

COMMISSION 14: ATOMIC AND MOLECULAR DATA¹ (*DONNEES ATOMIQUES ET MOLECULAIRES*)

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In recognition of its special interdisciplinary character, IAU Commission 14 is linked directly to the Executive Committee. The Commission's role is to inform the astronomical community of new developments in the diverse fields of research which involve atoms and molecules. Conversely it endeavours to sensitize the research community active in those fields to the specific needs of astronomy, especially concerning basic data and modeling tools. More generally, Commission 14 tries to foster long term relations and collaborations between the two communities and, when necessary, to alert funding authorities to the specific needs of ground and space based astronomy for specific atomic and molecular data.

This report is one of the main contributions of Commission 14 to the information of the astronomical community. Several meetings concerned, at least in part, with the need and availability of atomic and molecular data for astrophysics were also sponsored or co-sponsored. In the last triennium, Commission 14 cosponsored IAU Symposium 194 "Astrochemistry: From Molecular Cloud to Planetary Systems" held in Sogwipo (Korea) from Aug. 23 to 27, 1999 and organized by Commission 34. A Joint Discussion: JD1 on "Atomic and Molecular Data for Astrophysics, New Developments, Case Studies and Future Needs" has been planned for the XXIVth IAU General Assembly in Manchester (Aug. 7-19, 2000) and cosponsored by Commissions 15, 16, 29, 34, 36, 40 and 44. Several other Joint Discussions to be held at the Manchester General Assembly are co-sponsored by this commission.

The present report comprises six sections established by the specialized Working Groups of Commission 14. It is made available on the Commission 14 Website:

<http://ww.obspm.fr/IAU14>

and its mirror <http://cfa-www.harvard.edu/amp/iau14>.

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¹Committee of the Executive Committee.

1. WORKING GROUP 1: ATOMIC SPECTRA AND WAVELENGTH STANDARDS

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1.1. Energy Level Analyses, Wavelengths and Line Classifications

The references cited in this section are mostly papers on original laboratory research; compilations and data bases are covered in another section. The references, ordered by atomic number and spectrum, are given in parentheses following the spectral notations. They are designated by the first letter of the first author's last name and a serial number; these designations precede the full citations in the reference list at the end of the report.

Be I (K9), **Be II** (K8), **B II** (L2), **B III** (L1), **C I** (C2), **C IV** (T2), **O VII** (B1), **F II** (B5), **Ne III** (L3), **Ne IV** (B2, C4), **Ne V** (B3), **Mg I, II** (P7), **Al I** (B6), **Si VII** (K5), **Si VIII** (K7), **S IX** (J2), **S X** (K7), **Ar III** (K4), **Ar V** (C1), **Ar VII** (T1), **Sc X-Fe XV** (K6), **V I** (P1), **Cr III** (E1), **Mn VII** (W3), **Fe II** (B4, B7, N1), **Fe VIII** (W4), **Co I** (P3), **Co II** (P4, P5, P6), **Co IX** (W5), **As III, IV** (C3), **Kr III** (R4), **Zr III** (R1), **Zr IV** (R2), **Nb III** (G1), **Mo I** (P2), **Pd I** (E3, M1), **Ba I,II** (K3), **Ce III** (W6), **Dy III** (S1), **Ho I** (K10), **Er III** (W7), **W II** (E2), **Re II** (W1), **Os IV** (R6), **Pt II** (K1), **Au II** (R5), **Hg II** (R3), **Tl II** (J1), **Pb II** (K2), **Bi I, II, III** (W2)

The references for elements heavier than Ni ($Z > 28$) are limited to the first three or four spectra only, these data being of interest for solar and stellar spectroscopy. The references of the lighter elements are also incomplete, the selection being limited to those of highest astrophysical interest. The data in a number of references include and/or supersede all or most of the previously available energy-level and/or wavelength data for the indicated spectrum. Such references include those of Be I, Si VII, S IX, Ar III, Ar VII, Cr III, Co I, Co II (P5), Zr III, Zr IV, Nb III, Pd I, Ba I, Ba II, Dy III, Er III, W II, Os IV, and Au II. For elements heavier than Ga new and unpublished data will be included in the new compilation by Morton (1999) on atomic data for resonance absorption lines.

Current work in high-resolution laboratory spectroscopy of the lowest ionization stages of astrophysical significance is ongoing at Lund (mainly transition elements and rare earth elements), London (third spectra of iron group elements), and NIST (heavy elements, rare earths). The spectroscopy groups at Troitsk (Russia), Amsterdam (NL), Antogonish (CA), Meudon and Orsay (FR) have announced a project on spectroscopy of ions of the 5d elements (The Platinum Group Ion project), in addition to other projects in progress.

1.2. Wavelength Standards

The paper by Nave *et al.* (1997) on accurate Fe II wavelengths in the vacuum-ultraviolet region was discussed in the previous report by W.C. Martin. It has now been published and is mentioned here only for giving complementary information about the reference. A new campaign for very accurate wavelengths of selected lines has been initiated by the current work on the time variability of the fine structure constant (Webb *et al.* 1999). The data will certainly be of great interest for spectroscopy of the interstellar medium. The measurements will be carried out at London and Lund, and one paper has already been published for magnesium (Pickering *et al.* 1998).

1.3. Larger Compilations, Reviews, Conference Proceedings

We will mention a few compilations that have appeared during the period 1996-99, as most data are now available in various databases via Internet; some databases are listed in the next section. Kramida and Martin (1997) have compiled the Be I spectrum, and Shirai, Sugar and Musgrove (1999) have submitted a compilation on Ga I-Ga XXXII. Compilations on Highly Ionized Atoms (Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Kr, Mo), on the Ne I spectrum

and for all Argon spectra are in preparation in collaborations between NIST, Japan Atomic Energy research Institute and the Institute for Spectroscopy in Troitsk, Russia. At the latter institute compilations of various ionization stages of neon are completed or in progress. Morton (1999) has submitted a compilation of *Atomic Data for Resonance Absorption Lines. II. Wavelengths Longward of the Lyman Limit for Heavy Elements*.

A number of papers on atomic spectroscopic data are included in proceedings of the *Sixth International Colloquium on Atomic Spectra and Oscillator Strengths for Astrophysical and Laboratory Plasmas*, held in Victoria, Canada, August 1998. Invited papers are scheduled for publication (Wiese *et al.* 1999), and abstracts of contributed papers appear in a publication of the University of Columbia (Tatum 1999). A few papers on astrophysical data needs are included in the proceedings from the first international conference *ICAM-DATA* (International Conference on Atomic and Molecular Data and Their Applications), held at NIST, Gaithersburg, U.S.A., October 1997 (Mohr & Wiese 1998). Several papers deal with atomic databases. The proceedings of poster papers (Wiese & Mohr 1998) contain papers about spectroscopic data for astrophysics.

1.4. Atomic Spectroscopic Data on the Internet

The URL addresses for a number of World Wide Web sites offering laboratory data of the types covered by Working Groups 1 and 2 are listed below. The italicized names of particular databases or datasets are followed by symbols CL, EL, TP in parentheses, indicating types of data:

CL Experimental wavelengths given with energy-level classifications.

EL Experimental values for energy levels.

TP Transition probabilities and/or related quantities (oscillator strengths etc.)

A Weizmann Institute site maintains an updated list of atomic databases and datasets on the Internet: *Databases for Atomic and Plasma Physics* (Weizmann Inst. of Science, Israel)

<http://plasma-gate.weizmann.ac.il/DbfAPP.html>

This site has links to most of the databases listed here as well as to a number of others. Instructions are given for e-mail access to data from the *Vienna Atomic Line Data-Base* (CL, TP) and for ftp downloading of a *Spectral Bibliography Database (BIBL)*, developed and maintained by the Institute of Spectroscopy, Russia.

The *NIST Atomic Spectra Database* version 2.0, released in March 1999, includes data (CL, EL, TP) that have been critically compiled either at NIST or by other reliable sources.

<http://physics.nist.gov/asd>

The database contains CL, EL, and TP for H-Ni ($Z=1-28$), with additional EL for H-Kr ($Z=1-36$), Mo ($Z=42$) and the lanthanides ($Z=57-71$). The prominent lines from the first five ionization stages are included for Cu to Es ($Z=29-99$). The database also contains a compilation of "Ground Levels and Ionization Energies for the Neutral Atoms".

Spectral information can be obtained at *CDS* (Centre de Données Astronomiques de Strasbourg, France) and the *ADC, Astronomical Data Center* at NASA Goddard Space Flight Center, U.S.A.

<http://cds-web.u-strasbg.fr>

<http://adc.gsfc.nasa.gov>

At CDS, select "Catalogues" and "VI Miscellaneous" (CL, EL, TP) and choose from a list of catalogues including several with extensive atomic spectroscopic data, and use the "Scientific data" and search facility at ADC to get data on CL, EL, and TP. Of similar construction is the *WWW Server in NAOJ/ADAC* (National Astronomical Observatory, Japan)

<http://adac.mtk.nao.ac.jp>,

where one selects "Clickable list of the catalogs" and "Miscellaneous Data" (CL, EL, TP) yielding a list including the CDS catalogs (see above). The *AMODS* (The Atomic Molec-

ular and Optical Database System) database at Korea Atomic Energy Research Institute contains atomic data (EL,CL,TP) from the CDS and NIST databases on a menu at

<http://amods.kaeri.re.kr>

By selecting "Databases" at *Cfa Atomic and Molecular Physics Division* (Harvard-Smithsonian Center for Astrophysics)

<http://cfa-www.harvard.edu/amp>

one gets access to the widely used data on "Kurucz CD-ROM 18" and "Kurucz CD-ROM 23" (CL, TP) and "Kelly"'s UV/VUV line list (CL). There are also links to other sites. The Kurucz data can also be found on the European server at

<http://www.pmp.uni-hannover.de/projekte/kurucz/sekur.html>

Theoretical data (EL,TP) on selected ions of the elements, Cr, Mn, Fe, Co and Ni are available via ftp from "Atomic Physics Theory" at the University of Amsterdam.

<ftp://ftp.wins.uva.nl/pub/orth>

The compilation of "Atomic Data for Resonance Absorption Lines" at Herzberg Institute of Astrophysics, Canada, (Morton, 1991) is located at

http://www.hia.nrc.ca/STAFF/dcm/atomic_data.html

The *Atomic Data for Astrophysics* (University of Kentucky, U.S.A.) has a database on "Energy Levels, Wavelengths, Transition Probabilities" (CL, TP) and a number of links to other databases and datasets.

<http://www.pa.uky.edu/~verner/atom.html>

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