Relativistic effects in strong-field double ionization

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When an atom is exposed to an intense, long-wavelength laser pulse, an electron which is field ionized can be accelerated by the oscillating electric field in such a way that it returns close to the atomic core with high kinetic energy. If the kinetic energy at the time of the recollision is high enough, the returning electron may knock out another electron which is still bound. This process is commonly referred to as non-sequential double ionization (NSDI) [1], and has been widely studied, mostly in helium and other noble gases.

With a few exceptions [2], all studies of NSDI have been performed in non-relativistic systems. In this regime the laser pulse can be well described as a time-dependent electric field, neglecting the magnetic field component.

In this contribution, we theoretically investigate the NSDI process for moderately relativistic laser pulses, for laser intensities up to 10^{17} W/cm^2 (at 800 nm wavelength) [3]. Recollisions induced by high-intensity laser pulses are interesting since the maximum recollision energy increases linearly with the laser intensity. Both the effect of including the laser magnetic field in the Lorentz force, and the influence of second-order relativistic corrections to the equations of motion are investigated. The model employed is a classical trajectory model, similar to that employed in the non-relativistic case [4]. We consider He, Li^+, and Be^{2+} as target systems.

We find that the inclusion of the magnetic field in the Lorentz force can be important at laser intensities as low as 10^{15} W/cm^2. The reason is that the deflection caused by the $\mathbf{v} \times \mathbf{B}$ force prevents the electron from returning to the core for certain classes of trajectories. On the contrary, both total ionization probabilities and final momentum spectra are insensitive to the inclusion of the second-order relativistic corrections in the equations of motion, even for Li^+ driven by 10^{17} W/cm^2 laser light.

References:

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