Measurement of Charge Exchange Cross Sections in Collisions of Ne8+ Ions with H2 and He

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Abstract

Charge exchange (CX) or electron capture (EC), which predominates all other types of inelastic collisions at impact velocities less than one atomic unit ($<$ 25keV/u), affects the ionization balance and results in spectral line emissions in astrophysical regions or fusion devices. It is one of the most significant processes that occur during collisions between highly charged ions (HCIs) and atomic or molecular species. Neon ions are considered an important component of the solar wind and are one of the primary impurities appearing at various relative energies and ionization stages in plasmas. For these applications, there is a strong demand for accurate data on the cross sections of EC.
The experiment was performed on the 150 kV highly charged ion collision platform at Fudan University to measure the total and state-selective EC cross sections (1,2). The HCIs beam, generated by an ECR ion source, was directed to collide with neutral gases in a gas cell to measure the total EC cross sections. Through a thorough analysis of the systematic uncertainties associated with the experimental setup and measurement procedures, the experimental error for the absolute cross sections of single electron capture (SEC) was found to be less than 9%. For the relative state-selective EC cross sections, measurements were performed using a cold target recoil ion momentum spectroscopy (COLTRIMS) apparatus (3).

The total and n-resolved state-selective cross sections of SEC between Ne8+ ions and H2 and He were measured in the impact energy of 2.8 and 40 keV/u, covering velocities corresponding to fast solar wind and coronal mass ejections. The total EC cross section is crucial for assessing the probability of capturing electrons, however, it does not elucidate electron transition mechanisms in detail. By normalizing the relative state-selective SEC cross sections to the absolute total SEC cross sections, the absolute state-selective SEC cross sections of Ne8+ colliding with He and H2 gases were determined over a wide energy range(4).

The present CX cross section data fill the gaps in the relevant collision energy range, which can be valuable for establishing accurate plasma models to analyze the interstellar gas distribution and to interpret the observation of the diffuse soft X-ray emission.

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References

(1) J. Han et al., *APJS.* **(2021)** 253, 6.

(2) T. Meng et al., *New J. Phys.* **(2023)** 25, 093026.

(3) Z.H. Xia et al., *APJ.* **(2022)** 933, 207.
(4) P. Ma et al., *APJ.* **(2025)** 978, 6.