## Parasitism of *Striga* sp. on *Dolichos Lablab* Linn.

WHILE studying the possibility of germinating the seed of *Striga hermonthica* Benth. by means other than the excretions of the roots of gramineous plants it was found that excretions from the roots of many leguminous plants would also cause germination. Among these leguminous plants was Dolichos bean (*Dolichos Lablab* Linn.).

Experiments were therefore begun to discover if the growing of Dolichos bean in *Striga*-infested soil would rid the soil of the seed of this pest. It was found, however, that *Striga hermonthica* could parasitize the Dolichos bean with a consequent loss of crop.

In a pot experiment (fifteen replicates) in which Dolichos bean was sown in soil with and without *Striga* seed the results shown in Table 1 were obtained.

TABLE 1. MEAN DRY WEIGHT OF DOLICHOS BEAN.

| Soil type | Leaf weight in gm. | Root weight in gm. |
|---|---|---|
| Without *Striga* seed | 14·3 | 1·93 |
| With *Striga* seed | 8·1 | 1·75 |
| Percentage loss due to *Striga* | 43·3 | 9·1 |

The difference in leaf weight is very significant: that between root weight is not significant.

A second pot experiment (fifteen replicates) designed as the first experiment except that larger pots were used gave results shown in Table 2.

TABLE 2. MEAN DRY WEIGHT OF DOLICHOS BEAN.

| Soil type | Leaf weight in gm. | Root weight in gm. |
|---|---|---|
| Without *Striga* seed | 36·6 | 9·3 |
| With *Striga* seed | 13·6 | 5·3 |
| Percentage loss due to *Striga* | 62·4 | 43·0 |

The difference between leaf weight and root weight in the two series is very significant.

The difference in percentage loss due to *Striga* in the two experiments is probably due to the larger pots used in the second experiment, and to the fact that the experiments were started at different times of the year, the first experiment being sown in December and the second in September when better growth of the *Dolichos* was obtained.

The *Striga* plants on the roots of the *Dolichos* were small and appeared ill-nourished. When the experiments were ended (about three months after the sowing date) very few *Striga* plants had appeared about 1 cm. above ground, in contrast to the luxurious aerial growth that this parasite makes in that time on *Sorghum* spp.

It is hoped shortly to publish the full results of these experiments.

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## Planck's Radiation Formula Derived without Atomicity

IN a recent paper[1] I expressed the fourth-power law of temperature radiation in a form analogous to the relativity expression of the laws of motion, so that the implication of unobservable absolute radiation was eliminated. In this expression temperature was measured by the rate of reception by a specified instrument of a quantity $d\eta$, corresponding to what is usually called entropy, time being measured on a thermal time-scale in which equal times correspond to equal receptions of $\eta$ by a standard 'thermal clock'. It then appeared that what is usually regarded as the 'absolute entropy' radiated (that is, $a\theta^4/\theta$), which was denoted by $d\sigma$, was invariant under changes of temperature of the $\eta$-measuring instrument and thermal clock according to transformation equations which were derived.

If we now add the postulate, guaranteed by experience, that radiation is associated with a continuous range of frequencies, its distribution among which varies with temperature, it follows that the quantity $d\sigma$ measured in unit thermal time must be expressed by a function $f(\tau,\nu)$ ($\tau$ is temperature on proposed scale; $\nu$ is frequency according to the thermal time-scale) which is invariant under the transformation referred to, and that this condition may serve to determine the function. The condition leads to the relation

$$\int_0^\infty f(\psi\,;\,\nu)d\nu = \int_0^\infty f(\psi\psi_1^{-1}\,;\,\nu\psi_1^{-3/4})d\nu,$$

where $\psi = 1 + \tau/\zeta$, $\psi_1 = 1 + \tau_1/\zeta$ in the notation of the paper referred to, $\psi_1$ corresponding to the temperature of the arbitrary 'co-ordinate system' to which the transformation is made; and the solution must satisfy this relation, be independent of $\psi_1$, must not be the product of independent functions of $\psi$ and $\nu$, and must make the integrals finite. The function $f(\psi\,;\,\nu) = A\nu^2$, corresponding to the Rayleigh–Jeans formula in the ordinary theory, does not meet these conditions, but the function

$$f(\psi\,;\,\nu) = \frac{A\nu^3\psi^{-1/4}}{\exp.\,B\nu\psi^{-1/4} - 1},$$

corresponding to the Planck formula, does so. I am not able to show that this solution is unique, but in view of the rather stringent conditions to be satisfied it seems likely that it is so. Integrating and equating the result to $d\sigma$ we find that $B^4 = 6{\cdot}495\,A.$, leaving one constant to be determined by experiment.

How far the theory can succeed in deriving results not yet known or fulfil its promise of a new thermodynamics expressed in relativistic instead of Newtonian terms remains to be seen. The immediate reaction on our understanding of physical conceptions, however, seems to me to be of considerable importance.

The Planck formula, which originally introduced the conception of the quantum and in view of which Poincaré, in the words of Jeans[2], "shows definitely and conclusively that the mere fact that the total radiation at a finite temperature is finite requires that the ultimate motion should be in some way discontinuous", is now derived with no appeal at all to any microscopic or discontinuous conceptions. The only postulates are the fourth-power law of radiation, the perfect gas equation, the periodic character of radiation, and the relativity principle that physical laws should be unaltered by changes having no absolute physical criterion. It is the last-named postulate that is omitted in the so-called 'classical' derivation of the energy-distribution law; the omission of the atomic character of radiation is a defect *only if the atomic character of matter is previously postulated*, but so far as the phenomenon of black-body radiation is concerned at least, the correct formula can be obtained without postulating any atomicity at all.

A revision of the customary view of the relation between macroscopic and microscopic laws would seem to be called for. The former are commonly regarded as the limit to which the latter approximate when the number of units concerned is very large, and therefore less fundamentally 'true'. The suggestion is now obvious that the macroscopic and microscopic laws are rather equally valid *alternative* expressions of observed relations, and that, as I have for long maintained on quite general grounds, the principle of indeterminacy, for example, is characteristic not of natural phenomena but of the particular terms of expression of phenomena which we have hitherto found it useful to adopt.

The result also, I think, confirms the view of time measurement in Einstein's relativity which I have previously put forward[3], according to which the 'time dilatation' would not necessarily characterize the readings of an actual clock unless that were an 'ideal' one (that is, a beam of light travelling along a space-measuring scale), and the intimate association of time with space has nothing to do with Nature but follows logically from the fact that we have chosen to *measure* time in terms of space measurement. In the new theory we measure time in terms of 'entropy', and so, in the same sense, time 'becomes' entropy. The change of frequency of radiation from the same body at the same Kelvin temperature, when measured in summer and winter, for example, is in the ratio of something like $(300/273)^3$ on the thermal scale, whereas on the conventional space scale it is nothing at all if the body does not move. It is impossible to reconcile this with the hypothesis of any 'absolute' change on either scale.

Details of the above work will appear shortly in the *Philosophical Magazine*.

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[1] *Phil. Mag.*, 35, 499 (1944).
[2] "Radiation and the Quantum Theory" (second ed.), 29.
[3] *Nature*, 144, 888 (1939); 146, 391 (1940).

## Geodesic Form of Schwarzschild's External Solution

THE line-elements usually appearing in relativistic cosmological studies are particular cases of the geodesic line-element[1],

$$ds^2 = d\tau^2 + \sum_{i=1}^{3}\sum_{j=1}^{3} g_{ij}dx^i dx^j, \quad . \quad . \quad . \quad (1)$$

$$g_{ij} = g_{ij}\,(x^1, x^2, x^3, \tau),$$

obtainable from the most general form by subjecting the co-ordinate system to the restrictions[2],

$$\Gamma^{\alpha}_{44} = 0, \quad \alpha = 1, 2, 3 \quad . \quad . \quad . \quad (2)$$

and then choosing $\tau$ suitably. The conditions (2) imply that the world-line $(x^1, x^2, x^3)$ is a geodesic . . . . (3)

If observers in a gravitational field are required to be on geodesics, the form (1) is therefore the most convenient from the observer's point of view. A particular case of (1) having spherical symmetry is

$$ds^2 = d\tau^2 - e^{\lambda}d\rho^2 - \rho^2 e^{\mu}\,(d\theta^2 + \sin^2\theta d\varphi^2), \quad . \quad (4)$$

where $\lambda = \lambda(\rho,\tau)$, $\mu = \mu(\rho,\tau)$.

The most general solution of the form (4) of the field equations,

$$G_{\mu\nu} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

is given by

$$e^{\lambda} = \left[\chi(\rho) + \frac{2\rho}{3}\frac{d}{d\rho}\chi(\rho)\right]\left[\chi(\rho) \pm \frac{3}{2}\frac{\sqrt{2m}\,\tau}{\rho^{3/2}}\right]^{-2/3},$$

$$e^{\mu} = \left[\chi(\rho) \pm \frac{3}{2}\frac{\sqrt{2m}\,\tau}{\rho^{3/2}}\right]^{4/3}, \quad . \quad . \quad . \quad (6)$$

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