Popular science account of

Magnetic-film atom chip with 10 µm period lattices of microtraps for quantum information science with Rydberg atoms

By Julian Naber

Since the 1980s the "quantum computer" has become a widely discussed and well known concept in physics and information technology. In a nutshell, a quantum computer exploits quantum mechanical properties of a system to speed up calculations. One famous application, first suggested by Nobel Prize winner Richard Feynman, is the universal quantum computer, a device which can simulate the properties of every other quantum mechanical system. This is especially useful considering that simulating such systems on a "classical" computer quickly exceeds current capabilities, which are limited to simulating a few tens of particles. Two further applications in information science could yield a speed-up in searching a data base and in factorizing huge numbers. The latter is directly connected to standard methods in cryptography and encrypted communication.

Regarding the broad variety of possible applications different platforms for a quantum computer have been suggested and implemented: nuclear spins, superconducting electrodes, ions and atoms among others. All those systems cope with the challenge of preserving their quantum properties which are highly susceptible to disturbances from the environment. This poses a major technical challenge.

The system described in this publication tries to approach this technical challenge by combining the best of two worlds: the well-established manufacturing techniques of solid state devices and the stability of atomic ground states. The concept is to magnetically trap atoms and to manipulate their properties by laser light in a well-defined fashion. The atoms are trapped in independent clouds on a chip made from a permanent magnetic material which can, in principle, be shaped in any arbitrary fashion by solid-state techniques. This means that one has the complete freedom of designing any feasible trapping geometry.

As a proof-of-principle a combination of a square and hexagonal lattice was introduced on the chip, which can be clearly seen in the arrangement of the trapped atoms. This design freedom offers a possible solution to the problem of scalability in quantum systems, meaning the ability to arbitrarily increase its size. Other platforms usually do not offer this degree of flexibility. For example, a spacing of 10 µm was chosen in between neighboring clouds of atoms to allow easy and independent manipulation with laser light. In principle the structure can also be scaled down to distances of a few tens of nanometers entering a completely different regime of interactions which cannot even be accessed by another well-established system, namely optical lattices. Future work will be aimed at investigating the properties of trapped atoms and especially to introduce well-controlled interactions between trap sites to realize information exchange and to make a step further towards simulating interacting systems.