# A high repetition rate experimental setup for quantum non-linear optics with cold Rydberg atoms

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sing electromagnetically induced transparency and photon storage, the strong dipolar interactions between Rydberg atoms and the resulting dipole blockade can be mapped onto light fields to realise optical non-linearities and interactions at the single photon level. We report on the realisation of an experimental apparatus designed to study interactions between single photons stored as Rydberg excitations in optically trapped microscopic ensembles of ultracold 87Rb atoms. A pair of in-vacuum high numerical aperture lenses focus excitation and trapping beams down to 1 µm, well below the Rydberg blockade. Thanks to efficient magneto-optical trap (MOT) loading from an atomic beam generated by a 2D MOT and the ability to recycle the microscopic ensembles more than 20000 times without significant atom loss, we achieve effective repetition rates exceeding 110 kHz to obtain good photon counting statistics on reasonable time scales. To demonstrate the functionality of the setup, we present evidence of strong photon interactions including saturation of photon storage and the retrieval of non-classical light. Using in-vacuum antennae operating at up to 40 GHz, we perform microwave spectroscopy on photons stored as Rydberg excitations and observe an interaction induced change in lineshape depending on the number of stored photons.

- H2020 [3]
- RySQ [4]
- Result [5]
- 15.10.Ne Neutral atoms: electronic states [6]
- 15.10.Ry Rydberg atoms [7]
- 15.10.Ph Photons [8]
- 15.20.–e Quantum Optics: Experimental system [9]

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[3] http://qurope.eu/category/european-commission/h2020
[4] http://qurope.eu/category/projects/rysq
[5] http://qurope.eu/category/attribute/result
[6] http://qurope.eu/category/qics/10-quantum-computation/15-implementations-quantum-optics/1510ne-neutral-atoms-electron
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