Measurements of Proton-Lithium Charge Transfer Cross Sections at Low and Intermediate Energies

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Synopsis We report measurements of the total charge transfer cross section for collisions between protons and lithium atoms in the energy range 0.2 – 3.5 keV. Comparison of our results with prior measurements and theoretical predictions show agreement at higher energies. However, at lower energies our cross sections are significantly larger than previously measured, in agreement with the theoretical predictions.

Charge transfer between ions and neutral atoms is a process of fundamental interest. The transient molecular complex which arises during such a collision is challenging to model accurately, especially at low collision energy, and accurate experimental data are therefore important for testing the validity of different theoretical approaches. In addition, charge transfer plays an important role in a variety of different plasma environments. In tokamak plasmas, charge transfer collisions involving lithium atoms are particularly relevant since lithium is used as a first wall coating in some devices, while neutral lithium beams are injected into the plasma for diagnostic purposes.

We report preliminary experimental measurements of total charge transfer cross sections for collisions between lithium atoms and protons in the energy range 0.2 – 3.5 keV. In this energy range ionization collisions are negligible. Our experiments use crossed beams of lithium atoms and protons, unlike most prior experiments which pass the ion beam through a neutral gas cell. The crossed beams technique allows us to efficiently detect the lithium ion produced in a charge transfer collision, and to infer the target lithium density by laser absorption spectroscopy. Measuring the target density in this way allows precise determination of the density, which is often the least-well-known quantity in charge transfer experiments.

Figure 1 shows our results, along with those of the only prior experiment performed at collision energies lower than 2 keV [1]. Also shown are the experimental data of Aumayr *et al* [2] and several theoretical models [3-6]. At energies above about 1.5 keV, experimental data and theoretical predictions are in agreement, albeit with a significant variation from theory to theory and experiment to experiment. At 0.75 keV and below, the available theoretical predictions converge towards a single curve which is in closer agreement with our data than with prior work. We are continuing our experiments to confirm our preliminary measurements and quantify their uncertainties.

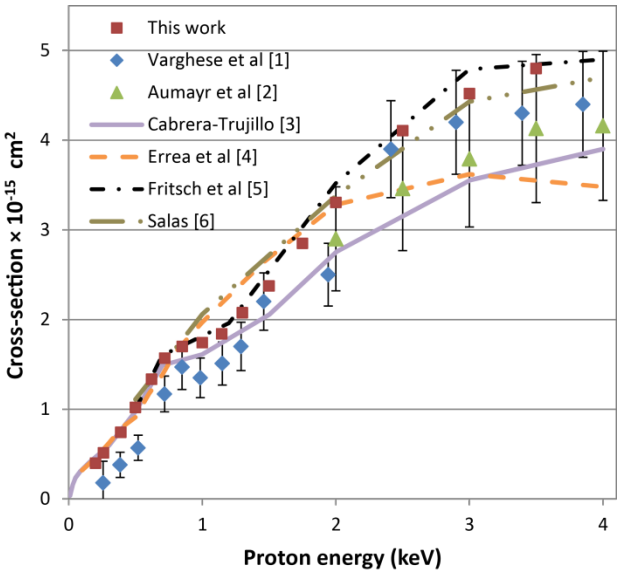

Figure 1. Cross sections for proton-lithium charge transfer collisions. Symbols show experimental data and lines show the results of theoretical calculations.

References

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