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Theoretical Investigation of Collision strengths for Fe X, of Importance for Measuring Magnetic Field Strengths in the Solar Corona

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In recent years, a new diagnostic technique, namely the magnetic-field-induced transition (MIT) method[1] caused by the pseudodegeneracy of two atomic levels has been applied to various EIS observations of Fe x EUV spectra to measure the coronal magnetic field strengths of solar active regions[2,3,4]. Chen et al. also validated the MIT technique for magnetic field measurements of solar active regions through forward modeling with a 3D radiation magnetohydrodynamic model[5]. More recently, Chen et al. have further extended the MIT technique to the measurements of the magnetic field strengths at the coronal bases of active stars[6]. However, the MIT method comes with large uncertainties originate in the relative intensity calibration and the atomic data, including a sufficiently accurate energy separation, as well as radiative and collisional data. Li et al. investigated the accuracy of the current atomic data and provided recommended values for MIT rates as a function of magnetic field strengths[7]. Consequently, in this work we will focus on the assessment of collision strengths that are important to model the Fe x EUV spectrum, in particular the lines in the wavelength range of 170–260 Å have been adopted for the coronal magnetic field measurements.

The energy structures were calculated using the relativistic GRASP code[8]. The relativistic parallel Dirac atomic R-matrix codes[9] were employed in the scattering calculations to generate the collision strengths and subsequently the Maxwellian-averaged effective collision strengths for temperatures in the range of 10^5 to 10^7 K. The present effective collision strengths were compared with previous theoretical studies and experimental results when available, especially for the EUV transitions in the wavelength range of 170 - 260 Å. In addition, we synthesized the EUV spectral line intensities using the new collision data and further measured the densities and coronal magnetic field strengths by comparing the theoretical predictions with Hinode/EIS observations, based on the MIT technique. Discrepancies between EIS observations and theoretical modeling were observed and their impact on the magnetic field strength measurement was discussed.

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