Invited Speaker

**Probing chemical bonds to natural and artificial atoms by atomic force microscopy**

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Atomic force microscopy with CO terminated tips has demonstrated outstanding spatial resolution on organic molecules [1], metallic clusters [2] and many other samples. Experimental evidence and calculations show that the CO tip is chemically inert and probes organic molecules mainly by Pauli repulsion [3]. Thus, images of organic molecules, graphene etc. observed with a CO tip can be interpreted as a map of the absolute charge density of the sample. The total charge density of a single adatom is approximately given by a Gaussian peak. While single silicon adatoms appear similar to a Gaussian peak when imaged by AFM with a CO terminated tip, copper and iron adatoms adsorbed on Cu(111) and Cu(110) appear as tori [2,4]. Experiments and DFT calculations show that the total charge density of Cu and Fe adatoms is approximately Gaussian – in contrast to the hybridization theory [4]. The bonding strength between the AFM tip and the atoms of the sample depends not only on the chemical identity but also on the coordination - corner atoms in clusters are more reactive than center atoms [5].

Progress in force resolution [6] opens up the fN-regime, allowing to study engineered surface structures such as quantum corrals that form artificial atoms and interact in a similar way as natural atoms, yet with a force of only 1/1000 of what is experienced in natural atoms [7].

![AFM images of various metallic adatoms using a CO terminated tip. A Copper adatom on Cu(111). B Copper adatom on Cu(110). C Iron adatom on Cu(111). D Quantum Corral after Crommie, Lutz and Eigler [8] on Cu(111).](image)

**References:**