

and then a physical standard (with the desired orientation and velocity) could be constructed 'similar' to a corresponding terrestrial standard; and the statements have no meaning unless we define the criterion of similarity. This is discussed rather fully in "The Philosophy of Physical Science" (pp. 73-85). It is concluded that the two standards must be constructed from a common specification; and the quantitative part of the specification must consist of *pure numbers* only, since it is required to precede the definition of length and all other physical quantities. This means that the specification must be a quantum specification; because it is only in quantum theory that a method has been developed of describing material structure by pure numbers—numbers of elementary particles the mutual arrangement of which is specified by quantum numbers. Thus appeal must be made to quantum theory for the definition of the interval ds , which is the starting-point of relativity theory.

Naturally the quantum theory must harmonize with relativity theory, and Dr. Swann is no doubt technically correct in saying that it must be relativistically invariant in form. But, as I have recently pointed out², this condition has been widely misunderstood and misapplied in quantum theory. It is often understood to mean that the equations should be Lorentz-invariant in form. But Lorentz invariance (or, more strictly, covariance) is no more than a special formula applicable when two systems, though considered in conjunction, are physically isolated—a condition rarely, if ever, arising in quantum problems. There is no more value in employing Lorentz-covariant equations in treating the internal structure of an atom or nucleus than in treating the internal structure of a star. 'Structural equations' are relativistically invariant as they stand, since they remain true whatever the motion of the body possessing the structure.

To come back to the original problem, if we suppose the fixed and moving rods to be calibrated by reference to the dimensions of hydrogen atoms sharing their respective motions, the rods will equally obey the Lorentz transformation whether the atoms are Dirac atoms or Schrödinger atoms. We have to go much more deeply into the general principles of relativity theory to obtain any useful guidance as to the form quantum theory must take.

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¹ "Mathematical Theory of Relativity", § 66, p. 152.

² *Proc. Camb. Phil. Soc.*, **35**, 186 (1939).

Physiology and Ecology of Cuticle Colour in Insects

THE interesting article in NATURE of October 11, p. 428, by Dr. Hans Kalmus requires comment upon a number of points, but first a protest must be entered against the use of the word 'frequently' in evidence for a 'rule'. Other vague statements might well be given more precise definition, such as 'pale' or 'dark'. The complications of pattern introduce great difficulties: Is an insect (non-lepidopterous, to fall in with Dr. Kalmus's excision of this group from most of the argument) with strongly contrasted areas of dark and light, conforming to the type of disruptive pro-

cryptic, or of aposematic, coloration, to be considered 'dark' or 'pale'? Dr. Kalmus's criteria would seem to be applicable only to unicolorous examples, or those of which the pattern gives a fairly uniform result, and thus must exclude immense numbers of insects.

The difficulties of applying Dr. Kalmus's 'rules' are great. For example, in the dry Ngamiland country of South Africa, I found large scavenging black Tenebrionid beetles running about in the hottest sun: equally large black and active predatory Carabids appear after dark, but another large predatory beetle, the black Cicindeline Manticora, hunts by day, as do a great number of its more brightly coloured relatives.

Among weevils, the hardness of many is proverbial, and experimental evidence by the late C. F. M. Swynnerton showed it to be decidedly of protective value. Yet some are 'pale', others 'dark'; some may be found freely exposed by day, others conceal themselves until night.

Among aquatic insects the Coleoptera might, on the whole, reasonably be classed as 'dark'. The much softer Hemiptera (Notonecta, Corixa, Naucoris) are 'pale', but the equally soft Nepa is very dark, or black. All may be found in the same pond. The explanation that dark cuticle is less easy to wet seems rather weak.

As regards the darkness of eggs, much more evidence is required. Contrast the dark eggs of the puss moth on willow leaves with the bright yellow eggs, on cabbage, of the cabbage white. The eggs of stick-insects (Phasmidæ) are notorious for their degree of cryptic resemblance to seeds in shape and colour: seeds are very often dark, and so are these eggs.

One would like to see figures in support of the statement that most non-black insects are found in the tropics: Are we to conclude that out of all non-black insects a majority occurs in the tropics, or that, of all insects in the tropics, a majority is non-black?

In connexion with the interesting point about liquid food, surely most aphids are not pale? One thinks of the black bean and dock aphids, and, at the moment, of a large bed of reed-mace, of which the leaves and stems are blackened with Aphis.

An interesting test of whether predators are darker than phytophagous species could be provided by a statistical study of two not widely separated families of Hemiptera—the predaceous Reduviidæ and the plant-sucking Coreidæ, which may be found side by side all over the world. Dr. Kalmus writes of the dark colour of the tse-tse fly. There are some twenty species of Glossina, and while some, such as *palpalis*, may be called 'dark', this term can scarcely be applied to *morsitans*. The former, inhabiting rain forest, can scarcely be said to be subject to the conditions of a dry region, while *morsitans*, in such a dry area as the Nuba mountains in southern Sudan, should be the darker species.

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I AM pleased that my article should have aroused the interest of such a well-known authority on adaptative coloration as Prof. G. D. Hale Carpenter. Before answering in detail, I should like to deal with his first general protest. He objects to the word "frequently" in formulating a rule and calls this a "vague" statement. It is interesting in this context to quote from a letter which I received from Dr. B. P. Uvarov, of the Imperial Institute of Entomology,