COMMISSION 14: ATOMIC AND MOLECULAR DATA (DONNÉES ATOMIQUES ET MOLÉCULAIRES)

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Introduction

As the pool of fundamental data available to astronomers continues to increase, the question of how best to promote the necessary cross-discipline interaction becomes increasingly important. Commission 14 has traditionally played an important role in this activity, by publishing triennial reports in the IAU Proceedings, as well as by responding to more specific requests for data. We are fortunate in having the support for these activities of some energetic Working-Groups and Chairmen, whos contributions to the present report are very gratefully acknowledged. With the expansion of available data it is appropriate that these reports take on more and more the form of references to review articles and other more specific data bases. The question of whether the field of activity of the Commission should be enlarged was discussed at Patras and will be reviewed again at the Delhi meeting. One possibility is to include nuclear processes and fundamental particle physics. On the other hand a rationale for limiting the scope of our activities might be the direct application to astronomical observations. Astronomical theorists are usually better placed to access the fundamental data themselves. The interaction between fundamental physics and astronomy will in general take two forms. There is the essential service role of making data available in a usable form. However, we should surely aim to stimulate the other very profitable mode, in which the two disciplines are brought together to form real scientific collaborations, in order to research the problems of astronomy.

WORKING GROUP 1: WAVELENGTH STANDARDS

This report gives some highlights of recent work in the field of wavelength standards; it is by no means to be considered a complete review.

In October, 1983, the Seventeenth General Conference of Weights and Measures ratified a new definition of the International Metre as follows: "The Metre is the length of the path travelled by light in vacuum during a time interval of 1/299792458 of a second". This action at once fixed the speed of light by convention at exactly 299792458 m/s and increased the accuracy of the definition of the Metre to about one part in 10^{13}, as given by the second, defined in terms of the Cs standard radiation. Any future improvement resulting from a redefinition of the second will automatically be reflected in the definition of the Metre.

It follows from the new definition that the wavelengths of electromagnetic radiation are given by 299792458m (exactly) divided by their frequency. The latter can be obtained for certain suitable radiations, by a process of direct frequency comparison techniques, in terms of the Cs standard. Working wavelength standards can be measured by reference to such radiations either by frequency or wavelength comparison methods. The latter are at present advantageous for wavelengths shorter than those in the near infrared, but because of diffraction effects, are progressively less accurate at longer wavelengths, becoming quite impractical in the microwave region of the Cs standard, where comparison by frequency techniques is far more accurate and simpler.

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K.M. Baird
Chairman of the Committee

WORKING GROUP 2: ATOMIC TRANSITION PROBABILITIES

The Data Center on Atomic Transition Probabilities at the National Bureau of Standards, Gaithersburg, Md., is continuing its critical compilation work and the updating of the bibliographical data base on atomic transition probabilities. Work is in progress on the revision of the existing NBS critical data compilations (Refs. A-D) for all allowed and forbidden transitions in Fe-group elements. A single volume containing all these data for the Fe-group elements Sc to Ni (Vol. III of the NBS series of atomic transition probabilities) is planned for publication in the near future. However, this compilation work is proceeding slower than expected due to numerous recent additions and revisions in the data base.

In Table 1 the most recent literature references covering the period since the last working group report (August 1981) up to the present time (summer 1984) are presented, ordered according to element and stage of ionization. For brevity, the references are identified there only by the running number of the general reference list, given at the end of this section.

In the general reference list (Refs. 1-427), the recent literature is ordered alphabetically according to authors. Each reference contains some code letter(s), indicating the method(s) applied by the author. Specifically, the code letters are defined as follows:

THEORETICAL METHODS:

Q quantum mechanical (including self-consistent field) calculations.
I - interpolation within isoelectronic sequences, spectral series, or homologous atoms; also, data that are presented in graphical, rather than tabular form.

EXPERIMENTAL METHODS:

E - measurements in emission (arc, furnace, discharge tube, shock tube, etc.).
A - measurements in absorption (King furnace, absorption tube, etc.).
L - lifetime measurements (including Hanle-effect).
H - anomalous dispersion (hook) measurements.
M - miscellaneous experimental methods (for example, Stark effect, astrophysical measurements, etc.).

OTHER:

C - additions or suggested revisions to data in previous articles, comments on particular theoretical or experimental methods, etc.
Cp- data compilations.
R - relative (non-absolute) oscillator strengths have been tabulated.
F - data on forbidden (i.e., other than electric dipole) transitions have been tabulated.

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Accurate frequencies and wavelengths, referred to the Cs standard, have been obtained for a number of highly reproducible standards in the visible and infrared by the use of direct frequency comparisons. These values have been approved and published by the International Committee of Weights and Measures(1), and are considered accurate to about one part in 10^{10}.

There are a number of active programs, principally at National Standards Laboratories, that have the aim of transferring the one in 10^{13} accuracy of the Cs standard to the near infrared and visible parts of the spectrum. These involve both the development of improved stabilized lasers (using, for example, cooled trapped ion absorbers) and the development of systems for better direct frequency comparisons of microwave and optical radiations. A notable example of the latter is the recent successful operation of CO_2, 10μm lasers phase locked to the Cs primary standard(2). Another example is the recent measurement of the frequencies of a grid of OsO_4 absorption lines at 10μm(3). Examples of source development are the programs at the Joint Institute of Laboratory Astrophysics and at the National Bureau of Standards in Boulder, U.S.A. These include work on laser-cooled trapped ions for absorption line reference frequencies, and the use of modulation side techniques to avoid low frequency noise in order to obtain extremely high resolution of narrow line profiles and servo control of lasers with respect to their centres(4,5).

Wavelength standards in the VUV and XUV regions are measured by length based comparison with visible standards. An example of recent important work is given in the following excerpt from a letter from W.C. Martin of the U.S. National Bureau of Standards:

"1. We are making high-accuracy measurements of the spectrum of a platinum hollow-cathode discharge for the region 110-330 nm(6). We expect to determine about 3000 wavelengths for Pt I, II and Ne I, II with uncertainties of ± 0.0002 nm or less for many lines. The wavelengths will be used for on-board calibration of High-Resolution Spectrograph for the Hubble Space Telescope. Our measurements will also allow use of the Pt hollow cathode as a source of calibration wavelengths for other spectroscopy in the above region.

2. Our recently completed determinations of an expensive system of energy levels for Y VI have given Ritz-type wavelengths standards in the XUV region 20-40 nm(7). Together with wavelengths to be similarly derived from our Y IV analysis(8) and work on Y V in progress, these wavelengths will comprise of a system of yttrium standards covering the range 18-70 nm with uncertainties of ± 0.001 to ± 0.0003 nm."

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Some research groups have communicated their work in progress. At the Center for Astrophysics, Cambridge, Massachusetts, lifetime measurements are underway formetastable levels of C II, C III, Si V, and Al II, utilizing laser-plasma excitation and ion traps to store the metastable ions. Also, transition probabilities for Si II and Co II are being measured with the hook technique. At the University of Lyon, lifetime measurements are underway for He-like, Li-like and Be-like ions of Cr, Fe and Cu, and for Li-like Al. At NBS, Gaithersburg, Maryland, transition probabilities are calculated for the $2s^2\ {}^1S_0 - 2s3p\ {}^{1,3}P_1^o$ transitions of Be-like ions using both non-relativistic and relativistic correlated wavefunctions.

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TABLE 1

Recent literature sources for atomic transition probability data of astrophysical interest

This table covers the period since the publication of our last IAU report (Transact. IAU XVIII A, 116, (1982)) to the present (August 1984). The table is arranged in alphabetical order of elements symbols with further sub-divisions according to stage of ionization (I,II, etc.). Theoretical papers containing data for some transitions along an isoelectronic sequence are separately identified. The numbers are the running numbers of the reference list following this table.

Ag I: 38,195,300,328,373,378,379
Ag II: 328

Al sequence: 215,383
Al I: 124,132,185,226,267,274,307 400,401
Al II: 96
Al III: 92,291,373
Al IV: 79,185
Al VII: 5

Ar I: 62,63,64,65,140,218,236 303,416
Ar II: 58,85,99,100,304,376,416
Ar III: 146
Ar V: 145
Ar VI: 71,124,127,147
Ar VII: 71,126
Ar VIII: 71
Ar IX: 72
Ar XV: 156
Ar XVI: 118,264
Ar XVII: 118
Ar XVIII: 178
Ar XXIII: 156

B sequence: 134,290,313,347
B I: 267,290,341
B II: 266,322
B III: 70,88,264,266,322,324
B IV: 268,341

Ba I: 17,18,21,42,143,241,318
Ba II: 318,373
Ba III: 84,95

Be sequence: 11,12,59,121,128,161 164,166,169,224,313, 361,364
Be^-: 20,25
Be I: 20,234
Be II: 33,34,35,89,135,233,306,324 335,369
Be III: 341

C sequence: 5,59,129,144,313
C I: 45,211,289,374,395
C II: 96,173,290
C III: 36,37,96,157,160,239
C IV: 81,118,256,335
C V: 46,118

Ca I: 28,141,200,217,253,287,318, 321,377,398,406,407,421,
Ca II: 280,318,368,373
Ca V: 146
Ca VIII: 127
Ca IX: 126
Ca XI: 329
Ca XVII: 43,112,121,156,353
Ca XVIII: 32,168,269,353,426
Ca XIX: 187,268,382

Cl sequence: 214,383,411
Cl I: 367
Cl II: 146
Cl III: 23
Cl IV: 23,145
Cl V: 23,124,127,147
Cl VI: 23,126
Cl VII: 23,227,291
Cl VIII: 23
Cl XVI: 46

Co sequence: 419
Co I: 77,97,186,190
Co II: 198
Co IX: 391,394

Cr I: 57,212,248,401,427
Cr II: 251
Cr IV: 338
Cr VI: 390,393
Cr XII: 127
Cr XIII: 126
Cr XIX 348
Cr XX: 75
Cr XXI: 75,389
Cr XXII: 389
Cr XXIII: 46,389

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W.L. Weise
Chairman of Working Group

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