to be compared with the experimental upper limit[3] of 3·3. This gives us added confidence in our model, but it is clearly desirable to have much more experimental confirmation of the anisotropy measured by Cooke *et al.*[3].

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Causality and Tachyons

In a recent article in *Nature*, Bilaniuk and Sudarshan[1] attack textbooks on the special theory of relativity which "still purport to show that causality arguments forbid the existence of faster-than-light particles" despite their demonstration[2–4] that particles going backward in time can be reinterpreted as antiparticles going forward in time. The causality argument is, however, strong, and does not seem to have been overcome by these authors. It is worth restating the argument in a simple form so that it can be seen what properties a particle travelling faster than light must have if it is not to violate the principle that a cause must precede an effect.

A tachyon is supposed to have the following properties[3]. Its velocity is always greater than the velocity of light and increases as the energy is reduced. As the energy tends to zero, the velocity increases to infinity, but the momentum is never less than some definite lower limit. As a result of the relativistic law of composition of velocities, if there are two frames of reference moving away from one another with velocity u, and a tachyon is moving with velocity v (in the first frame of reference) from the origin of the first frame of reference towards the origin of the second frame, its velocity in the second frame of reference is

$$v' = \frac{v-u}{1-uv/c^2}$$

In particular, for a tachyon with very low energy, and therefore very high velocity, in the first frame, the velocity in the second frame of reference is $-c^2/u$, and it arrives at the origin of the second frame before it leaves the origin of the first frame, according to the time system of the second frame of reference. We are told that in the second frame of reference such a tachyon can be reinterpreted as an antitachyon travelling from the origin of the second frame to the origin of the first frame, and in this way the paradox of arrival at the end of a journey before departure at the beginning disappears.

A thought-experiment to test the applicability of the special theory of relativity to tachyons can be set up in the following way. Two experimenters A and B are each equipped with a box full of low-energy tachyons, and a tachyon-detector, which may, for example, consist of a block of material which absorbs tachyons—even low energy tachyons have a large momentum, and the recoil of the block when it absorbs tachyons can easily be observed. The box of tachyons can be opened, and it will then emit a collimated beam of high-velocity tachyons. B is to be sent off at a high velocity, and A wishes him to send a signal back as soon as he receives a signal from A. Because A understands that B will interpret particles that are tachyons travelling towards B (in A's reference system) as antitachyons travelling away from B, he instructs B to open his box of tachyons and send a signal back to A as soon as his tachyon-detector starts to emit a beam of antitachyons towards A; the recoil of the detector transforms in the usual way, so there is no difficulty in observing such an emitted beam.

B goes off with his apparatus at a velocity of 10^8 m s^{-1}, and, when he is at a distance of 5×10^7 km, A sends off a signal, which reaches B almost instantaneously. B responds to the observed emission of antitachyons from his detector by immediately opening his box of tachyons, and, as a result, A's detector appears to emit a beam of antitachyons almost a minute before he sent the signal out. To B there is no paradox although he may wonder why the antitachyons emitted from his detector were so well collimated. To an outside observer the chain of events may be explicable as a causal sequence. Only to A is the result deeply paradoxical, because he knows that he could have changed his mind between the time at which his detector responded and the time at which he sent out a signal.

It is clear that B can be replaced by an automatic device in this experiment. The paradox seems to remain if the following conditions are satisfied. (1) The production of low-energy tachyons can be controlled. (2) Tachyons can be detected. (3) Tachyons can travel over a large distance. Without the first two conditions, it is hard to imagine how tachyons could be of interest to the experimental physicist. If the third condition is not satisfied, then the violation of causality would only be for small intervals of time, and this might be acceptable.

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Role of Satellite Photographs in Photogeology

Favourable comments on the geological applications of satellite photographs[1,2] imply the possibility of new horizons in photogeology. In the Photogeology Unit of the Institute of Geological Sciences a study of satellite photographs has been made to determine how far these may replace or supplement conventional air photographs, particularly in reconnaissance geological mapping at medium to small scales.

Material studied included 35 mm colour transparencies of Gemini IV, V, VII and IX, and of Apollo–Saturn 6 and Apollo 7 flights, covering regions in Africa, Arabia, Hong Kong and South America. Subsequent generation black and white photographs and coloured book reproductions[3] were also examined. Detailed analysis was made of 70 mm transparencies of the Republic of South Yemen (formerly Aden Protectorate) and of Oman, regions affording good conditions for satellite photography and of which the geology is known to me.

Transparencies were projected and geological interpretations were made on paper attached to the projection

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