Investigation of cross sections of Be^{4+} and hydrogen atom collisions using classical models

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In recent decades, reactors such as the International Thermonuclear Experimental Reactor (ITER) have taken a significant step in supplying energy cleanly and safely by developing power plants whose energy is produced due to the nuclear fusion process. Due to the unique thermophysical properties and low atomic number, beryllium is defined as a plasma-facing material. Therefore, it plays a key role in the wall structure of next-generation fusion reactors. On the other hand, impurities are one of the main problems in controlled thermonuclear fusion plasmas. As a common plasma impurity, Be ions also play a role in the loss of radiant energy that causes the plasma to cool when colliding with the primary plasma components such as neutral hydrogen atoms. To determine the Be impurities in the plasma, knowledge of the cross section for various channels of interaction such as ionization, electron capture, excitation, and state-selective electron capture is very important.

The standard three-body classical trajectory Monte Carlo method (CTMC) cannot compete with quantum calculation in many aspects because of lacking the quantum feature of the collisions [1]. Therefore, we developed a three-body quasi-classical Monte Carlo model taking into account the quantum features of the collision system, where the Heisenberg correction term is added to the standard three-body classical trajectory Monte Carlo model [2]. In our research work, we use both the standard CTMC and the QCTMC-KW models to show the ionization [3], electron capture [3] , excitation [3], and state-selective cross sections in Be^{4+} and H(1s) collisions [4-6]. The calculations were performed in the impact energy range between 10-1000 keV/amu. We show that the QTMC-KW model may have an alternative of the quantum-mechanical models providing the same results with maybe low computation efforts [7].

References

[1] K Tőkési and G Hock, Versatility of the exit channels in the three-body CTMC method, Nucl. Instrum Meth. Phys. Res. B 86, (1994), 201-204

[2] I Ziaeian and K Tőkési, The effects of Heisenberg constraint on the classical cross sections in proton hydrogen collision. To be published in Physical Review A.

[3] I Ziaeian and K Tőkési, Interaction of Be^{4+} and ground state hydrogen atom-classical treatment of the collision, Atoms 8, (2020), 27-38

[4] I Ziaeian and K Tőkési, State-selective charge exchange cross sections in Be^{4+}-H(2lm) collision based on the classical trajectory Monte Carlo method, EPJD J. 75, (2021), 138-142

[5] I Ziaeian and K Tőkési, State selective classical electron capture cross sections in Be4+ and H(1s) collisions with mimicking quantum effect. Scientific Report **11** 20164 (2021).

[6] I Ziaeian and K Tőkési, *nl*-selective classical charge exchange cross sections in Be^{4+} and ground state hydrogen atom collisions. Accepted in Physics Letter A.

[7] I Ziaeian and K Tőkési, State- selective electron capture cross sections in collision between fully striped ions and ground state hydrogen – classical treatment of the collision. To be published in Atomic and Nuclear Data Tables.