Studying Cold Potassium Rydberg Atoms with an AC-MOT

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Synopsis A new method is described for the detection and study of cold Rydberg atoms. Cold atoms held in an AC-driven magneto optical trap (AC-MOT) are selectively laser excited to a Rydberg state in a stepwise process. Ions or electrons from interactions between Rydberg atoms are then electrostatically extracted and detected via a channel electron multiplier. The apparatus is capable of studying Rydberg atoms from n = 15 to n ∼ 220.

A new method for Rydberg atom detection and study is described. A beam of ^{39}K atoms is produced by an oven source and is then slowed by a Zeeman slower before being further cooled and trapped in an alternating current magneto-optical trap (AC-MOT) [1].

In the AC-MOT, the trapping laser polarisation is switched synchronously with an alternating magnetic **B**-field. This allows the trapping fields to be switched off in less than 20 µs, ∼300 times faster than for a conventional MOT. Field-free experiments can then take place without any loss of trapping efficiency. Figure 1 shows a simplified block diagram of the experiment.

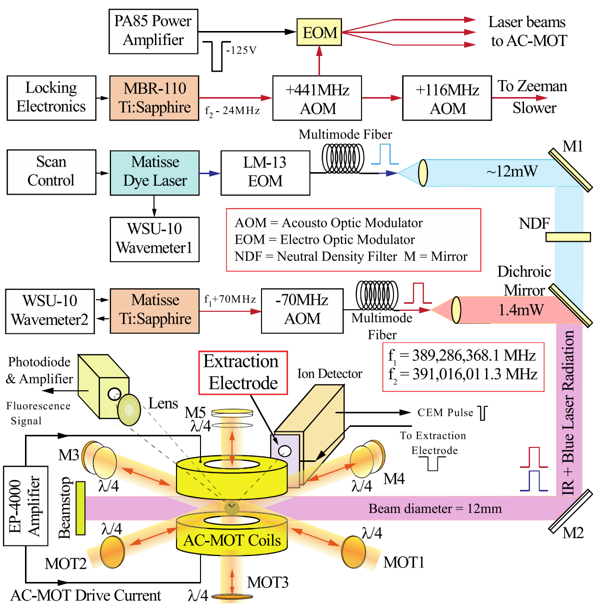

Figure 1. Simplified block diagram of the experiment.

Trapped atoms are selectively laser excited to Rydberg states in a stepwise process. Ions or electrons from interactions between Rydberg atoms are then detected using a threshold penetrating-field detector [2]. The experiments take place in a field-free interaction region that is set by the two MOT coils, and four electrostatic deflector plates in the horizontal plane (not shown). The trapping light is provided by a continuous wave (CW) MBR-110 Ti:Sapphire (Ti:S) laser. A second CW Matisse Ti:S laser is switched into the experiment by an AOM to resonantly excite ground state atoms to the $4^2P_{1/2}$ state. These atoms are further excited to Rydberg states by a UV-pumped, tunable CW Matisse dye laser ($\lambda \approx 418 \rightarrow 470$ nm) that is switched in by an EOM. These lasers are typically switched on for a few µs, after which a penetrating field is switched to deflect ions or electrons into the detector.

The laser frequencies are measured to within 1 MHz by WSU-10 wavemeters calibrated by saturated absorption [3]. This highly sensitive technique allows cold Rydberg atoms from n = 15D → n ∼220S to be created and detected. Figure 2 shows the measured spectra for 15D to 196S, collected by scanning the dye laser. The amplitude variation is mainly due to varying dye laser power.

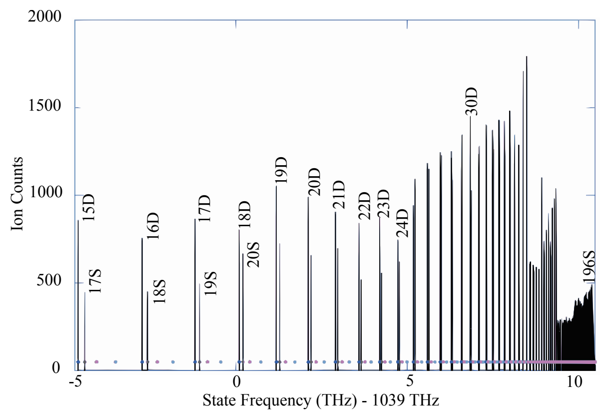

Figure 2. Excitation of Rydberg atoms from n = 15D to n = 196S using CW laser radiation, offset from 1039 THz.

The progress of these studies will be presented at the conference.

References

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