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Measurements of electron-impact single and multiple ionization for ions of astrophysical interest

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Accurate cross-section data for electron impact ionization (EII) are needed in order to interpret the spectra of collisionally ionized plasmas. In astrophysics, such plasmas are formed in stars, supernova remnants, galaxies, and galaxy clusters. Spectroscopic diagnostics of such plasmas rely on accurate ion balance calculations, which depend, in turn, on the underlying rates for EII and electron-ion recombination. Single ionization is usually the dominant EII process, but in some dynamic systems multiple ionization can become important. We have been carrying out EII measurements using the TSR storage ring located at the Max Planck Institut für Kernphysik in Heidelberg, Germany. Storage ring measurements are largely free of metastable contamination, resulting in unambiguous EII data. In order to guide theory, we have focused on providing at least one single ionization measurement for as many isoelectronic sequences as possible. To date, we have measured single ionization for ions from 13 isoelectronic sequences: Be-like sulfur, B-like magnesium, and F-like through K-like iron. For multiple ionization, there is no adequate theory capable of calculating the needed cross sections. All such data are based on experimental measurements and supplemented by semiempirical extrapolations. We have performed several measurements of double ionization for Fe ions. However, very little experimental data exist for multiple ionization and more is needed in order to generate reliable ionization balance calculations for dynamic plasmas.