Lattices of magnetic microtraps, Rydberg atoms, and quantum simulation

*Robert Spreeuw**

Van der Waals-Zeeman Institute, Univ. of Amsterdam, the Netherlands

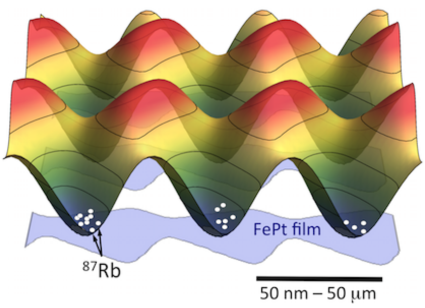
(*) r.j.c.spreeuw@uva.nl

We investigate lattices of magnetic microtraps holding mesoscopic clouds of ultracold ^{87}Rb atoms as a platform for the study of strongly interacting Rydberg atoms.

At the heart of our experiment is an atom chip made out of permanently magnetised film, lithographically patterned to create a two-dimensional lattice of Ioffe-Pritchard type magnetic traps [1]. Excitation of Rydberg atoms in these tight magnetic traps takes us into a very interesting regime, confining ensembles of atoms to a volume comparable to a typical Rydberg orbit. Strong dipole blockade is thus expected, and the strong magnetic field gradient will strongly distort the Rydberg wavefunction. The Rydberg atoms will also be excited only few μm from a metal surface and will interact with their mirror image.

Our atom chip contains lattices with square as well as hexagonal symmetries, both with a $10\,\mu$m lattice parameter [2]. We populate a few hundred microtraps, each holding an ensemble of about a hundred ultracold rubidium atoms. Quantum information can be stored in these ensembles as superpositions of collective hyperfine states. Switchable interaction will be enacted by transient excitation or dressing to Rydberg levels.

In addition we are developing lattices with lattice parameter in the 100 nm range. This should yield an implementation of the Hubbard model in novel parameter regimes, with strongly increased energy scales compared to current optical lattices.



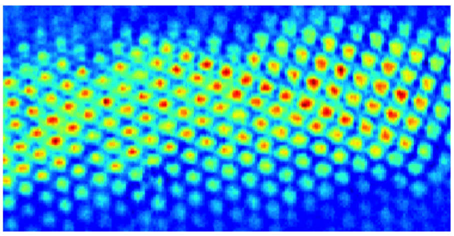


Figure 1: Left: patterned, magnetised film (blue) with the calculated magnetic potential landscape. Right: absorption image of joined square and triagonal lattices of microtraps for Rydberg experiments, with $10\,\mu$m lattice period.

References

[1] V. Y. F. Leung, A. Tauschinsky, N. J. van Druten, and R. J. C. Spreeuw, Quantum Inf. Proc. **6**, 955–974 (2011)

[2] V. Y. F. Leung, *et al.*, Rev. Sci. Instr. **5**, 053102 (2014)