Kinetic theory for charge-exchange spectroscopy: Effects of magnetic and electric fields on the distribution function after charge-exchange

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In plasmas equipped with neutral beam injection, excitation of atomic spectral lines via charge-exchange with neutral atoms is the basis of one of the standard plasma diagnostic techniques for ion density, temperature and velocity. In order to properly interpret the spectroscopic results, one must consider the effects of the energy dependence of the charge-exchange cross-section as well as the motion of the ion after charge-exchange during the period when it is still in the excited state. This motion is affected by the electric and magnetic fields in the plasma. The present paper gives results for the velocity distribution function of the excited state ions and considers in detail the cross-section and ion motion effects on the post charge-exchange velocity. The expression for this velocity in terms of the charge-exchange cross-section and the pre charge-exchange velocity allows that latter velocity to be determined. The present paper is the first to consider the effect of the electric as well as the magnetic field and demonstrates that electric field and diamagnetic terms appear in the expression for the inferred velocity. The present formulation also leads to a novel technique for assessing the effect of the energy dependence of the charge-exchange cross-section on the inferred ion temperature.

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