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 \( n \sim 220 \).

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 \( 20 \mu s \), \( \sim 300 \) 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.

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 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 (\( \lambda \approx 418 \rightarrow 470 \text{ nm} \)) that is switched in by an EOM. These lasers are typically switched on for a few \( \mu s \), 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 \( n = 15D \rightarrow n \sim 220S \) 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.

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**Figure 1.** Simplified block diagram of the experiment.

**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**

