Differential and total excitation cross sections in the collision of protons with He atoms at intermediate and high energies under a three body formalism

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Abstract

A three-body model is devised to study differential and total cross sections for the excitation of helium atom under impact of energetic protons. The actual process is a four body one but in the present model the process is simplified into a three-body one. In this model, an electron of helium atom is assumed to be inactive and only one electron of the atom is active. Therefore, the active electron is assumed to be in an atomic state with a potential of the nucleus, $T$, being screened by the inactive electron, $e$, and, thus, an effective charge of $Z_e$. As a result, the ground state, $1^1S$, or the excited states, $2^1S$ and $2^1P$, wave function of the active electron is deduced from similar hydrogenic wave functions assuming effective charge, $Z_e$ for the combined nucleus ($T+e$). In this three-body model, the Faddeev-Watson-Lovelace formalism for excitation channel is used to calculate the transition amplitude. In the first order approximation, electronic and nuclear interaction is assumed in the collision to be $A^{(1)}_{xy} = f_{T_{xy}} |i\rangle$ and $A^{(1)} = f_{T_{T}} |i\rangle$, respectively. Here, $A^{(1)}_{xy}$, $T_{xy}$, $|i\rangle$ and $|f\rangle$ are the first order transition amplitude, the transition matrix for the interaction between particles $x$ and $y$, the initial state and the final state, respectively. The transition matrix for the first order electronic interaction implemented into $A^{(1)}_{xy}$ is approximated as the corresponding two-body interaction, $F_{xy}$. In order to calculate first order nuclear amplitude $A^{(1)}$, the near-the-shell form of transition matrix $T_{T}$ is used. Calculations are performed in the energy range of 50 keV up to 1 MeV. The results are then compared with those of theoretical and experimental works in the literature.

Keywords: Faddeev, differential cross section, excitation channel, helium, active electron

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