Total cross section measurements for low energy electron scattering from cold metastable helium atoms

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Electron scattering from helium atoms has been extensively investigated, both experimentally and theoretically, yielding a satisfactory quantitative agreement. Considering that the helium system is one of the most simple to study, this is not unexpected. What is more unexpected is that for comparable experiments on metastable helium atoms, there exists a considerable disagreement between experiments and the most recent theoretical calculations [1]. We report progress on a novel method of experimentally studying this elementary scattering process.

An atomic beam, obtained from a liquid nitrogen cooled source of metastable helium is collimated, slowed, focussed using laser cooling methods and eventually trapped in a magneto-optic trap (MOT). About 10^7 atoms are collected at a density of $\sim 10^9$ cm^{-3} in 200 ms. The temperature of the trapped atoms is $\sim$ 1 mK, and the trap depth is $\sim$ 1 K.

The line integrated trap density is monitored using a weak probe laser beam using RF spectroscopy [2]. A weak, $\sim$ 900 MHz phase modulation side band is added to the probe laser using an electro-optic modulator (EOM). The center laser frequency is locked to the crossover between the $2^3S_1 \rightarrow 2^3P_1$ and $2^3S_1 \rightarrow 2^3P_2$ transitions in a DC gas discharge cell, 1.15 GHz from each transition. The laser is then frequency shifted by -250 MHz to yield one of its sidebands to be close to the $2^3S_1 \rightarrow 2^3P_2$ resonance. The laser beam is passed through the cold atom cloud, causing the sideband close to resonance to be phase shifted with respect to the other. The laser beam then strikes a fast photodiode, and we monitor the signal modulation at the EOM frequency using an RF spectrum analyser. For small phase shifts, the RF signal is proportional to the line integrated trap density. This method provides a very fast, reproducible and non-destructive measurement of the change in the line integrated trap density.

For the experiment, the MOT magnetic fields are switched off, and after 1 ms the trapping laser fields are switched off using an acousto-optic modulator. After a variable delay a low energy electron beam is pulsed on, typically for a few ms. The collimated electron beam is produced by a standard, high-current electron gun, with a total current of $\sim 100\mu$A at an energy of 5–100 eV and a spread of < 1 eV. We monitor the decay of the trap density, and measure the difference in decay times with and without the electron beam. The experiment can be repeated several times per second, and typically 1000 shots are averaged.

Measurements are currently in progress and initial results will be presented at the conference.

[1] D.V. Fursa and I. Bray, J. Phys. B. **30**, 757 (1997).

[2] J.E. Lye, B.D. Cuthbertson, H.-A. Bachor and J.D. Close, J. Opt. B. **1**, 402 (1999).