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**High-Resolution Rydberg-spectroscopy on ultracold Rubidium atoms** TILMAN PFAU, 5. Physikalisches Institut, University of Stuttgart, ROLF HEIDEMANN, AXEL GRABOWSKI, VERA BENDKOWSKY, EVA KUHNLE, JUERGEN STUHLER — Rydberg atoms can have huge static electric dipole moments. We are working on the investigation of electric dipole-dipole interaction between them as well as the interaction between Rydberg atoms and ground-state atoms of a BEC. The starting point of our Rydberg spectroscopy measurements is a cloud of magneto-optically trapped $^{87}$Rb-atoms. Using two narrow band, frequency stabilized cw laser systems, we perform two-photon excitation via the $5P_{3/2}$-level of ground state ($5S_{1/2}$) Rb atoms to high lying Rydberg states with linewidths below 1 MHz. For the coherent control of the excitation, we need high spectral resolution and precise control of the Rabi-frequencies on both of the transitions. To demonstrate the spectral resolution and stability of our system, we investigated the Stark splitting of the two 41D-finestructure-states by measuring the number of Rydberg atoms as a function of the excitation frequency for different electric fields. We found it to be in excellent agreement with our calculations using perturbation theory on the Rubidium-wavefunctions. The Rabi-frequencies were measured by observation of the Autler-Townes-splitting while driving one of the transitions strongly and probing the other one. A line broadening mechnism due to ionic background charges is discussed.

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