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Storage ring meets astrophysics: Dielectronic recombination of L-shell and M-shell iron ions

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Synopsis A status report is given on an ongoing experimental effort to provide reliable rate coefficients for dielectronic recombination of highly charged iron ions for the modeling of astrophysical and other plasmas. The experimental work has been carried out at the Heidelberg heavy-ion storage-ring TSR.

Dielectronic recombination (DR) is an important electron-ion collision process governing the charge balance in atomic plasmas [1, 2]. Accurate DR rate coefficients are therefore required — along with many other atomic data — for the interpretation of observations of such plasmas be they man-made or astrophysical. Because of the vast atomic data needs most of the data that are presently used in plasma modeling codes have been generated by theoretical calculations. In order to assess the reliability of these calculations and to point out directions for their improvements benchmarking experiments are vitally needed [3, 4].

For more than a decade, our collaboration has performed measurements of absolute DR rate coefficients employing the electron-ion merged-beams method at the heavy-ion storage ring TSR of the Max-Planck-Institute for Nuclear Physics in Heidelberg, Germany. In particular, we have concentrated on iron ions because of their prominent role in X-ray astronomy. Iron is the most abundant heavy element and still contributes to line emission from astrophysical plasmas when lighter elements are already fully stripped. The present status of our experimentally-derived Fe DR data base has been summarized recently [5].

Figure 1 shows our experimentally-derived rate coefficients for DR of some iron ions with an open M-shell. At low plasma temperatures, there is no systematic behavior of the rate coefficients as a function of charge state. This is due to the individually very different DR resonance structures of each ion. Therefore, accurate low-temperature rate coefficients cannot be obtained by interpolation along isonuclear or isoelectronic sequences of ions, an approach that has been used in past theoretical work. At low temperatures our DR rate coefficients are orders of magnitude larger than those from a widely used compilation [6]. In general, modern state-of-the-art DR calculations [7] result in much better agreement with our data, but significant discrepancies still remain for some systems.

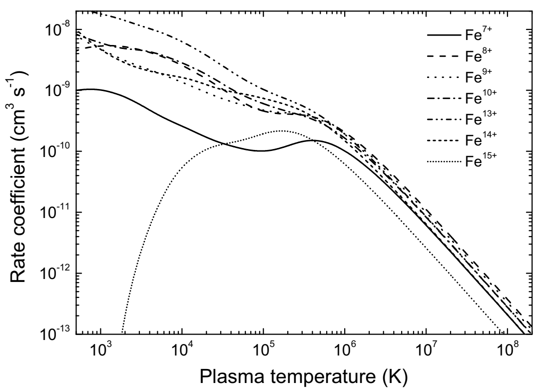

Figure 1. Presently available, experimentally-derived rate coefficients for DR of Fe M-shell ions in a plasma. Rate coefficients for Fe L-shell ions (not shown) are available as well [5].

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