Trapped Rydberg Ions

Igor Lesanovsky (University of Nottingham)

Currently, there is great interest in the study of ensembles of atoms excited to Rydberg states. These highly excited atoms interact strongly and over comparably long distances via a static or induced dipole-dipole interaction. In the past years this property has found numerous applications in the domains of strongly correlated many-body physics, quantum optics and quantum information processing.

In principle it is also possible to exploit the unique properties of Rydberg states in trapped ions experiment. In the context of quantum information processing the expected long-ranged interaction is a good candidate for realizing quantum gate protocols that are independent of the vibrational mode structure of ion crystals. This could highlight a direction towards achieving a scalable trapped ion quantum computer.

In this talk I will present recent results on trapped Rydberg ions obtained in the framework of the R-ION consortium. I will show that even the excitation of a single Rydberg ion from an ion crystal in a Paul trap can in general not be described within a single particle picture. This effect is due to a strong coupling between the electronic dynamics and the vibrational modes of the ion crystal and counterpart in experiments with neutral atoms. I demonstrate that this effect can find applications in the creation of non-classical motional states of trapped ions and that it can be employed to dynamically shape the structure of vibrational ion crystal modes. Moreover, I will briefly discuss the technological challenges encountered in experiments with trapped Rydberg ions.