Electron-impact excitation of forbidden and allowed transitions in Cr II

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Synopsis The B-spline R-matrix method is used to investigate the electron-impact excitation of Cr II. The close-coupling expansion contains 512 fine-structure levels of Cr II and includes all levels of the $3d^5$, $3d^44s$, $3d^34s^2$, $3d^44p$ and $3d^34s4p$ configurations. The present results considerably expand the existing data sets for Cr II, allowing a more detailed treatment of the available measured spectra from different space observatories.

The radiative and collision rates of Cr II are of significant importance for the analysis of stellar and nebular spectra. Until recently there was an apparent lack of the collision data available in the literature for the electron-impact excitation of Cr II. Extensive R-matrix calculations were carried out by Wasson et al. [1,2] who reported data for selected transitions between levels of the $3d^5$, $3d^44s$, and $3d^44p$ configurations. The purpose of the present work is to perform more elaborate and more extensive calculations for the electron scattering from Cr II to provide independent test of the existing data sets and to obtain more realistic estimations for accuracy of collision parameters. We extend the scattering model by including all fine-structure transitions among the 512 levels arising from the principal $3d^44s$, $3d^5$, $3d^44p$, $3d^34s^2$, and $3d^34s4p$ configurations.

The present calculations were performed with the BSR codes [3] which are based on the R-matrix method and employ B-splines as a basis for the representation of the continuum orbitals. The BSR codes were considerably extended and modified in last two years in order to deal with such extremely complicated atomic systems as iron-peak elements. The use of non-orthogonal orbital sets allowed us to generate a more accurate description of the target states than those used in previous collision calculations. In particular, we use extensive multi-configuration expansions with carefully chosen configurations and, as a distinguish feature of the present calculations, we employ the term-dependent one-electron orbitals in configurations with different occupation in the 3d-subshells. To further improve the accuracy of our final collision rates, experimental energies through the fine-tuning process have been used, not only for target level energies, but also to enhance the accuracy of the term-mixing coefficients in the wave functions.

The comparison of the present effective collision strengths for the electric dipole-allowed transitions with R-matrix calculation [2] is given in Fig.1 The overall agreement is very reasonable considering the complexity of the system. Some discrepancies can be explained on the basis of more accurate target wave functions used in our calculations. Comparison between these two extensive independent calculations carried out with different computational methods allows us to make conclusive assessment of the accuracy of the effective collision strengths in these data sets. Overall, our results are estimated to be accurate to 30% or better for most of the transitions, with lower accuracy for transitions between closely lying levels.

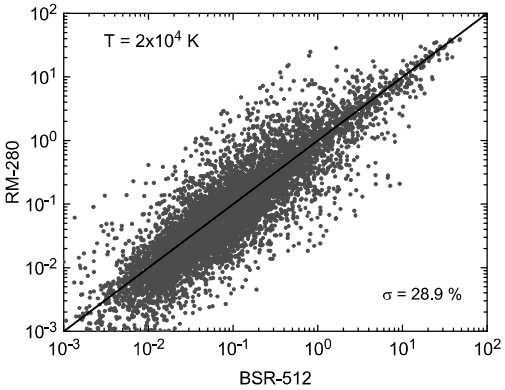

Figure 1. Global comparison of effective collision strengths obtained in the present BSR-512 model with the RM-280 calculations of Wasson et al. [1,2].

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References

[1] Wasson I R *et al* 2010 *A&A* **524** A35
[2] Wasson I R *et al* 2011 *ApJS* **196** 24
[3] Zatsarinny O 2006 *Comp. Phys. Commun*. **174** 273

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