First Session: The New Atomic Databases (Monday August 22, afternoon)

NEW ATOMIC DATA FOR ASTRONOMY: AN INTRODUCTORY REVIEW

M. J. SEATON

Department of Physics and Astronomy, University College London
London WCIE GBT, U.K.

Astronomers require the following basic atomic data: energy levels and wavelengths; radiative transition probabilities; cross sections for photo-ionisation and for collisional processes; and line profile parameters. They also require processed data such as: level populations; opacities; radiation forces; line emissivities; and collisional rate-coefficients.

Many of the data used by astronomers come from theoretical work. Experimental work is of importance in determining accurate wavelengths, in providing essential checks on theory for radiative probabilities and collision rates, and in the determination of line-profile parameters. Experimental studies are particularly important for processes of collisional ionisation.

Most atomic physics computations are based on the conceptual structure of the central field model. Work on atomic structures and radiative probabilities use a variety of methods: Hartree-Fock; configuration-interaction; employment of semi-empirical potentials and semi-empirical integrals. The close-coupling method is used in both atomic-structure work and for electron-atom collision calculations: practically all modern close-coupling work employs R-matrix methods, which are very efficient.

The importance of configuration-interaction (CI) for complex atoms is discussed by comparing results of *f*-values in Fe VIII to XIII computed using fairly elaborate R-matrix methods with results obtained using simpler methods which include less CI. The simpler methods can give large errors for individual transitions but may be of adequate accuracy for problems, such as the calculation of opacities, requiring very large amounts of atomic data.

A great deal of recent work has been done on the calculation of cross sections for collisional excitation of atoms and ions by electron impacts. The power of present-day computers is such that one can now tackle problems which would have been unthinkable a few years ago. There is still a need for further work on transitions between excited states of importance, for example, in NLTE studies of stellar atmospheres.

There have been major advances in the computation of Rosseland-mean opacities for stellar interiors (the OPAL work at the Lawrence Livermore Laboratory and the

https://doi.org/10.1017/S1539299600012065 Published online by Cambridge University Press

work of the internbational Opacity Project). The new results obtained are of particular importance for studies of pulsating stars. The atomic data from the Opacity project are available in the database system TOPbase. Some recent work involves the use of those data for the calculation of forces due to radiation pressure.

There have been a number of advances in the calculation of emissivities due to radiative recombination, including new results for may transitions at UV, optical and infra-red wavelengths.

SUMMARY OF THE IRON AND OPACITY PROJECTS

KEITH A. BERRINGTON

Department of Applied Mathematics and Theoretical Physics,
Queen's University, Belfast BT7 1NN, U.K.

Considerable effort has been made recently by international collaborations, exploiting advances in atomic physics and in supercomputing, to compute complete sets of accurate data for astrophysically important processes; in particular, the Opacity Project and the IRON Project.

The Opacity Project computed atomic data for opacity calculations

- for H, He, Li, Be, B, C, N, O, F, Ne, Na, Mg, Al, Si, S, Ar, Ca, Fe.
- energies of terms having effective quantum numbers $\nu \leq 10$ and total angular momentum $L \leq 3$ or 4, all spin and parity combinations;
- *gf*-values for all dipole transitions between these bound terms;
- total cross sections for photoionizaion from all calculated bound terms, tabulated on a grid of photon energies suitable to describe the resonance structure in sufficient detail to calculate reliable opacities;
- line broadening parameters.

28 key research papers arising from the Project, together with calculated energies and oscillator strengths for light ions, are reprinted in 'The Opacity Project Volume 1' (Opacity Project Team, 1994, IOP Publ. ISBN 0 7503 0288 7). All data are available from TOPbase, an on-line database at the CDS (Cunto et al. 1993, A&A 275, L5).

The IRON Project aims to systematically compute electron excitation cross sections for the iron group of elements. Particular attention is given to requirements for the interpretation of data from specific space observations.

In the first stage of the Project excitation cross sections have been computed for fine-structure transitions in the ground configuration of all ions of astrophysical interest. These data are essential for the interpretation of IR lines to be observed by ISO, as well