MINOR CONTRIBUTIONS AND NOTES

WAVE-LENGTH DETERMINATIONS AND GENERAL RESULTS OBTAINED FROM A DETAILED EXAMINATION OF SPECTRA PHOTOGRAPHED AT THE SOLAR ECLIPSE OF JANUARY 22, 1898.[1]

IN this paper the results are given of a detailed study and measurement of a series of spectra photographed at the eclipse of 1898, with a glass prismatic camera of 2¼ inches aperture. Ten exposures were made, all yielding good negatives, in which the great extension in the ultra-violet is a marked feature.

The first two photographs of the series were exposed at 20 seconds and 10 seconds before totality respectively, and are images of the cusp spectrum. They show the Fraunhofer lines with great distinctness, although the latter are much less dark than in the ordinary solar spectrum. The lines were measured and identified for the purpose of facilitating the reduction of the bright line spectra obtained during totality.

Spectrum No. 3 was exposed for four seconds, beginning two seconds before second contact. In this the flash spectrum is fully developed, and extends from λ 3340 to λ 6000. The majority of the bright arcs, including those due to the upper chromosphere, extend over 40° of the limb, implying a depth of 1″.3 for the gases composing this layer. The total depth of the chromosphere deduced from the hydrogen arcs is 8″.2, and from the calcium arcs 11″.6. There are 313 measurable lines in this negative, and the wave-lengths and identifications of these are given in Table I.

Spectrum No. 4, exposed for half a second shortly after second contact, gives the spectrum of the upper chromosphere and prominences. Seven of the latter are shown. The images are about equally dense in calcium radiations, although in hydrogen there is a marked variation of intensity between the different prominences.

[1] Abstract. Read before the Royal Society on January 17, 1901.

A conspicuous feature in the spectrum of two of the prominences is a band of continuous spectrum, beginning at λ 3668 near the end of the hydrogen series, and extending indefinitely in the ultra violet.

Good measures were obtained of the images of a small prominence at the center of the plate, the wave-lengths being given in Table II.

Spectrum No. 5.—This plate had a long exposure near mid-totality. The continuons spectrum of the corona is strongly marked, and the green corona line is well shown at position angles 60° to 78°, and 95° to 105°. A new corona line is faintly impressed at λ 3388 ±, the maxima of intensity being at the same position angles as those of the green line.

Spectrum No. 7 shows the reappearing arcs of the flash spectrum, the exposure ending about four seconds before third contact. The green corona line is shown on both east and west limbs, and there is a faint corona line near H. The wave-length values of the lines measured on this plate are given in Table I.

Spectrum No. 8.—This was exposed almost at the instant of third contact, the reappearing photosphere showing as four narrow bands of continuous spectrum due to Baily's beads. The flash spectrum arcs extend between and across the bands, and can be traced over an arc of 55°, the depth of the layer, in this case exceeding 2″.

The focus in this negative is poor, and no measures were made; but as far as can be judged, comparing this plate and No. 3, the spectra of the east and west limbs of the Sun are identical.

Spectra Nos. 9 and 10.—These are cusp spectra, very similar to Nos. 1 and 2.

GENERAL RESULTS AND CONCLUSIONS.

The flash spectrum.—Comparing the wave-length values of the flash spectra given in Table I with Rowland's wave-lengths of the solar lines, it is at once evident that practically all the strong dark solar lines are present in the flash as bright lines; and all the bright lines in the flash, excepting hydrogen and helium, coincide with dark lines having an intensity greater than three on Rowland's scale.

The relative intensities of the lines in the two spectra are, however, widely different, many conspicuous flash lines coinciding with weak solar lines, and some of the strong solar lines being represented by weak lines in the flash spectrum.

This, however, applies only to the spectrum taken as a whole. Selecting the lines of any one element, it is found that the relative intensities in the flash spectrum agree closely with those of the same element in the solar spectrum. This is particularly well shown in the case of the elements iron and titanium.

The want of agreement in the relative intensities of the lines of different elements in the bright line and dark line spectra is probably due to the unequal heights to which the various elements ascend in the chromosphere, a low-lying gas of great density giving strong absorption lines, but weak emission lines, on account of the excessively small angular width of the radiating area.

The more extensively diffused gases of small density, on the other hand, give strong emission lines in the flash spectrum, and weak absorption lines.

The spectrum arcs obtained with a prismatic camera are not true images of the strata producing them, but *diffraction* images more or less enlarged by photographic irradiation. Monochromatic radiations from a layer 2″ in depth will produce arcs or "lines" which are as narrow as can be defined by instruments of ordinary resolving power.

The intensities of these images do not represent the intrinsic intensities of the bright lines of the different elements; the apparent intensity of the radiation from an element depending on the extent of diffusion of that element above the photosphere.

But in the dark line spectrum the intensities depend on the total quantity of each absorbing gas above the photosphere irrespective of the state of diffusion of the different elements.

The flash spectrum as a whole appears from these results to represent the upper, more extensively diffused portion of a stratum of gas, which, by its absorption, gives the Fraunhofer spectrum.

Fifteen elements are recognized with certainty in the flash spectrum (No. 3), and five are doubtfully present. The atomic weights of these elements in no case exceed 91. All the known metals having atomic weights between 20 and 60 seem to be present in the lower chromosphere, but among these there does not seem to be any relation between the atomic weights and the elevations to which the gases ascend in the chromosphere.

The only non-metals found are *H*, *He*, *C*, and possibly *Si*.

Of the 225 lines measured in the ultra-violet region of the spectrum only 29 remain unidentified.

The hydrogen spectrum.—Twenty-eight hydrogen lines are shown in spectrum No. 3. The wave-lengths obtained are compared in Table III with the theoretical values derived from Balmer's formula. With the exception of $H\delta$, which seems to be unaccountably displaced towards the red, the wave-lengths of the ultra-violet lines are found to agree closely with the formula. A slight deviation occurs in the most refrangible lines, the positions of which seem to be distinctly more refrangible than those assigned by theory.

The continuous spectrum given by the prominences in the ultra-violet, beginning at the end of the hydrogen series, seems analogous to a feature noticed by Sir William Huggins in the absorption spectra of first type stars, and is possibly due to hydrogen.

Hydrogen and helium in the lower chromosphere.—From the character of some of the helium lines it is inferred that this element is probably absent from the lowest strata, whilst parhelium appears to be separated from helium, and to exist at a lower level.

Unlike helium, hydrogen gives very intense lines in the flash layer. These lines are well defined and narrow, even in the very lowest strata.

Reasons are given to show that the absence of hydrogen absorption in the ultra-violet, and of helium absorption in the visible spectrum, may be due to insufficient quantity of these elements above the photosphere, not to equality of temperature between the radiating gas and photospheric background.

The corona spectrum.—The wave-length of the green line deduced from measures of No. 3 and No. 7 spectra confirms the value obtained by Sir Norman Lockyer at the same eclipse. The only other lines shown on these photographs are at λ 3388 and near H.

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