GHz-Bandwidth Four-Wave Mixing Spectroscopy with Rubidium in a Micrometer Wedge Cell

Felix Moumtsilis[1], Alexander Döring[1], Max Mäusezahl[1], Moritz Seltenreich[1], Jan Reuter[2,3], Haim Nakav[4], Hadiseh Alaeian[5], Harald Kübler[1], Matthias Müller[2], Charles Stuart Adams[6], Robert Löw[1], Tilman Pfau[1]

[1] 5. Physikalisches Institut, Universität Stuttgart, Germany
[2] Forschungszentrum Jülich GmbH, PGI-8, Germany
[3] Universität zu Köln, Germany
[4] Weizmann Institute of Science and AMOS, Israel
[5] Elmore Family School of Electrical and Computer Engineering, Purdue University, USA
[6] Department of Physics, Joint Quantum Centre (JQC), Durham University, UK

Fast coherent control of Rydberg excitations is essential for quantum logic gates and on-demand single-photon sources like our concept based on the Rydberg blockade of room-temperature rubidium atoms in a wedged micro-cell. The quasi-static frozen regime forming the base of this platform is a unique and tunable landscape with GHz-interaction energies in µm proximity to alumina coated fused-silica cell walls.

We explore the physical properties of this environment by tuning laser frequencies, pulse timings, Rabi frequencies, cell thicknesses, and temperatures aiming towards optimal control in the proposed four-wave mixing process via the 6P and 40S states. After separating the generated light with multiple narrow line-filters and etalons, we obtain sub-ns time resolved access to the developing emission properties using single-photon detectors. Using pulsed light-induced atomic desorption (LIAD), we also tune the velocity and density distribution of the atomic ensemble to study the influences of a rapidly changing density gradient. Our results exhibit emission backgrounds, line shifts, and broadening varying on the ns-timescale which are dependent on the chosen detunings and cell thickness.

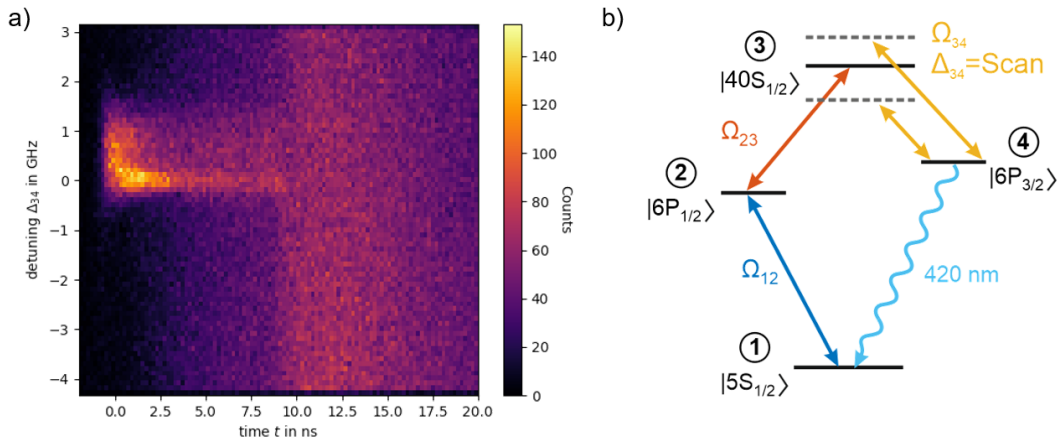

Figure 1. a) Preliminary data showing the temporal development of four-wave mixed photon emission while scanning the Rydberg excitation laser frequency Δ_{34}. b) Level scheme during the pulsed excitation. We excite the 40S Rydberg state from the Rb ground state via the $6P_{1/2}$ transition and de-excite the Rydberg state through the $6P_{3/2}$ channel with 10ns pulses.