Exploring collective effects through Rydberg interactions on atom chips

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Rydberg states are a promising tool to control interactions in ultracold gases, making them relevant for quantum simulation. In our atom chip experiment we trap rubidium atoms in a highly elongated magnetic trap and excite them to Rydberg states. For typical parameters, the radial size of our cloud is smaller than the range of the Rydberg–Rydberg interactions, meaning we are effectively in a one-dimensional regime. The excitation coherence can be severely limited by stray electric fields, making it hard to see interaction effects. We are able to characterize all three vector components of these fields using an on-chip electrode [1]. Using a pair of lasers which are frequency-narrowed and stabilized to a cavity [2] we are able to observe Rydberg–Rydberg interactions; for instance, we see strong saturation of the Rydberg excitation fraction (i.e. Rydberg blockade, see Figure 1) and have observed asymmetric line broadening related to the Van der Waals interaction. Presently we are investigating these effects in the time domain.

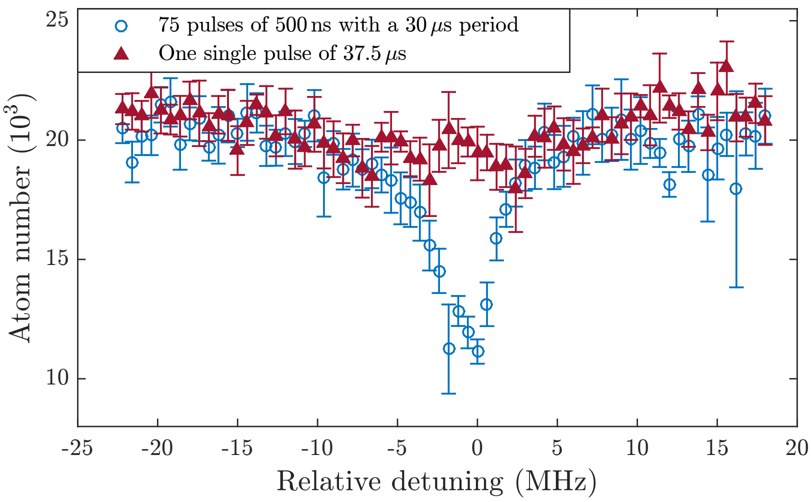

Figure 1. $28D_{5/2,5/2}$ state probed with either a single pulse (solid triangles) or multiple, separated pulses with the same total flux (open circles). For the single pulse, the losses from the Rydberg excitation are strongly reduced, indicative of Rydberg blockade.

[1] N. Cisternas, Julius de Hond, G. Lochead, R.J.C. Spreeuw, H.B. van Linden van den Heuvell, and N.J. van Druten, Phys. Rev. A **96**, 013425.

[2] Julius de Hond, Nataly Cisternas, Graham Lochead, and N.J. van Druten, Applied Optics, **56**, 5436–5443 (2017).