuum tunnelling of spin-polarized electrons [5]. The resulting technique, Spin-Polarized Scanning Tunnelling Microscopy (SP-STM), nowadays provides unprecedented insight into collinear and non-collinear spin structures at surfaces of magnetic nanostructures and has already led to the discovery of new types of magnetic order at the nanoscale [6,7]. More recently, the detection of spin-dependent exchange and correlation forces has allowed a first direct real-space observation of spin structures at surfaces of antiferromagnetic insulators [8]. This new type of scanning probe microscopy, called Magnetic Exchange Force Microscopy (MExFM), offers a powerful new tool to investigate different types of spin-spin interactions based on direct-, super-, or RKKY-type exchange down to the atomic level. By combining MExFM with high-precision measurements of damping forces, localized or confined spin excitations in magnetic systems of reduced dimensions now become experimentally accessible. Moreover, the combination of spin state read-out and spin state manipulation, based on spin-current induced switching across a vacuum gap by means of SP-STM [9], provides a fascinating novel type of approach towards ultra-high density magnetic recording without the use of magnetic stray fields.
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