SPECTRAL SERIES EMISSION AND ATOMIC POPULATIONS IN SOLAR ASTROPHYSICAL AND LABORATORY FUSION PLASMAS

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Abstract

This thesis seeks to provide spectroscopic diagnostic tools through the advancement of atomic modelling techniques. Issues of opacity (and its consistent treatment from bound to free states), excited state population modelling and spectral feature generation are dealt with. The escape factor technique is used to account for opacity in emergent flux and atomic population calculations. A thorough treatment of low series member opacity is given in the code ADAS 214, which modifies adf04 files for subsequent population processing via ADAS collisional-radiative routines. The escape factor expressions are analytically extended from bound to free states, allowing opacity to be dealt with smoothly across the ionisation threshold. The continuity approach of this thesis is contrasted with the usual technique of introducing an ionising plasma microfield which gradually 'dissolves' the highly excited quantum shells into the continuum. A comprehensive plan is outlined which will allow collisional-radiative modelling of arbitrary heavy species. This scheme works in a new coupling picture, for which new Gaunt factors have been developed. The bundled-$(J_p)nl$ and bundled-$(J_p)n$ block primitives of this model have been developed, as has a test module for a single n-shell of the bundled-$(J_p)nlj$ block primitive. A scheme for automatic determination of bundling cut-offs has also been demonstrated. The new model is designed in a modular manner to allow future developments to be performed in testable steps and to take advantage of modern high performance computers. The population, opacity and continuity modelling are then brought together in the generation of a synthetic spectrum for series limit wavelengths of hydrogenic systems. A specific code is written to allow JET divertor Balmer series limit observations to be analysed, returning diagnostic information on plasma electron density, temperature and recombination state. The code is shown to provide good fits to typical divertor spectra and will be developed into an ADAS spectral fitting procedure. The future directions for application of the work are outlined.

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