Inelastic Electron Tunneling Spectroscopy with the STM to access Electron and Nuclear Spin States

In inelastic electron tunneling spectroscopy one measures conductance steps of a tunnel junction associated with vibrational, spin, or rotational excitations of atoms and molecules in the junction. The excitation energies are characteristic for the respective system and allow chemical identification, determination of the magnetic properties, or of the molecular rotational eigenstates.

Using the STM allows to perform IETS on a single adsorbed atom or molecule. However, molecular rotations could so far not be characterized with STM-IETS. We demonstrate rotational excitation spectroscopy with the STM and illustrate its potential for physisorbed hydrogen and its isotopes. The observed excitation energies are very close to the gas phase values and show the expected scaling with mass. Since these energies are characteristic for the molecular nuclear spin states we are able to identify the para and ortho species of hydrogen and deuterium, respectively. We thereby demonstrate nuclear spin sensitivity with unprecedented spatial resolution.

In a second part we discuss STM spin excitations on single magnetic adatoms on graphene and monolayer oxides and show how a combination with X-ray magnetic circular dichroism (XMCD) ensemble measurements can lead to an improved understanding of these systems. We comment on the perspective to create single atom magnets, i.e., bistable magnetic behavior in a single atom.

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