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COMMUNICATION FROM THE OBSERVATORY AT LEIDEN.

Additional note on the continuous spectrum of the corona, by *J. Woltjer Jr.*

1. Some time ago I developed the intensity-distribution in the continuous spectrum of the corona to be expected on the hypothesis of scattering by free electrons *). Two sources of discrepancy between the coronal spectrum and the mean solar spectrum were examined. The fact that the scattered light was derived from different parts of the solar surface appeared to give rise only to inappreciable deviations. However the dependency of the coefficient of scattering on the frequency of the scattered light caused an excess of infra-red radiation in the coronal spectrum. This last conclusion was somewhat hypothetical as PAULI's frequency-law for the number of "collisions" between lightquanta and electrons had been tentatively used for non-isotropic radiation. A letter from Mr. P. A. M. DIRAC now has drawn my attention to the fact that the way in which PAULI's frequency-law has to be used for non-isotropic radiation is perfectly unambiguously involved in the formula for isotropic radiation, which asserts that the number of "collisions" is proportional to

$$\rho_\nu + \frac{c^3}{8\pi\, h\, \nu_1^3}\rho\, \rho_{\nu_1}. \qquad (1)$$

Indeed, stimulation of the process of scattering by light of frequency ν_1 is only possible by quanta moving in the same direction as the scattered radiation that has the frequency ν_1, for if the stimulating radiation moved in any other direction a change of frame of reference would destroy the frequency-relation with the scattered radiation.

Hence formula (1) may be used generally if we take for ρ_{ν_1} the radiation density that would exist if the radiation were isotropic corresponding to the intensity of the radiation actually moving in the direction of the scattered rays.

Consequently in the application to the corona it appears that the excess of infra-red radiation is only scattered in directions that prolonged backwards pass through the solar body; in these directions the excess is even larger than computed in my former note. However, coronal light moving in these directions is inaccessible to observation as the corresponding parts of the corona necessarily are seen projected on the solar disc. In other directions the stimulating influence is wholly absent.

Thus the conclusion of my former paper must be modified: the coronal light accessible to observation has the same spectral distribution of intensity as mean sunlight within the errors of observation, if scattered by free electrons.

*) *B. A. N.* 94.

2. ANDERSON *) recently has assumed a rather considerable amount of temperature radiation to be emitted by the free electrons of the corona. A simple calculation however shows this amount to be quite negligible.

If an encounter takes place between two electrons the amount of energy radiated may be calculated according to the classical theory of electrons. The corresponding formulae have been used by EDDINGTON**) in his treatment of the absorption-coefficient inside a star. By his formulas the emission of a unit volume of free electrons per unit of time appears to be equal to:

$$\frac{2\pi}{3}\frac{N^2 e^4}{m_e^2 c^3} k\, T; \qquad (2)$$

N is the number of free electrons per unit volume; m_e is the mass of an electron; T the temperature of the corona; e, k and c have their usual meaning.

The amount of energy scattered by a unit of volume per unit of time equals a fraction of the density of incident radiation:

$$\frac{8\pi}{3}\frac{N e^4}{m_e^2 c^3}. \qquad (3)$$

The radiation density is approximately equal to

$$\frac{F}{c} \qquad (4)$$

*) *Zeitschrift für Physik*, 37, p. 342 etc.

**) A. S. EDDINGTON, *M. N.* 84, p. 118.

F being the net flux of energy per unit area; this quantity F is equal to

$$\sigma T_e^4 \tag{5}$$

T_e being the effective temperature of the sun and σ the well-known radiation constant.

An estimation of N may be obtained in this way: PETTIT and NICHOLSON have determined the total radiation of the corona at the eclipse of January 24, 1925 *); they found this quantity equal to

$$11.2 \times 10^{-7}. \tag{6}$$

in terms of sunlight; one half of the light of the corona appeared to come from a zone extending only 3′ from the limb of the sun. Thus we may roughly consider one half of the coronal light to be furnished by a cylindrical shell co-axial with the line Sun-Earth and bounded by two cylinders with radius r_0 (the solar radius) and $1.2\, r_0$ and two planes distant $1.2\, r_0$ from the solar centre. The volume of this shell is:

$$0.44\, \pi\, r_0^2 \times 2.4\, r_0 = 3.3\, r_0^3. \tag{7}$$

Hence if the whole amount of coronal light consists of radiation scattered by the free electrons we have:

*) *Astroph. J.* 62, p. 202 etc.

$$\frac{2}{4\pi} \times \frac{8\pi}{3} \frac{N e^4}{m_e^2\, c^4}\, 3.3\, r_0 = 11.2 \times 10^{-7} \tag{8}$$

corresponding to

$$N = 4.7 \times 10^7 \text{ per cm}^3 \tag{9}$$

The ratio of thermal emission to scattered radiation is equal to the ratio of (2) to (3) × (4), hence equals:

$$\frac{N}{4} \frac{k\, c\, T}{\sigma\, T_e^4}. \tag{10}$$

For the purpose of this computation we may identify T with T_e, then the numerical value of (10) is equal to:

$$0.89\, N \times 10^{-13}; \tag{10^a}$$

substituting from (9) we get:

$$4.2 \times 10^{-6} \tag{10^b}$$

The adoption of thermal equilibrium for the computation of the relative velocities of the electrons involved in (2) is very doubtful; however only the order of magnitude of (10) is of interest; so the emission of the free electrons seems quite negligible.

It may be remarked that the foregoing computation does not include emission caused by encounters between the free electrons and the positive ions.