Study of electron impact ionization and excitation cross sections of beryllium isoelectronic sequence

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Synopsis Collisions involving electrons with atoms and molecules are one of the most fundamental interactions in physics. These interactions are basic to a variety of processes such as plasma physics [1], radiation physics, and astrophysics [2]. Electron- impact (EI) is also the most common form of ionization in commercial mass spectrometers and is used as an analytical tool for measuring species concentrations in gaseous samples.

In the present study, we have calculated electron impact ionization and excitation cross sections of beryllium isoelectronic sequence such as B^{+}, C^{2+}, N^{3+}, O^{4+}, F^{5+} and Ne^{6+} by employing Distorted Wave (DW), Binary Encounter Dipole (BED), and Coulomb-Born Exchange (CBE) approaches employed in the flexible atomic code [3] and compared with the available theoretical and experimental results.

Theoretical methods: Ionization cross sections of the beryllium isoelectronic sequence (as B^{+}, C^{2+}, N^{3+}, O^{4+}, F^{5+} and Ne^{6+}) are computed using the DFS method used in the FAC [3].

The electron ionization processes is described using the DW, CBE and BED approaches. The required bound and continuum wave functions for every ion are produced using the local central potentials for the ground configurations.

Relativistic Distorted Wave theory: The direct ionization cross section from initial state to a final state can be expressed as

$$\sigma_{01} = \frac{\pi}{k_0^2 g_0}\Omega_{01}$$

Where g_0, is the statistical weight of the initial state and k_0 is the kinetic momentum of the incident electron.

Coulomb-Born Exchange approach: By using the CBE approximation, cross sections have also been computed. In comparison to the DW method, this approach computes radial integrals more quickly. In the CBE approximation, reduced radial integrals obtained are not sensitive and, in that approximation, hydrogenic values have been used in place of DW radial integrals. While in DW method fitting parameters are used to calculate total ionization cross sections at different enrgies.

Binary Encounter Dipole Theory: The total ionization cross sections (TICS) have been obtained by integrating the above equation which can be written as,

$$\sigma_i(t) = \int_0^{(t-1)/2} \frac{d\sigma}{d\omega} d\omega$$

$$\sigma_i(t) = \frac{S}{t+u+1} \left[D(t)\ln t + \left(2 - \frac{N_i}{N}\right)\left(1 - \frac{1}{t} - \frac{\ln t}{t+1}\right)\right]$$

A unique quality of the BED theory is the energy denominator, which reduces the ionization cross sections at low energies. When the experimental and theoretical results compared for the low Z ions are found reasonable agreement by introducing such scaling factor.

References

[1] A. Müller, *Adv. At. Mol. Opt. Phys.*, **55**, 293-417. (2008).

[2] T.R. Kallman, P. Palmeri, *Review of Modern Physics*, **79**, 79-133 (2007).

[3] M. F. Gu, flexible atomic code, *J. Can. Phys.* (2008).

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