Static-field ionization rates of He-like ions by MCTDHF method

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Ultraintense laser pulses having intensities of 10^{20} W/cm^2 or above are currently becoming available at facilities such as the ELI Beamlines in the Czech Republic and the Shanghai Super-Intense Ultrafast Laser Facility. In order to use these laser pulses for scientific research, the pulses must be well characterized. Ciappina et al.[1] proposed a method for determining the peak field intensity of ultraintense laser pulses by recording the relative yields of H- and He-like ions generated through the field ionization proceeding in the laser field. In order that this method is to be implemented, a reliable theoretical formula for the intensity-dependent field ionization rates of He-like ions needs to be developed.

We derive a general formula for the static-field ionization rates of He-like ions with nuclear charge numbers $Z \leq 36$, valid in both the tunneling and over-the-barrier regimes of ionization.[2] The formula is derived by fitting a modified Perelemov-Popov-Terent'ev (PPT) formula[3,4] to ionization rates calculated by the multiconfiguration time-dependent Hartree-Fock (MCTDHF) method.[5] The newly proposed formula reproduces well the rate obtained by the MCTDHF method both in the tunneling and over-the-barrier regimes.

We also compare the rates obtained by the MCTDHF method and the rates obtained by a single-active electron (SAE) approximation. We find that the SAE rates are larger than the MCTDHF rates by as much as 30% for He and by about 2% for He-like Kr ($Z = 36$). We ascribe the difference to the omission of the exchange interaction between the bound electron and the electron being ejected in the SAE approximation. We conclude that it is necessary to employ properly antisymmetrized two-electron wave functions to obtain accurate static-field ionization rates of He-like ions.

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