Although this may be inevitable in the case of a directly estimated quantity of the type here in question[2], it has the form and effect of a paradox, the influence of which upon the progress of colorimetry as a branch of physical science it will be an important problem to remove, if the underlying nature of colour is to be made clear and if colour as a physical concept is to preserve and maintain its true and proper signification in the fullest possible sense.

It may be mentioned that these considerations are not put forward with the object of indicating academic propositions without effect upon the practical development of the subject. They affect directly its practical development in a fundamental sense, and arise in a manner unusual in physical investigation merely because of the unusual types of quantities and magnitudes with which we have at present to deal in the physical investigation of colour.

J. W. PERRY.

Adam Hilger, Ltd.,
98 St. Pancras Way,
London, N.W.1.

[1] NATURE, 148, 506 (1941).
[2] *Proc. Phys. Soc.*, 53, 275 (1941).

Philosophy of Physical Science

THE recent discussion between Sir James Jeans and Sir Arthur Eddington [see NATURE of Oct. 25, p. 503 and earlier references], in so far as it involves the Fitzgerald-Lorentz contraction, prompts me to direct attention to an aspect of this matter which I presented recently before the American Physical Society Symposium on Philosophy and Science[1].

For many years I have maintained that the Michelson-Morley experiment has rather an illusory significance in relation to the theory of relativity and is, in fact, not fundamental to it[2]. There are, in fact, two aspects to the meaning of invariance under the Lorentzian transformation. The first, A, is a pure mathematical one and is concerned with the fact that if the equations are transformed from one set of variables to another by a Lorentzian transformation, they revert to the same form. The test of this is a pen and paper affair. The second aspect, B, implies all that is contained in the first and, in addition, the postulate that the second set of variables is that which an observer, moving with velocity v in relation to the origin of co-ordinates of the first system, would automatically use.

Suppose that in a system S I have a rod to which I impart a velocity v. In this process, all sorts of acoustical vibrations are set up. These die down in time, but how does the rod decide that it must settle down to a new length determined by the Fitzgerald-Lorentz contraction? The acoustical vibrations cannot be dismissed lightly, since they are part and parcel of the whole mechanism by which the rod received its motion. It seems that the quantum theory, if relativistically invariant in form, possesses the power to give the necessary answer.

According to the quantum theory, the form and stability of the rod at rest in S are determined by its being in a 'ground state'. Now if the equations are invariant in the sense A, we know that if we have, in S, one solution for, let us say, the Ψ function, satisfying the usual conditions of continuity, etc.; then associated with this solution we have an infinite number of other solutions obtainable from it by a Lorentzian transformation, and *these are all possible quantum states in the systems.* (It is quite true that on the aspect B any one of them would also be a quantum state in a system S' of measurements moving in relation to S with velocity v. I wish to make no use of this fact, however.) Any one of these states presents, of course, as one of its aspects, the picture of the rod moving along with a velocity which, measured in S, is equal to the value of v which occurs in the transformation, and the state can, therefore, by the quantum theory, be a possible state for such a rod. The ground state for the rod moving with velocity v is the state obtainable by a Lorentzian transformation from the ground state of the rod before the motion was imparted. It is, therefore, the state which the moving rod may be expected to assume unless the perturbation forces involved in the production of the motion are so large as to have produced the kind of quantum transitions of finite and, in general, large magnitudes which are associated with what we may call non-reversible changes in structure. In general, we may say that the kind of forces which are associated with the determination of structure are those characteristic of molecular affinity, and the quantum transitions necessary to produce non-reversible changes in structure are such quantum transitions as would be involved in molecular quantum transitions.

It thus appears that a relativistically invariant quantum theory, or something closely analogous to it, is a necessary supplement to the general principle of invariance of equations if we are to provide for the Fitzgerald-Lorentz contraction and for the customarily accepted form of the theory of relativity symbolized by what we have called the form B.

W. F. G. SWANN.

Bartol Research Foundation,
Franklin Institute,
Swarthmore, Pa.
Sept. 23.

[1] Held at Providence, R.I., June 21, 1941. The address and a special amplifying paper concerning the specific point in question are published in *Rev. Mod. Phys.*, 13, 190 and 197 (1941).
[2] Swann, W. F. G., *Phys. Rev.*, 35, 336 (1930); *Rev. Mod. Phys.*, 2, 243 (1930).

I HAVE terminated my correspondence on the philosophical controversy; but since Dr. Swann's letter deals with a purely scientific question regarding the relations of relativity theory and quantum theory, I venture to offer some remarks.

As Swann points out, the Lorentz transformation is no more than a mathematical change of variables unless it is coupled with a theory of the 'similarity' of the fixed and moving systems. I would remark, however, that the problem of similarity arises in physics at a much earlier stage, namely in defining a standard of length. Swann's question, how a rod decides its extension when it is given a different motion, is only part of the general question how it decides its extension when it is given a different location in space and time. Surely the answer is given by the law of gravitation, which definitely expresses the fact that the rod decides its extension by measuring itself against the local space-time curvature—that being the only linear characteristic available for comparison[1].

Dr. Swann's conclusions are reached in a general form if we adopt a more elementary starting-point. When we make statements about lengths in a remote star or at a remote epoch, it is implied that there