LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Relativity and Indeterminacy

The fundamental postulate of the special theory of relativity, and a vital principle of the general theory of relativity, is that there exists a maximum speed of propagation, confining the link between cause and effect to the surface or interior of the light cone. It is important to realize that, particularly in the special theory, this postulate is used essentially not in the mathematical but in the logical sense. That is to say, it is asserted that causal links and links of information outside the light cone do not exist, rather than that such links are more difficult to describe mathematically than links on or within the light cone. This logical assertion is used to the full in the denial of the possibility of clock synchronization.

It should be pointed out that this logical assertion would be meaningless if a fully deterministic description of Nature were possible. Thus relativity demands a non-deterministic theory such as is given at present by quantum theory. This contradicts the widely held view, repeatedly expressed by Einstein, that there is some conflict between the two theories.

The argument may be stated in the following terms. In a fully deterministic theory there are no uncaused events. Accordingly, an event A need not be considered necessarily as a consequence of an event B (say, on its past light cone); it may equally well be held to be a consequence of the causes of B. Most of these, if not all, will lie well within A's past light cone. In an expanding universe all causes can be traced back so far that an arbitrarily low velocity of propagation of information can be considered sufficient.

Conversely, instead of relating A to B, we may relate it to the consequences of B simultaneous with (or even later than) A. In such a case an infinite or even negative velocity would have to be assigned to the propagation of information. It might be argued that conceivably B might not have any later effects; but the causes of B will have such effects unless the chain of events culminating in B has no connexion with the rest of the universe other than A. In that case A would appear to be uncaused, contrary to the fundamental assumptions of a deterministic theory. Accordingly, no significance whatever can be attached to the expression 'limiting velocity of propagation of cause and effect' in such a theory.

The difficulty is familiar from the attempts to discover the velocity of propagation of gravitation on the basis of general relativity. Any gravitational problem has a solution with fully determined orbits. To suggest that a point on the world line of one particle has a link of special significance with a particular point on the world line of another particle is logically futile. It may be that the link is mathematically somewhat simpler than similar links with other points on the world line of the second particle, but though this could be of some mathematical interest, it is of no logical significance.

However, as soon as, in conformity with experience, we abandon the deterministic framework, the velocity of propagation of caused links becomes definite. The spread of the effects of an *uncaused* event (which was only statistically determined by previous events) has immediate logical significance, and the difficulty mentioned does not arise. Far from relativity being opposed to quantum theory, relativity in fact becomes logically tenable only when the classical picture has been abandoned.

The argument of this communication may be put differently: the flow of time has no significance in the logically fixed pattern of events demanded by deterministic theory, time being a mere co-ordinate. In a theory with indeterminacy, however, the passage of time transforms statistical expectation into real events.

H. Bondi

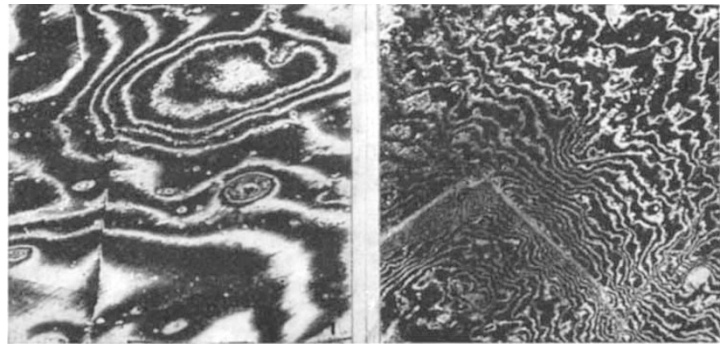
Faculty of Mathematics,
University of Cambridge.
Dec. 24.

Interferometric Studies on Coals

The familiar known correlation between the rank and the reflectivity of coals prompted me some years ago to apply interference methods to the examination of polished coals, and it is the purpose of this brief note to indicate the possibilities of this new approach which I am now making. It can be expected that at least three different features will be revealed by an interferogram of a polished sample of coal. Thus the general topography will largely be determined by the homogeneity or heterogeneity of the material, especially if there exist regions of different resistance-hardness to polishing. Then again, inclusions and cleavages might be expected to reveal themselves. Finally, the local fringe-width will afford a critical indication of local reflectivity and of local mattness.

As examples of what can be obtained by simple methods, Figs. 1 and 2 show Fizeau fringes (with a certain degree of multiple-beam interference) given respectively by a homogeneous anthracite and a heterogeneous ordinary coal. The differences between these two are quite striking. The more homogeneous nature and higher reflectivity of the anthracite is clearly rendered (magnification, × 40).

There is no question that a systematic interferometric survey of coals of known composition is well worth undertaking, and a start in this direction is



(1) (2)

Interference fringes (× 40) from (1) polished anthracite; (2) polished soft coal