Origins of the Zodiacal Light

I REFER to an important paper[1] by Prof. H. P. Robertson of Princeton, tracing out the effects of the Poynting principle of suction of fine orbital dust or gas into the sun or other strongly radiating star. It concerns me directly as in an amendment of the numerical factor for the reprint in Poynting's "Collected Papers" I inadvertently doubled the final value by adding the effects in the two frames of reference, that of the sun and that of the orbital particle, instead of taking them as alternative.

There could not be a permanent zodiacal light at all unless the particles that deflect it were sustained against falling into the sun, and that could only be by an orbital motion of planetary type for each particle, whose centrifugal influence holds it up against gravitation to the sun. The perhaps unexpected result is here involved that the rather thick disk around the sun, extending beyond the earth's orbit, which shines permanently throughout astronomical times, must be a residue of the original whirling solar nebula, which its presence indeed goes far to establish: for it can scarcely be conceived as formed by ejection of particles nearly tangentially from the sun's surface. Perhaps this arresting conclusion may not really be unfamiliar: Poynting had possibly known of it. The radiation incident from the sun exerts according to his principle a dynamical retardation which gradually converges each orbit spirally into the sun in a time not great on the astronomical scale, provided, however, the particles are not large compared with the wave-length of the radiation. This gradual subsidence demands a renewal from outside, in a steady stream, which is more rapid and so less dense for the smaller particles or gaseous atoms and ions. The particles must not collide as in a gas, else all would be broken up soon, and the gas ultimately sustained otherwise as a close-fitting atmosphere in Maxwellian manner.

Thus we are led to contemplate a nebula surrounding the sun, which has now become of the type of the rings of Saturn, but enormously less close packed. This favouring paucity of collisions is reasonable if only on account of the extreme tenuity of the distribution, like that in a comet's tail, the mean distances of neighbouring particles being comparable with miles. The mode of slow subsidence of a gaseous rotating nebula of this non-colliding type would perhaps be an interesting subject for mathematical analysis after the manner of the Saturn ring theory, conceivably even connecting up with a distribution of atoms not entirely negligible throughout the depths of space.

The immediate cause of this note is, however, a recent announcement from the MacDonald Observatory in Texas by C. T. Elvey and P. Rudnick[2] that the zodiacal light is ordinary reflected sunlight and shows no sensible proportion of a Stokes-Rayleigh scattering such as produces the blue sky. This shows, as they remark, that the particles which mainly deflect it have dimensions of the order of several wave-lengths at least. We note here in confirmation that by the Poynting analysis, smaller particles would, as *supra*, be sucked into the sun far more rapidly and be gradually winnowed out, more rapidly the nearer the sun, and therefore for given influx from beyond the replenishing stream would have far smaller density: the distribution of the larger particles would, in fact, require little replenishment, but could scarcely extend out indefinitely.

Diffuse nebulæ are held likewise to shine by illumination from blazing stars located in front of them, because they send the same kind of light; but for them the sideway scattered bluer light would have little chance of being important. No inference as to size of particles in these nebula would thus arise. This perhaps clears up the general question of colour in nebular cosmogony. The inference from colour as regards the zodiacal light would likewise be vitiated if the effective length of the source that is in the line of sight is large compared with distance of that line from the sun, which may be not improbable. But however that be, the Poynting dynamical train of reasoning here presented for the solar nebula would remain firm.

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[1] *Mon. Not. Roy. Astro. Soc.*, **97**, 423–38 (1937).

[2] *Astrophys. J.*, Oct. 1937, as quoted in *Science Abstracts*, Dec. 1937.

The Liquid State of the Primitive Earth

IT has often been suggested that the earth must have been in a liquid state at an epoch near the very beginning of its formation. I wish to give an argument which confirms this view. If we suppose that the earth was originally in a gaseous state, we can imagine a model, which we call the globe, defined as a polytropic gas sphere of mass 6×10^{27} gm., equal to the present mass of the earth. Assuming (following Jeffreys) that the central temperature must have been equal to the effective temperature of the sun at the time of formation, that is, about 6000° K., and considering the polytropic indices $n = 3$, 1 or $\frac{1}{2}$, one finds a radius of $2 \cdot 2 \times 10^{10}$, $1 \cdot 28 \times 10^{10}$ or $1 \cdot 24 \times 10^{10}$ cm. The smaller values of n correspond to a lower compressibility than is generally assumed for the stars (Eddington). The values of the density are such that the material of the globe is very nearly a perfect gas. The pressure and temperature in the globe can then be calculated from Emden's tables, as functions of the distance from the centre.

On the other hand, by means of the Clapeyron-Clausius law, one can estimate the boiling temperature of the metallic vapours as a function of the pressure, and consequently as a function of the distance from the centre in the globe.

If the polytropic temperature and the boiling temperature of iron (the most abundant metal) are plotted against this distance, it is found that in a thick outer layer of the globe, the conditions are such that the iron must condense into liquid metal and consequently precipitate in drops towards the centre. Any other reasonable choice of the characteristics of the globe such as would give a good model of the earth leads to the same conclusion. This condensation may be considered as spontaneous. The thickness of the layer is about $\frac{3}{4}$ of the radius of the globe for $n = 3$, and about $\frac{1}{2}$ for $n = 1$ and $n = \frac{1}{2}$.

This conclusion provides an explanation of the occurrence of the iron core which is generally regarded as occupying the centre of the earth.

A full account of this theory will appear shortly in the *Archives des Sciences physiques et naturelles*.

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