High-resolution spectroscopy of Rydberg states in an ultracold cesium gas

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Transitions between high Rydberg states of ^{133}Cs atoms have been studied by high-resolution millimeter-wave spectroscopy of an ultracold sample. The spectroscopic measurements were performed after releasing the atoms from a magneto-optical trap. Switching off all trapping fields and compensating the stray electric and magnetic fields to below 1 mV/cm and 2 mG, respectively, prior to the spectroscopic measurement enabled the recording of millimeter-wave spectra of Rydberg states with principal quantum number beyond n=100 under conditions where the inhomogeneous broadening by stray fields is minimal and no dephasing of the Rydberg-atom sample can be detected over measurement times up to 60 μs.

The Fourier-transform-limited linewidths of better than 20 kHz enabled the observation of the hyperfine structure of nS and nP Rydberg states of Cs beyond n=90. The analysis of the lineshapes of transitions to Rydberg states with n~230 indicated that field inhomogeneities across the atomic sample represent the dominant cause of spectral broadening at high n values. The analysis also revealed that the initial polarization of the atomic sample (F=4,M_F=4) is preserved for several tens of microseconds, the depolarization being caused by slow precession along the magnetic stray fields.

We have recently added an optical dipole trap to the setup to investigate the Rydberg excitation in dense samples of ultracold atoms. The current status of these experiments will be presented.