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2012 J. Phys.: Conf. Ser. 388 092004

(http://iopscience.iop.org/1742-6596/388/9/092004)

XXVII International Conference on Photonic, Electronic and Atomic Collisions (ICPEAC 2011) IOP Publishing
Journal of Physics: Conference Series **388** (2012) 092004 doi:10.1088/1742-6596/388/9/092004

Merged-beam study of mutual neutralization of H^- and H^+

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Synopsis Total and partial cross sections have been measured for the mutual neutralization of H^- and H^+ by means of a merged and inclined beam set-up. The low energy data between 10 meV and 5 eV contradict one previous set of measurements, while above 5 eV the data fall in excellent agreement with previously published results by two other groups.

Hydrogen chemistry in the early universe played a central role in the formation of the first stars. Of particular importance are those reactions controlling the H_2 abundance as this molecule is an important coolant in primordial clouds for temperatures below 8,000 K. A recent paper by Glover *et al* [1] has revived interest in mutual neutralization studies, by stressing the need of the astrophysics community for a precise determination of the low-energy cross section of the $H^- + H^+ \rightarrow H + H$ reaction. Mutual neutralization acts as a sink for the H^- ions. These anions would otherwise undergo associative detachment with ground state H, which is the dominant formation mechanism of H_2 during this epoch of the cosmos [2].

We have modified our merged cation-anion beams apparatus to incorporate coincident imaging techniques, giving access to the branching among accessible neutral channels as well as the total cross section. Using a combination of merged and inclined beam geometries, absolute measurements in the range 10 meV to 250 eV have been performed, that rule out the experimental work of Moseley *et al* [3] throughout the energy range. Our measurements above 5 eV fall in excellent agreement with the data of Szücs *et al* [4] and Peart and Hayton [5], whose works were restricted to higher collision energies due to limitations of their coincidence electronics. Further treatment of the angular acceptance of the various detectors used at different collision energies and beam arrangements is still needed to fully evaluate the systematics.

The present results compare satisfactorily with the most recent theoretical predictions [6], although being slightly below them at all collision energies, and support the rate coefficient compiled by Croft *et al* [7]. Additionally, the branching ratio between the different excitation channels, as measured between 10 and 200 eV, is consistent with the calculations of Stenrup *et al.*

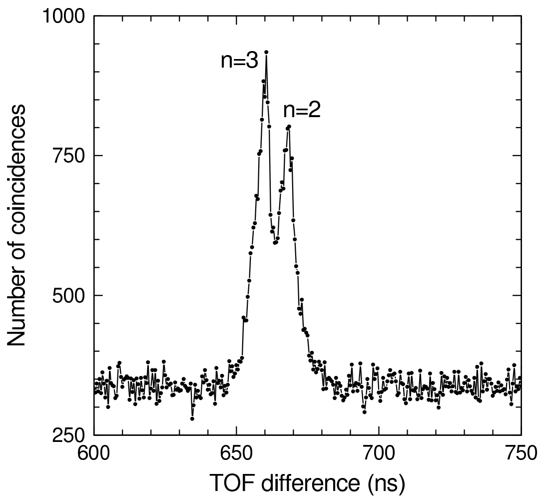

Figure 1. Time-of-flight difference spectrum recorded at $E = 72$ eV (beam energies 6 keV and 8 keV, for H^+ and H^- respectively) at the end of a 5.25 m long drift tube.

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