Giant Rydberg atoms confined in a micro-glass cell

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Rydberg atoms are highly sensitive atoms, as one electron is only loosely bound. Compared to 'normal' atoms which are one tenth of a nanometer in size those giant atoms are ~100 nanometers large. Due to their sensitivity they are very useful for quantum logic operations.

As they can feel each other over distances up to several micrometers they can be used as conditional switches for quantum states, for example to connect nodes of a quantum network. The miniaturisation of such quantum devices will seemingly also be hindered by this large sensitivity as Rydberg atoms were expected to also interact strongly with confining walls.

Now researchers of the 5. Physikalisches Institut at the Universität Stuttgart, Germany, showed contrary to that expectation that it is possible to confine giant Rydberg atoms in microscopic glass cells und circumstances without significant disturbance. For this micron sized glass cells fabricated by them were filled with 'normal' hot atoms in the vapor phase. Then they were converted into Rydberg atoms by laser excitation.

They report on the progress in a recent publication in *Nature Photonics*. It seems that hot Rydberg atoms confined in micro-glasscells have become hot candidates for miniaturized quantum devices at or even above room temperature.

Researchers from the 5. Physikalisches Institut are working with those giant atoms for several years now. Up to now their research concentrated on ultracold atoms. Using elaborate cooling techniques in big UHV chambers the atoms could be isolated from the environment. They have investigated the interaction between Rydberg atoms and have observed a novel molecular bond based on Rydberg electrons recently. The apparatus for those experiments is however quite complex and certainly not well suited for applications. Therefore they were looking for an easy to handle alternative which are scalable and suited for massively parallel production.

Microstruturing of glass is well established technique and is applied also in flat-panel display technology. In order to use this technology for the confinement of atoms, it was necessary to investigate the interaction of Rydberg atoms with nearby glass walls. If the sensitive Rydberg atoms would be disturbed by the wall, then application like quantum information processing would become impossible. Now the group succeeded to investigate the interaction of Rydberg atoms with glass walls. The confined them between two glass walls separated by less than 1 micrometer and detected the energy shifts using a coherent spectroscopy technique which is very sensitive to loss of quantum information (decoherence). They found, that different Rydberg states interact with the wall with different strengths and found a specific state which was almost not affected by the wall. Therefore it now seems feasible to apply Rydbergatoms in microcells for quantum information purposes.

More information: Harald Kübler, James P. Shaffer, Thomas Baluktsian, Robert Löw, Tilman Pfau: Coherent excitation of Rydberg atoms in micrometre-sized atomic vapour cells, Preprint: arXiv.org/abs/0908.0275 .

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