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Invited Speaker

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

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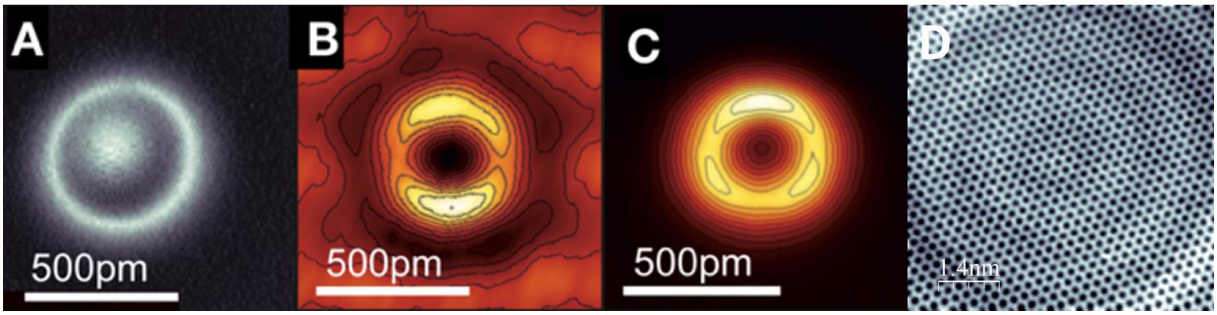
Atomic force microscopy with CO terminated tips has demonstrated outstanding spatial resolution on organic molecules [1], metallic clusters [2] and many other samples. Experimental evidence and calculations show that the CO tip is chemically inert and probes organic molecules mainly by Pauli repulsion [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).*

References:

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[6] A. Liebig et al., *New Journal of Physics* **22**, 063040 (2020).
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[8] M.F. Crommie, C.P. Lutz, D.M. Eigler, *Science* **262**, 218 (1993).