Data needs of ion-atom collisional processes relevant for fusion applications

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Synopsis Neutral beam injection is widely used in fusion applications to heat plasmas or to diagnose plasma conditions. Modeling of neutral beam interacting with atoms and ions in plasmas and measured spectroscopic signals requires detailed information on data of atomic processes that involve the neutral beam particles. In this talk, ion-atom data needed to model neutral beam interaction with plasmas are presented.

Neutral beam injection is a standard method to heat the plasma in fusion experiments and it is intended to be used for power control in ITER and perhaps in a reactor. The attenuation of beams in fusion plasmas is directly related to the transmission of beam power through the plasma and the potential for damaging heat loads on machine structures. Neutral beams also have important diagnostic uses, both via photoemission from the beam neutrals due to interaction with the plasma and via photoemission from plasma impurities after interaction with the beam. Collisional-Radiative (CR) modelling of beam penetration into the plasma and of the spectroscopic signals relies on detailed data for atomic processes involving the neutral beam particles. The design of ITER charge exchange diagnostic is based on the knowledge of uncertainties in attenuation of the diagnostic beam as the beam transmission determines the signal levels in the core region of plasmas. High quality cross-section data for the charge-exchange and beam emission processes are required for the spectral analysis.

In spite of the importance of the data there are quite significant gaps, especially related to processes starting from an excited state of the neutral atom. On the other hand, for processes starting from the ground state of the neutral atom there are often several different families of calculated or measured data, obtained using different approximations or experimental methods, and it is important to assess their uncertainties and to recommend best data.

An IAEA Coordinated Research Project (CRP) on Data for Atomic Processes of Neutral Beams in Fusion Plasma [1] is organized to provide evaluated and recommended data for the principal atomic processes relevant to heating and diagnostic neutral beams in fusion plasmas. The goals of this CRP include:

1) Assess the sensitivity of predictions of hydrogen beam penetration and of beam emissions and predictions of charge transfer impurity spectra (CXRS or CHERS) in fusion plasma to uncertainties in atomic data,

2) Develop, assemble and evaluate state-resolved cross sections and (where needed) density matrix elements for excitation, ionization and charge transfer in collisions between hydrogen (H, D, T) neutrals and protons or deuterons at collision energy of the neutrals from about 1 keV to 1 MeV,

3) Develop, assemble and evaluate state-resolved cross sections for excitation, ionization and charge transfer in collisions between hydrogen (H, D, T) neutrals and the principal fully stripped impurity ions (elements He, Be, C, N, O; other light elements and Ne, Ar, Kr with lower priority) at hydrogen energy from about 1 keV to 1 MeV.

4) Develop recommendations for state-resolved cross sections for collisions between hydrogen neutrals and the most relevant partially stripped impurities (elements Ar, Fe, Kr and W) at hydrogen energy from about 1 keV to 1 MeV.

In this talk, the scope of the IAEA CRP and ion-atom collisional processes relevant to neutral beam heating and diagnostics in fusion applications will be discussed.

References


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