The effect of coupled states on the differential and total cross section in excitation channel

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Synopsis In this work, a semi-classical multi-channel formalism is applied to calculate the scattering amplitudes in the excitation channel for the collision of fast charged ions with hydrogen-like atoms. The effect of state coupling was investigated for the excitation to $2lm$ states, it show a stronger coupling for $1s$ → $2s$ state as compared with $1s$ → $2p$ states.

The results of ion-atom impact cross section in different channels are needed for many applications such as astrophysics, plasma, gas-discharge and controlled-fusion. The coupling between different states of atom is important in the calculation of cross sections, particularly in low impact energy range and elastic scattering, which provide useful information about polarizing interactions. In the present work the effect of state-coupling has been obtained when fast ions pass through the matter.

We have applied one of the limited states of multi-channel Eikonal formalism. The hydrogen-like target atom was considered to be in its ground state, while the excitation occurred to nlm excited states. In this calculation, based on the selection rules, the transition for odd $l-m$ was forbidden. The results for differential cross sections for 100 keV proton-hydrogen impact are plotted in figure (1) for final $2lm$ states, where it has been compared with the experimental results of Park [1] and the Born-Faddev theoretical results [2].

In figure (2), the results for the total cross sections have been depicted for the same interaction and the same transition in the energy range of 10keV-1MeV. The results are compared with the Born results [3], the coupled channel theory [4] and the experimental data [5]. The result shows poor agreement at the middle energies, while it agrees well otherwise.

We note that most of the state-coupling were ignored to simplify the calculation. However, the discrepancy of the results at intermediate energies is related to the importance of state coupling in $1s \rightarrow 2s$ transition. We also infer that the effect of state-coupling at high impact energy range is negligible for $1s \rightarrow 2s$ transition, while it is not of importance for $1s \rightarrow 2p$ transition.

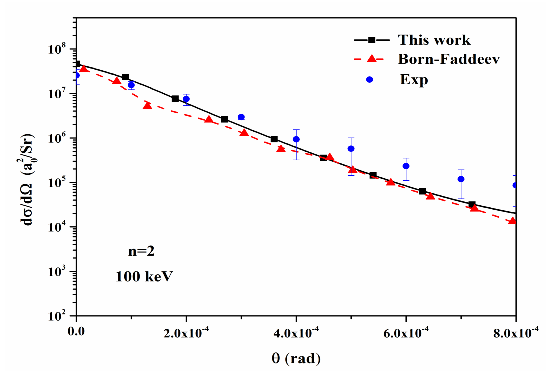

Figure 1: Results of differential cross section for $1s \rightarrow n=2$ transition in 100 keV

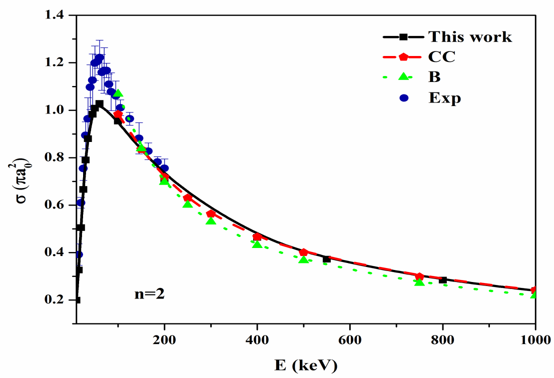

Figure 2: Results of total cross section for $1s \rightarrow n=2$ transition

References

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