Dynamics of Atoms Within Atoms

Shiva Kant Tiwari*[1], Felix Engel[2], Marcel Wagner[3], Richard Schmidt[3], Florian Meinert[2], and Sebastian Wüster[1]

[1]Department of Physics, Indian Institute of Science Education and Research, Bhopal – India
[2]Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany – Germany
[3]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany – Germany

Abstract

Recent experiments with Bose-Einstein condensates have entered a regime in which, after the excitation of a single atom into a highly excited Rydberg state, thousands of ground-state condensate atoms fill the Rydberg-electron orbit. Scattering off the electron then sets these into motion, such that one can study the quantum-many-body dynamics of atoms moving within the Rydberg atom. It has been suggested to use these features for tracking the motion, detecting the position, and inferring or decohering the quantum state of isolated Rydberg impurities. Here we numerically model this scenario using Gross-Pitaevskii and truncated Wigner theory. Our focus is on the cumulative effect of multiple sequential Rydberg excitations on the same condensate and the local heating dynamics. We also investigate the impact of details in the electron-atom interaction potential, such as the rapid radial modulation, which is important for the condensate response within the Rydberg orbit but is less relevant for subsequent density waves outside the Rydberg excitation region.

*Speaker