Nano-scale atom traps on a chip

Peter Kruger

*Midlands Ultracold Atom Research Centre*
*School of Physics and Astronomy*
*The University of Nottingham*
*Nottingham NG7 2RD, United Kingdom*

Microtraps for cold atoms based on patterned surface-mounted structures have been very successful over the past 15 years. The miniaturization of traps has a number of advantages and new types of experiments become possible through structuring and manipulating quantum gases on small scales. The closer the atoms are trapped to the surface, the wider the range of possibilities becomes. In addition to shaping the environment of the quantum gas, the surface itself can become the focus of investigation when the atoms function as a microscopic probe of local magnetic fields and/or surface structure.

Here we focus on ways and benefits of reducing the atom-surface separation beyond current experiments where the atoms can typically not be trapped closer than a few microns from the surface. Submicron trapping distances will open the path to new possibilities in

- Structuring quantum gases with a tailoring resolution on the order of and beyond characteristic length scales of the gas (healing length) with interesting applications in disorder, controlled tunnelling, and transport
- Reaching nano-scale resolution in microscopic field measurements
- Measuring atom-surface forces (Casimir forces) in the submicron regime with relevance in various areas of physics including near-field scanning microscopy
- Advancing towards observing backaction from the atoms onto the surface with applications in quantum interfaces, two-way atom-surface coupling, and hybrid quantum devices

The main obstacles in these endeavors are noisy currents in surface conductors (Johnson noise), corrugations of magnetic fields due to minute wire imperfections, and fluctuation induced (Casimir) forces. In this talk and throughout the associated session on atom-surface interactions, we outline these seemingly detrimental issues and describe potential solutions to overcome the current few micron atom-surface separation limit. We also discuss the newly accessible regime in terms of fundamental experiments and applications.