Putting $h\nu/kT=x$, the required quantity is given by

$$\int_{\nu}^{\infty} E_{\nu}d\nu=8\pi^2R^2.\frac{k^4}{h^3c^2}.\ T^4.\int_{x_0}^{\infty}\frac{x^3dx}{e^x-1},$$

where $x_0=h\nu_0/kT$; ν_0 is a certain minimum frequency. The total energy E_0 radiated by the sun is obtained by putting $x_0=0$. In this case, the integral $=\pi^4/15=6{\cdot}494$. Let us denote by I_2 the integral

$$I_2=\int_{x_0}^{\infty}\frac{x^3dx}{e^x-1}.$$

We have then

$$\frac{E}{E_0}=\frac{I_2}{6{\cdot}494}.$$

The values of I_2 have been calculated and tabulated by Zanstra, and are shown in Table 8.

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59. SPECTRA OF COMETS

(*Sci. & Cult.*, **1**, 476, 1936)

In a recent discussion on the ionosphere held under the auspices of the National Institute of Sciences, India, the writer of this note expressed the view that the ionization of the upper atmosphere and the spectrum of the night sky can be best explained if we suppose that the sun does not radiate like a black body in the ultraviolet, but sends out strong ultraviolet emission lines which can be identified with the resonance and other strong ultraviolet lines of He, He^+, H, O.. etc. Two lines of argument were cited in favour of this view; (1) that Slipher has established that the spectrum of the morning or evening flash gives strongly the band-spectrum of N^+_2, even on days perfectly free from Aurora; (2) that the equilibrium of ozone formation requires that the number of quanta emitted between 3000 A° and 2200 A° must be as great as that between 2000 A° and 1300 A°.

Recently further corroboration of this view has been obtained in the spectra of comets. It is well known that when comets are very far from the sun, they appear like a faint star (called the *nucleus*) which becomes enveloped in a kind of mist (*coma*) as the comet approaches the sun. With further approach to the sun, the comet develops a tail *i.e.* a long appendage which is held to consist of molecules repelled from the nucleus by the action of pressure of sunlight. With these characteristic changes in the appearance of the comet, it is observed that the spectrum also changes, the nucleus at a distance shows a continuous spectrum crossed with Fraunhofer lines showing that the comet consists of meteorites and the continuous spectrum is due to reflection of sunlight from these. When the comet approaches closer, the meteorites get heated and evolve gas. The spectrum of the coma shows emission bands due to CN, C_2 (Swanbands) CH (doubtful). Zanstra thinks that these emission bands are due to absorption of sunlight by the vapour in the coma and subsequent re-emission just as in his well-known theory of nebular luminosity. The tail shows lines due to ionized CO^+, and ionized N^+_2 (second negative bands).

The excitation potential of the N^+_2 band has been definitely proved to be 21·10 and that of CO^+ bands (comet tail bands) is *ca* 17 e.volts. It is clear (for further details, reference may be made to the author's forthcoming paper in the *Proc. Nat. Inst. Sci.*) that if we regard that sun radiates like a black body at a temperature of 6000°K, there is not sufficient number of ultraviolet quanta of the proper frequency which can produce the observed ionization of the cometary gases N_2 and CO. In fact, it was shown that most probably the resonance line of He are responsible for the ionization of N_2 to N^+_2 (excited) in the upper atmosphere. The same can be said of the cometary phenomenon. The observed ionization of N_2 to N^+_2 in the comet tail and that of CO to CO^+ may be supposed to be due to the ultraviolet emission lines of He and other elements from the sun.

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4.12.1935

60. CAN ELECTRONS ENTER THE NUCLEUS

(*Sci. & Cult.*, **2**, 273, 1936)

A number of experiments have been performed of late to find out whether high energy electrons can be made to enter the nucleus, but with no definite result. The maximum potential so far applied has been 800 K Volts (See *Phys. Rev*, 1935). The failure of these experiments is not difficult to understand, as the de-Broglie wavelength is nearly 100 times larger than the diameter of the nucleus.

But from these experiments, it is not safe to assume that the electron can never enter the nucleus. In fact, the uncertainty principle enables us to find out the energy which the electron must have in order that it may enter the nucleus: if we wish to accommodate a particle in a space of dimension 'l', the uncertainty in its momentum is given by

$$\Delta p \text{ nearly } = \frac{h}{l}.$$

Putting $l=a\,10^{-13}$ cm (dimension of the nucleus) we have Δp

$$\text{nearly} = \frac{h}{a\,10^{-13}}$$

$$\text{nearly} = \frac{6{\cdot}54}{a}\,10^{-14}\text{ gm}\times\text{cm}.$$

Now $\Delta p < < p < < mc$, where m is the relativity-mass of the electron. We have therefore

$$mc > > \frac{6{\cdot}54}{a}\,10^{-14}\text{ gm}\times\text{cm or } \frac{m}{m_0} > > \frac{2{\cdot}4}{a}\,10^3.$$

Taking a nearly $=2{\cdot}4$ (diameter of the N-nucleus), we find that electrons can enter the nucleus if

$$\frac{m}{m_0}\text{ nearly}=10^4,$$

i.e, the energy is nearly 5×10^9 e volts. Now electrons of such high velocity are found in cosmic rays and it can be easily shown that in course of their passage through the atmosphere a good fraction of them must suffer nuclear collisions. The number of such collisions can be easily calculated. It is given by

$$\pi\ a^2\ (10^{-13})^2\times2{\cdot}8\times10^9\times z=1{\cdot}8\times10^{-6}z,$$

where z is the equivalent height of the atmosphere through which the electron has passed. Even at a height of 30 Km, the electron, at vertical coincidence, has passed through 65 meters of air, *i.e.*, suffered $1{\cdot}17\times10^{-2}$ nuclear collisions *i.e.*, one electron in a hundred suffers a nuclear collision—on the sea level, the number of nuclear collisions would be about 1·5, *i.e.*, even at a height where the pressure is $\frac{2}{3}$ the atmospheric pressure (5 kms), the primary electron must have passed through the nucleus. This incident cannot be without influence on the general cosmic ray phenomenon.

The effect of the entry on the nucleus would probably be to explode the nucleus, and give rise to secondaries.

15.8.1936