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Photo-excitation of singly-and doubly-excited Rydberg states in the presence of a strong electric field.

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Photo-excitation in an electric field has been used since the beginning of atomic physics as a sensitive test of our theoretical understanding of excited states. In recent years, most experimental work has concentrated on the high-resolution probing of Rydberg states with principal quantum number typically around 15-50. With states of high n fields as low as a few volts per cm produce strong effects, and indeed stray electric fields are one of the hurdles to be overcome when studying Rydberg states with high resolution.

The major limitation of laser spectroscopy however is the range of states open to study. Techniques such as 4-wave mixing can produce laser photons of up to 20eV, but it is in this range when the use of synchrotron radiation becomes advantageous. The doubly-excited states of helium are still today an important test of our theoretical understanding, and their evolution under an electric field has never been observed experimentally.

Our experimental apparatus is capable of applying a voltage of up to 120kV to one of two highly-polished 120mm diameter electrodes which surround the interaction region. The other electrode is slotted for the efficient collection of photo-ions, and a further detector is sensitive to neutral particles (photons or excited targets) which travel in the direction of the ground state atomic beam. With an electrode separation of 8mm, to date we have performed measurements in fields of up to 90\kVcm.

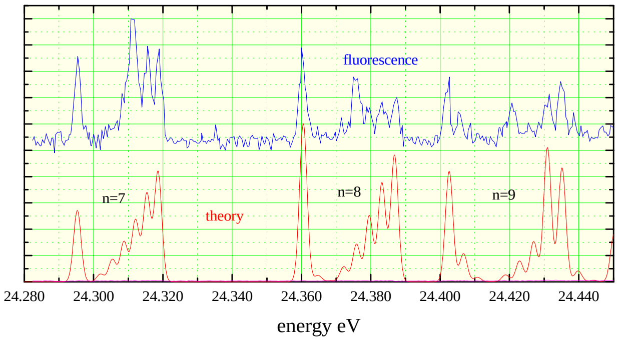

Figure 1. Experimental fluorescence yield at 25kV, predicted spectrum at 28kV.

Using the high-resolution available at beamline 20A we have performed preliminary studies on the singly-excited helium Rydberg states. This study also serves to characterise our electric field -- due to the slotted electrode it is not sufficient just to know the electrode separation. Figure 1 shows a comparison between the experimental fluoresecnce yield, and a spectrum predicted using simple perturbation theory. Compared to earlier work on these states[1,2] we can achieve better resolution and can apply stronger fields, and plan to continue studying these states, along with other species including small molecules such as H2.

For the first time we have observed the photo-excitation of the doubly-excited states of He in an electric field. Figure 2 shows the ion yield near the N=2, n=5—7 states at a range of field strengths. The spectra are remarkably different from those predicted by recent theoretical work [3].

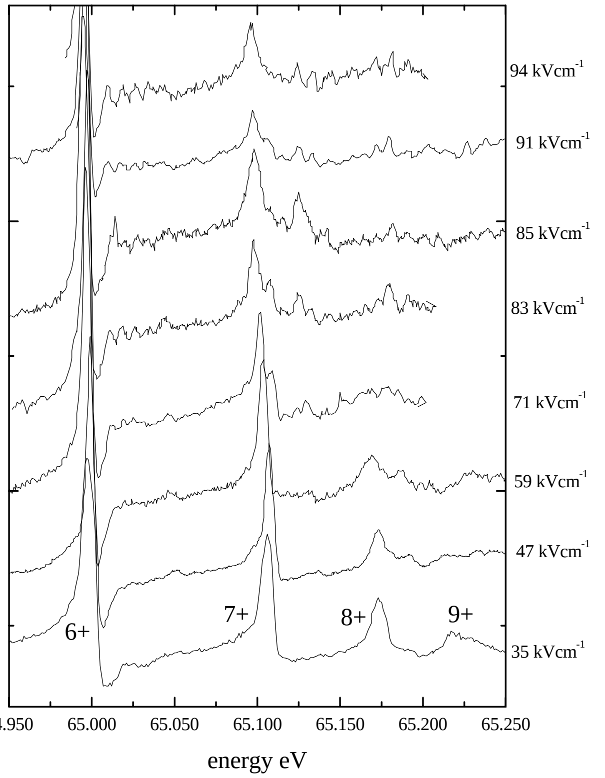

Figure 2. Ion yield over the doubly-excited region at a range of field strengths.

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