14. COMMISSION DES ETALONS DE LONGUEUR D'ONDE ET DES TABLES DE SPECTRES SOLAIRES

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SOUS-COMMISSION DES TABLES D'INTENSITÉS

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I. THE PRIMARY STANDARD

Barrell has given (*Proc. Roy. Soc.* A, **186**, 164, 1946 and *Revue de Métrologie Pratique et Légale*, 2ᵉ série, **7**, 33, 1947) a summary of nine directly measured values of the wave-length of the red line of cadmium in terms of the International Metre.

TABLE I

Values of the Wave-length of the Cadmium Red Line in Terms of the International Metre (1 A. = 1×10^{-10} m.)

Date	Observers	Original value	Corrected value	Differences from mean: 10^{-10} m.	Differences from mean: Parts per million
1892–3	Michelson and Benoît	6438·4722	6438·4691	−0·0005	−0·08
1905–6	Benoît, Fabry and Perot	6438·4696	6438·4703	+0·0007	+0·11
1927	Watanabe and Imaizumi	6438·4685	6438·4682	−0·0014	−0·22
1933	Sears and Barrell	6438·4711	6438·4713	+0·0017	+0·26
1933	Kösters and Lampe	6438·4672	6438·4689	−0·0007	−0·11
1934–5	Sears and Barrell	6438·4709	6438·4709	+0·0013	+0·20
1934–5	Kösters and Lampe	6438·4685	6438·4690	−0·0006	−0·09
1937	Kösters and Lampe	6438·4700	6438·4700	+0·0004	+0·06
1940	Romanova, Varlich, Kartashev and Batarchukova	6438·4677	6438·4687	−0·0009	−0·14
		Mean	6438·4696	±0·0009	±0·14

The values originally reported (column 3) are corrected in column 4 to take account of subsequent conclusions regarding the values to be attributed to the ruled standards of length employed and adjustments to uniform conditions of normal air.

The statistical mean deviation associated with the average value of $6438{\cdot}4696 \times 10^{-10}$ m. derived from the nine experimental determinations amounts to $\pm 0{\cdot}0010 \times 10^{-10}$ m. This mean value of all (corrected) measurements of the cadmium red wave-length is identical with that originally reported by Benoît, Fabry and Perot which was internationally adopted in 1907 as the primary standard for spectroscopic measurements of wave-lengths and the definition of the international angstrom unit.

Alternative sources of the cadmium red line have been discussed by Williams and Gogate (*Proc. Roy. Soc.* A, **167**, 509, 1938) and by Meggers (*Rev. Mod. Phys.* **14**, 59, 1942).

Attention is drawn to the recent production of monochromatic radiation (purer than the cadmium red line) from a single isotope of even mass number, thus eliminating isotope shifts and hyperfine structure. In 1940 Wiens and Alvarez (*Phys. Rev.* **58**, 1005, 1940) first demonstrated that mercury 198 (resulting from the bombardment of gold 197 with neutrons) emitted a sharp green line (5461 A.); but with cyclotrons it is impractical to make sufficient Hg^{198} for permanent lamps (*Phys. Rev.* **70**, 910, 1946). In 1945 many milligrams of Hg^{198} were made in chain-reacting uranium piles and grams of pure artificial mercury are now in prospect. Lamps containing 5 or 10 mg. of Hg^{198} have been prepared and studied by Meggers (*J. Opt. Soc. Amer.* **38**, 1, 1948) who has measured the wave-lengths relative to the cadmium standard. Preliminary values for the green and yellow lines of Hg^{198} are 5460·753, 5769·598 and 5790·663 A. The Hg^{198} lamps are more intense and convenient than Michelson's cadmium lamp and the order of interference obtainable with Hg^{198} is more than double that of any radiation from natural elements.

Similar results are reported to have been obtained in Germany with the yellow-green line (5650 A.) from krypton sources containing a single isotope Kr^{84} or Kr^{86} cooled in liquid air.

TABLE 2

Red and Infra-red Wave-lengths of the Iron Arc in Air

M. & K. (1924)	M. (1935)	B. (1947)	M. & K. (1924)	M. (1935)	B. (1947)
6750·157	—	·158	7937·172	·166	·164
6945·211	—	·211	7945·882	·878	·873
6978·857	—	·856	7998·980	·972	·971
7068·418	—	·414	8028·356	·341	·346
7090·410	—	·409	8046·084	·073	·073
7130·946	—	·943	8085·207	·200	·198
7164·472	·469	·471	8198·960	·951	·954
7187·341	·341	·339	8207	·767	·766
7207·422	·406	·411	8220·413	·406	·403
7219·690	—	·686	8232	·347	·338
7223·670	—	·671	8239	·130	·129
7239·896	—	·892	8248	·151	·154
7284·843	—	·846	8293	·527	·519
7288·764	—	·760	8327·069	·063	·060
7293·073	—	·064	8331·956	·941	·948
7311·103	—	·102	8339	·431	·426
7320·694	—	·683	8360	·822	·825
7389·423	·425	·421	8365	·642	·643
7401·691	·689	·694	8387·787	·781	·780
7411·184	·178	·175	8439	·603	·605
7418·676	·674	·673	8468·422	·413	·414
7445·778	·776	·774	8514·088	·075	·078
7495·092	·088	·085	8526	·685	·695
7511·047	·045	·041	8582	·267	·266
7531·178	·171	·171	8611	·807	·807
7546·177	—	·170	8621	·612	·610
7568·931	·925	·924	8661·915	·908	·906
7583·801	·796	·796	8674	·751	·753
7586·050	·044	·047	8688·641	·633	·632
7620·538	·538	·537	8757	·192	·191
7653·783	—	·786	8764	·000	·004
7661·230	·223	·222	8793	·376	·380
7664·306	·302	·302	8804	·624	·627
7710·397	·390	·389	8824·238	·227	·226
7748·282	·281	·279	8838	·433	·432
7780·594	·586	·584	8866	·961	·964
7832·233	·224	·223	8999	·561	·562
7912	·866	·867			

II. Secondary Standards

(*a*) *Iron Lines*

As the result of previous reports and actions of the International Astronomical Union there now exist 306 secondary standards among iron lines ranging in wave-length from 2447·708 to 6677·993 A. The number of standards shorter than 3100 A. can be greatly increased, and extended to 2100 A., when another independent and concordant set of values is reported for this range (cf. *Trans. I.A.U.* **6**, 79, 1939).

The Fe I spectrum has been observed by Green (*Phys. Rev.* **55**, 1209, 1939) to 1862·318 A. and ultra-violet standards may be calculated from relative term values in so far as these are fixed by other standards (*Trans. Amer. Phil. Soc.* **34**, Part II, 111, 1944).

Vacuum wave-length measurements in the iron spectrum by means of the reflection echelon grating were reported by Williams and Middleton (*Proc. Roy. Soc.* A, **172**, 159, 1939) for 47 lines (3286·7508–5371·4905 A.). The values apply to a low-pressure source (Schüler lamp) and are from 0·002 to 0·006 A. smaller than the adopted secondary standards.

In 1947 Dr Burns measured the wave-lengths (unpublished) of red and infra-red iron lines with interferometers. He employed a 6-ampere arc in air and observed light from a central 3 mm. of a 9 mm. arc gap. His values for wave-lengths greater than 6750 A. appear in column 3 of Table 2 where column 1 shows the values published by Meggers and Kiess (*Sci. Pap. Bur. Stand.* **19**, 273, 1924), and column 2 the values reported by Meggers (*J. Res. Nat. Bur. Stand.* **14**, 33, 1935).

The values in column 1 soon deviate systematically from those in columns 2 and 3, which are in good agreement on the whole. There is no satisfactory explanation of the discrepancies. It appears necessary to await another independent set of observations before recommending the adoption of secondary standards of wave-length for iron lines beyond their present limit in the red.

(*b*) *Neon Standards*

In 1935, eight-figure values of neon wave-lengths, ranging from 5852·4878 to 7032·4127 A., were adopted (*Trans. I.A.U.* **5**, 86, 1935) as secondary standards. Because a Geissler tube containing neon is a reproducible, intense, and convenient source, and because the neon spectrum contains many strong lines in the near infra-red, it may eventually supply useful secondary standards in this portion of the spectrum. In 1934 Meggers and Humphreys reported interference measurements of neon wave-lengths from 4334·125 to 9665·424 A. (*J. Res. Nat. Bur. Stand.* **13**, 293, 1934). The values were determined relative to the cadmium red standard and/or neon orange and red standards. In 1947, Dr Burns measured (unpublished) the longer wave-lengths of neon lines relative

Table 3

Red and Infra-red Wave-lengths of Neon

M. & H. (1935)		B. (1947)		M. & H. (1935)		B. (1947)	
7059·109	(3)	·1081	(5)	8300·3258	(16)	·3244	(24)
7173·9389	(15)	·9376	(30)	8377·6069	(19)	·6055	(29)
7245·1668	(19)	·1664	(38)	8418·4274	(14)	·4259	(20)
7438·8989	(17)	·8972	(32)	8495·3601	(17)	·3585	(29)
7488·8720	(14)	·8706	(21)	8591·2584	(14)	·2583	(22)
7535·7745	(13)	·7732	(23)	8634·6482	(14)	·6466	(23)
7544·046	(4)	·0445	(15)	8654·3834	(13)	·3830	(25)
7943·1802	(10)	·1806	(9)	8780·6222	(12)	·6223	(16)
8082·4582	(8)	·4590	(8)	8783·755	(12)	·7538	(15)
8118·5495	(5)	·5507	(4)	8853·866	(7)	·8670	(7)
8259·380	(2)	·3792	(4)	8865·759	(4)	·7554	(6)
8266·0763	(7)	·0781	(6)				

to neon standards. His values are shown in column 2 of Table 3 where column 1 displays the mean values reported by Meggers and Humphreys. The number of observations is shown in parentheses.

(c) *The 'Winmac' Machine*

A new device that may prove important in accelerating the determination of secondary standards of wave-length has been described by the secretary of Commission 14 (George R. Harrison, 'Direct Determination of Wave-Lengths from Fabry-Perot Interferometer Patterns', *J. Opt. Soc. Amer.* **36**, 644, 1946). This is a new type of measuring and computing engine designed to determine wave-lengths and wave-numbers directly from spectrograms that have been made by crossing the dispersion of a Fabry-Perot interferometer with that of a concave diffraction grating. The machine first determines the wave-length of a spectrum line to six-figure accuracy from the grating dispersion, using the method previously used in the M.I.T. automatic comparator (Harrison, *J.O.S.A.* **25**, 6, 1936; Harrison and Molnar, *J.O.S.A.* **30**, 343, 1940). It then converts this wave-length to wave numbers and computes the order of interference corresponding to the wave-length setting of the comparator from the thickness of the etalon separator which has been pre-set into the machine.

The interference pattern of each spectrum line is projected on to a screen in front of the operator with a magnification automatically made proportional to the square root of the order of interference, and falls on a set of parabolic fiducial lines drawn to fit the optical system originally used to project the interference fringes on the slit of the grating spectrograph. The operator moves the screen carrying these parabolic lines up or down until they coincide with the density maxima of the interference pattern. The partial order of interference in the centre of the pattern can then be read to three figures from a dial. By turning the control handle of the machine slightly, the operator then makes a dial-reading of the machine coincide with that of this dial, and other dials then give the wave-length and wave number of the line correct to seven or eight figures, depending on its sharpness. Cams are used to introduce corrections for the dispersion of air and the variation of phase-change with wave-length.

This engine, designated 'Winmac' (Wave-length Interferometric Measuring and Computation), greatly increases the speed and precision of reduction of Fabry-Perot patterns. Repeat readings on sharp lines are found consistent to within a few ten-thousandths of an angstrom, and only a few seconds are needed to determine the wave-length of a line.

Since the first description of the machine appeared, automatic scanning of interference patterns has been developed. A disk, on which is engraved a parabolic slit in polar co-ordinates, rotates between the enlarged image of the interference pattern and two photomultiplier tubes whose circuits alternately pick the centres of gravity of each of the various interference maxima. The pattern is thus scanned radially outward in both directions from the centre by a series of slits that move with velocities that decrease as the dispersion in the pattern diminishes. The width of the slit also varies with the dispersion. A stroboscope lamp is flashed by the maximum-picker as the centre of each pattern is crossed, and this illuminates two rotating dials calibrated in thousandths of an order of interference. Maxima may thus be recorded individually or in groups on each side of the centre. The two rotating dials give the fractional orders on either side of the central image; and an adjustment is provided so that the operator can move the plate slightly until the readings for the two sides are equal, thus insuring symmetrical measurement of patterns. Fifteen fractional-order determinations are thus made per second. The operator sets a pointer on the flickering centre of gravity of the readings, thus obtaining a single average value that feeds through the remainder of the 'Winmac' and gives a corresponding wave-length value.

It is planned to use the 'Winmac' for the measurement of lines distributed fairly uniformly throughout the spectra of complex atoms, which will then be used as working standards for interpolation of wave-lengths of lines photographed with diffraction gratings.

III. Solar Spectrum Tables

(*a*) *Long-wave Portion*

In the *Carnegie Institution of Washington Publication* No. 579, 1947, H. D. Babcock and C. E. Moore give wave-lengths and intensities for more than 7400 lines in the solar spectrum from 6600 to 13,495 A. Where international standards are lacking (the present limit being 9889 A.) wave-lengths have been interpolated between the Mount Wilson interferometer values, or, beyond this limit (10,604 A.), referred to adopted solar standards in overlapping orders of concave grating spectra. Preliminary values of the wave-lengths selected to establish the scale of the infra-red solar spectrum to its present photographic limit have been published elsewhere (*Ap. J.* **83**, 115, 1936; *Trans. I.A.U.* **6**, 99, 1938). The intensities are calibrated in terms of equivalent width (solar lines only). The change of intensity observed in passing from the spectrum of the solar disk to that of a sunspot is tabulated as far as 11,508 A. Identifications of solar lines are thought to be as definitive as present knowledge permits. Excitation potentials are given for all classified solar lines.

Unblended solar wave-lengths are more homogeneous than the laboratory values of the corresponding lines. For example, strong multiplets in the first spectra of C and of Si are displayed in the solar spectrum more accurately and in greater detail than they are in existing laboratory data. Series of lines in the first spectrum of Mg are found well developed in the solar atmosphere but have not yet been observed in the laboratory.

Table 4

Reference Standards of Wave-length in the Solar Spectrum*

λ in air 15° 760 mm.	El.	Int.	λ in air 15° 760 mm.	El.	Int.	λ in air 15° 760 mm.	El.	Int.
2995·841	Fe	2	3015·204	Cr	6	3064·379	OH^- / Co	1
2996·398	Fe	5	3018·143	Fe	3	3064·715	Pt	1
2996·590	Cr	5	3022·749	Mn	3	3066·696	Fe ?	−2
2997·224	—	2 N	3024·804	—	3	3067·783	OH ?	1
2997·980	Pt	2	3029·992	—	3	3068·946	Fe	−1
2998·499	—	1	3030·609	Fe^-	2	3071·431	—	−1
3004·122	Fe	3	3033·107	Fe	2	3082·628	Co	2
3004·632	Fe	3	3033·819	V^+	3	3083·751	Fe	4
3005·054	Cr	4	3042·265	V^+	3	3086·402	Co / OH	1
3005·310	Fe	3	3042·488	Co	3	3089·507	—	−1
3005·970	Fe ?	2	3043·131	V	1	3091·878	—	0
3006·742	—	3	3043·357	Mn	2	3095·080	Zr^+	0
3006·870	Ca	3	3046·048	Fe	1	3098·455	Nd^+ ?	−2
3008·803	Ce^+ ?	−2	3046·505	—	0	3104·169	—	0
3010·182	Fe ? / Fe^+	2	3046·807	Fe	0	3109·624	—	1
3010·630	Fe	1	3048·221	V^+	3	3117·770	OH	1
3011·169	Mn	0	3052·493	—	1	3118·143	Ti / Cr^+	1
3011·279	—	1	3056·112	—	1	3118·255	Co	0
3012·452	Fe	3	3056·342	V	2	3118·829	Ti^+ ?	0
3013·499	—	1	3058·708	—	3	3122·081	Ti^+	0
3013·597	Co	2	3060·347	—	−1	3125·922	Zr^+	0
3013·972	Fe ?	−1	3060·457	V	0	3133·493	Zr^+	0
3014·322	V	1						

* October 1949. A note from H. D. Babcock states that all wave-lengths in Table 4 should be diminished by 0·002 A. See *Ap. J.* **110**, 104, 1949.

TABLE 5

Corrections for Changing Wave-lengths from the Scale of 1922 to the Scale of 1928

Region	Correction to 1922 λ	Region	Correction to 1922 λ
2995–3133 A.	−0·0012 A.	6125–6290 A.	−0·006 A.
3133–3370	(−0·0010)*	6290–6455	−0·007
3370–3705	−0·0006	6455–6630	−0·008
3719–3849	−0·0015	6630	−0·009
3850–3969	−0·0015	6800	−0·010
4000–5600	−0·002	6900	−0·012
5600–5780	(−0·003)*	7000	−0·014
5780–5960	(−0·004)*	7100	−0·016
5960–6125	−0·005		

* Values in parentheses are interpolated.

(*b*) *Short-wave Portion*

In Mt Wilson Observatory Contribution 745 (*Ap. J.* **107**, 287, 1948) H. D. Babcock, C. E. Moore, and M. F. Coffeen give a thorough revision of existing solar data in the region 2935–3063 A., where atmospheric absorption greatly reduces the intensity of the spectrum but high dispersion can still be used at ground stations. By means of overlapping orders the wave-lengths of 67 selected ultra-violet solar lines (see Table 4) were determined in terms of adopted standards in the blue region. With the aid of these ultra-violet reference lines, 1165 wave-lengths, 2935–3153 A., are found; and of these 665, in the range, 2935–3063 A., appear in this contribution. Wave-lengths, intensities, identifications, and low excitation potentials are given. About 75 % of the lines are identified. Nearly one-half of the identified lines are related to singly ionized elements. In the range 2975–3063 A., over which the spectrograms are of best quality, the average number of solar lines per angstrom is 6, and a large proportion of these are blends.

The paper should be helpful in relating the more familiar parts of the solar spectrum to the new observations, made at much lower dispersion, from rockets in flight above nearly all of the effective absorption in the atmosphere.

In Table 5 revised corrections are given for changing wave-lengths expressed on the scale of 1922 to the scale of 1928. This supplements the table given in *Trans. I.A.U.* **4**, 60, 1932.

(*c*) *Tables of Atomic Energy Levels and Application to Solar Spectra*

A critical compilation of *Atomic Energy Levels* as derived from the observation of more than 490 optical spectra of 83 elements is being made at the National Bureau of Standards to replace that of 231 spectra of 69 elements published in 1932 by R. F. Bacher and S. Goudsmit. The data from H through V are now in the Press (*Cir. N.B.S.* 467, 1949). The manuscript is completed for 255 spectra which include nearly all those of light elements through the Ca I isoelectronic sequence. The levels are listed by terms, starting with the ground state zero. A standard notation is suggested, and detailed electron configurations are given. In addition, arrays of observed terms and of predicted terms of the leading isoelectronic sequences, arranged similarly, are included in order to enable the user to grade the analyses, to detect related terms, to ascertain what laboratory observations are needed, etc.

In the far infra-red precise wave-lengths are lacking. The recent observations of the solar spectrum beyond 15,000 A., reported by the solar workers at the University of Michigan, can be interpreted only with the aid of predicted wave-lengths compiled from term lists of spectra whose lines are likely to be present. The solar wave-length scale beyond 15,000 A. is based chiefly on identifications of Fe I lines whose wave-lengths may be calculated from the differences of atomic energy levels, often fixed by the secondary and tertiary standards of wave-length. Important multiplets are, for example, the combinations of $e\,^5D$ with $u\,^5F°$ and $t\,^5D°$, involving the configurations $3\,d^6\,4\,s\,(a\,^6D)\,5\,s$ and $3\,d^6\,4\,s\,(a\,^6D)\,5\,p$, respectively. Identifications of other elements can be made in a similar manner.

Preliminary multiplet lists of laboratory data and predicted estimates of solar intensities of lines expected to be present in the solar spectrum between 2200 and 3000 A. have been prepared for use in the interpretation of recent rocket solar spectrograms (*Phys. Rev.* **71**, 827, 1947). Because these spectra have a dispersion of approximately 44 A./mm. and low resolution, blending is serious. Consequently, only conspicuous lines whose identity is unquestionable can be used to establish the solar wave-length scale and laboratory wave-lengths suffice. Notable features of the rocket spectra are:

Mg I	2852·120 A.	Mg II	2795·523 A., 2802·698 A.
Si I	2881·595 A.	Fe I	2700–2850 A.
Fe II	2382–2410 A.		

In anticipation of future developments in this field of rocket research, an ultra-violet extension to the Revised Multiplet Table (*Contr. Princeton Univ. Obs.* No. 20, 1945) is being compiled. This is discussed further in the report of Commission 12.

IV. Intensity Tables

Observational and theoretical quantitative data on the intensities (i.e. transition probabilities, or f-values) of lines in atomic spectra are extremely meagre and inhomogeneous compared with those available on wave-lengths and term analysis. The basic reason for this situation appears to be that a large part of the spectroscopic data, including intensities, now available to astronomers has been obtained by physicists whose main purpose was the elucidation of the extra-nuclear structure of atoms and ions. After physicists had verified certain general theoretical laws for line intensities by precise measurement of a few typical examples, qualitative intensity estimates were usually sufficient for their purposes. This is not so for the astronomer, who is finding an increasing need for extensive quantitative data on relative and absolute transition probabilities of spectral lines to aid him in the precise determination of abundances, temperatures, and other detailed features of stellar atmospheres. Moreover, at the present time, he is faced with the fact that many physicists have in recent years turned their attention from spectroscopy to other fields. As a consequence, astronomers can expect little additional spectroscopic material, including intensity data, to be supplied by physicists. If the present scanty supply of data is to be materially increased, the initiative in stimulating research in intensities must be assumed by astronomers themselves.

It was against this background that the International Astronomical Union, in 1946, formed a new sub-commission on 'Intensity Tables' under Commission 14. The original membership of the new sub-commission felt that it should have two main objectives:

(*a*) To encourage and co-ordinate quantitative work on the line intensity problems of importance to astrophysics.

(*b*) To collect and compile available intensity data for the purpose of eventual publication in a form useful to astrophysicists.

Transition probabilities, or f-values, may be derived from three main sources:

(i) Laboratory investigations.

(ii) Theoretical investigations.

(iii) Astrophysical observations.

The source from which the desired data may be best derived will depend upon the individual case. For example, spectra of atoms in high states of ionization are relatively simple, yet they are very difficult if not impossible to excite in the laboratory under conditions suitable for the measurement of transition probabilities. In such cases theoretical attack may be practicable. On the other hand, many complex spectra of neutral and singly ionized atoms are so complicated and terms so perturbed as to discourage theoretical approach. Many such spectra, however, are readily obtained in the laboratory in arcs or furnaces under known and controllable conditions of excitation and the transition probabilities of the lines may be measured by well-established methods. In some cases, where laboratory or theoretical attack is impracticable, the spectra of certain stellar atmospheres, when suitably calibrated, may be the best available sources of material for transition probabilities.

The inclusion of intensities from astrophysical sources in the scope of activities of the sub-commission appears natural, but this overlaps certain phases of the programmes of Commissions 12 and 36. This question was taken up by the president of Commission 14 with the presidents of Commissions 12 and 36. It was agreed that the compilation of tables of transition probabilities in atomic spectra logically belongs to the new sub-commission on Intensity Tables of Commission 14.

The quantitative measurement or calculation of transition probabilities is difficult and laborious. Many factors which may introduce systematic errors in the results are involved, and, in comparison with measurement of wave-length, accidental errors are large. Also, on the experimental side, the established methods of excitation are limited in their applicability. Consequently, much work still needs to be done in developing new and improving old methods by which the range and variety of spectra that may be excited under known conditions (e.g. thermodynamic equilibrium) can be extended. Likewise, new methods of recording should be developed in order to speed up the measurement of intensities. Reliable auxiliary data, such as vapour pressures, are badly needed to permit the determination of absolute transition probabilities. At the present time, the existence of such data for elements of particular astrophysical importance is purely a matter of chance.

Considering the magnitude of the problems involved, and the small number of active workers in the field, it must be realized that the accumulation of quantitative intensity data will be slow. It is the hope of the sub-commission that it may be able to stimulate interest in the work from the point of view of astrophysics, to increase the output, and eventually to accomplish its objective of providing comprehensive tables of quantitative line-intensities for the use of astrophysicists.

W. F. Meggers
President of the Commission

Report of meeting

President: Dr W. F. Meggers.

Secretary: Mrs Dr Charlotte Moore-Sitterly.

The business meeting of Commission 14 was attended by the following members: Allen, Edlén, Meggers, Menzel, Minnaert, Mrs Moore-Sitterly and Swings, and by guests Miss Adam, Danjon, Goldberg, Mrs Herman, Lyot, Mohler, Miss Oterma.

A visible quantity of an artificial chemical element was exhibited at this meeting of Commission 14 when Dr Meggers presented to Dr Danjon an electrodeless lamp containing 3 mg. of pure Hg^{198} obtained from neutron bombardment of pure Au^{197}. Dr Danjon was requested to deliver to Dr Pérard, Director of the International Bureau of Weights and Measures in Sèvres, France, this gift from the National Bureau of Standards in Washington, D.C. On August 3, Dr Meggers, *en route* to this meeting, presented a similar lamp to Sir C. I. Darwin, Director of the National Physical Laboratory in Teddington, England.

Dr Meggers remarked that the red radiation from cadmium, adopted in 1907 as the primary standard of wave-length, still appears to be the best length standard provided by nature. However, the great improvement in homogeneity of spectral lines emitted by a single even isotope of mercury and the unique advantages of mercury lamps and lines for metrology indicate that Hg^{198} will inevitably replace Cd as a source of the primary

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standard. Furthermore, it is now clear that no other chemical element, natural or artificial, can compete with an even isotope of mercury in applications of interferometry to length measurements. It, therefore, seems certain that a wave-length characteristic of Hg^{198} must logically be accepted as the ultimate standard of length. Because this matter belongs primarily to metrology, and because final values of the wave-lengths to be assigned to Hg^{198} lines are not yet available, no recommendations were made. After the International Conference on Weights and Measures has considered this matter and taken final action it will be proper for this Commission to recommend that the I.A.U. adopt a new primary standard of wave-length.

Dr Meggers called attention to new observations of long-wave iron and neon lines by Burns, but since no wave-length can become a secondary standard unless three accordant, independent measurements exist, an extension of our system of standards rests on a third observer. He also stated that Harrison's 'Winmac' machine promises to excel previous measurements in quality as well as in quantity, and emphasized the need of interferometric standards at the extremes of the solar spectrum, that is, shorter than 3700 A. and longer than 9900 A., in which regions tentative standards derived from overlapping spectral orders, or from atomic energy levels, are being used. Mohler suggested that the PbS photo-cell could be applied to extend interferometer measurements beyond the photographic limit in the infra-red.

14. *Report of meeting of Sub-Commission on Tables of Intensities*

President: Dr R. B. King.

Although Dr King was unable to attend this meeting, he suggested, in a letter, two main topics for discussion by those present:

(1) *Notation and nomenclature, including definitions and relationships of such terms* as f-value, line-strength, transition probability, and intensity.

(2) The need of a critical bibliography of published material on both theoretical and experimental intensities, and on methods used in making quantitative measurements of line intensities.

Meggers called attention to the fact that these topics are treated in some detail in the report of Commission 36 (p. 369) and suggested a division of labour that will avoid duplication. Minnaert stated that a bibliography is not sufficient, the greatest present need being a compilation of existing f-values. Goldberg suggested that a list of lines of astrophysical importance be prepared as a guide for further determinations of f-values. It was agreed that the main task of this sub-commission will be the preparation of tables of f-values of spectral lines.