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Experimental studies of electron collisions with atomic ions for astrophysical plasmas

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Synopsis We have measured dielectronic recombination (DR) and electron impact ionization (EII) for a range of astrophysically relevant atomic ions (Fe^{9+}, Fe^{10+}, O^{3+}, and Mg^{6+}). The experiments were performed in a merged beams setup at the heavy-ion storage ring TSR in Heidelberg, Germany. Here we discuss the importance of our data for astrophysical modelling and compare our experimental results with the previously recommended data and with modern theoretical calculations. We have parameterized our data using simple fiting formulae for convenient inclusion into astrophysical modelling codes.

Iron is a cosmically abundant ion which serves as an important astrophysical diagnostic tool. It is observed, for example, in collisionally ionized gas such as the solar corona or in photoionzed gas such as seen through X-ray absorption spectra in active galactic nuclei. Spectral analysis of the latter leads to significant discrepancies between observed and modelled X-ray spectra which are attributed to errors in the relevant DR data [1]. To address this issue, we have measured energy-resolved merged-beams DR rate coefficients (MBRRC) for a series of M-shell iron ions [2, 3, 4, 5]. From these we have derived temperature-dependent plasma recombination rate coefficents (PRRC). Our experimentally derived PRRC confirm that the previously recommended PRRC [6] did indeed severely underestimate the DR rate coefficient at temperatures relevant in photoionized plasma. Comparison of our experimental results to modern theoretical Multi-Configuration Breit-Pauli (MCBP) calculations [7] show significant discrepancies with the observed resonance structure. However, the derived PRRC from both agree within the experimental error bars.

Recently we have begun extending our experimental methods to DR and EII measurements for other astrophysically relevant ions, where — due to the long storage times — heavy-ion storage rings are able to produce ion beams purely in the ground state. Here we report on our preliminary results for O^{3+} and Mg^{6+}.

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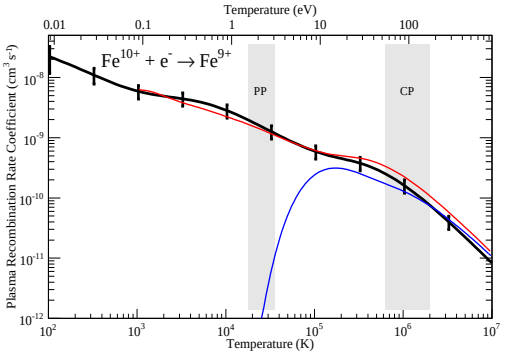

Fig. 1. DR PRRC for Fe^{10+} forming Fe^{9+}. The black curve gives our experimentally-derived results [5] and the red curve shows the MCBP results [7]. The blue curve presents the previously recommended data [6].

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