

at this pressure. Low-pressure systems can and have been built. Further work in this region on hydrogen refrigeration and on closed-cycle helium refrigeration undoubtedly would yield improvements of greater relative magnitude from the technological point of view than can be expected from the preparation of still more conventional superconductors. This is precisely the point I make in my letter.

I have no quarrel with the author in regard to the fundamental scientific significance of preparing new superconductors, but the justification for this should not be based on the technological advantages that might accrue from the work but rather on its scientific merit alone. From the economic point of view, at this point, a better return on your money will come from refrigerator research.

WILLIAM A. LITTLE
Stanford University
Stanford, Calif.

Charged-tachyon replies

In his recent letter (May, page 11) Howard Robbins raises the question of whether or not a charged tachyon could have a trajectory that is consistent with relativity. He points out that the motion must be accelerated because of Cerenkov radiation and that rectilinear, accelerated motion is not an invariant concept and thus the trajectory of a charged tachyon could not be predicted with knowledge of its position and velocity at one time. This question has also been raised in some detail by H. K. Wimmel¹ who concludes that no satisfactory answer exists at present.

It should be pointed out, however, that this problem is not unique to tachyons but arises in any problem that includes radiation reaction as a significant ingredient. In these cases the differential equation of motion includes the time derivative of the acceleration and hence the initial value of the acceleration must also be given (this is the "new dynamical quantity" suggested by Robbins).

It can be shown² that a properly Lorentz-invariant classical theory of Cerenkov-emitting, charged tachyons may be given in terms of an extended, Lorentz deformable particle. Such a particle follows a law of motion given by

$$\frac{d^2U}{ds^2} - \left(\frac{\kappa e^2}{ma_0^2}\right) U = 0$$

where U is the tachyon's space-like 4-velocity, ds is the increment of invariant length of the world line, m is its mass, a_0 its "size" and κ a constant of order unity depending on the details of the

charge distribution. Such a law of motion is clearly covariant, and the special class of frames in which the particle motion is rectilinear is picked out by the initial conditions, not by the law of motion.

References

1. H. K. Wimmel, *Nature Physical Science* 236, 79 (1972); *Lett. Nuovo Cim.* 1, 645 (1971).
2. F. C. Jones (to be published).

FRANK C. JONES
NASA-Goddard Space Flight Center
Greenbelt, Maryland

With reference to Robbins's letter, in a just-finished work (H. Bacry, Ph. Combe and P. Sorba "Connected Subgroups of the Poincaré Group" Preprint 72/p. 449, Marseille, 1972) we suggest a group theoretical definition of the motion of a charged particle in a homogeneous field. Our definition has the advantage of being valid for all kinds of particles, namely tardyons, luxons and tachyons. It is a natural assumption based on the following property: all worldlines of charged massive particles (tardyons) in a homogeneous field are orbits in space-time of some one-dimensional subgroup of the Poincaré group.

As an example, in the case of a homogeneous electric field pointing in the z direction, a possible motion for a tachyon is the following one: at time zero, the tachyon is at point 0; its speed is finite in both positive and negative directions! At a given time $t > 0$, it has two distinct positions A and B, symmetric with respect to 0 and a finite speed. As time is increasing, the speed becomes smaller and tends to c , the velocity of light, when time becomes infinite. For negative times, the tachyon does not exist at all!

Various other peculiar motions can be found with the aid of this method.

H. BACRY
Centre de Physique Theorique
Marseille

Einstein in 1905

Without in any way belittling the impressive accomplishments of nuclear physicists in 1932 I wish to note that, while it may have been "the most exciting time yet in the history of physics," it may not have been the most productive—by far! For years I have been describing to physics classes the remarkable discoveries published by one man in a single year: Albert Einstein in 1905. In that year he founded two revolutionary fields, quantum theory (from the photoelectric effect) and special relativity, and made a

continued on page 79

Spectroscopy Molecular Beams AC Polarography Semi- Conductors

Q. What do they have in common?

A. The Ithaco 353 lock-in amplifier.

ONLY THE 353 PROVIDES:

- Automatic phasing.
Measure signals with changing phase, without touching the phase controls. Vector amplitude and phase outputs.
- Log, ratio or log-ratio.
Make absorbance and dual beam ratio measurements simply and economically.
- In-phase and quadrature.
Simultaneously measure two quadrature signals—or their ratio.
- Signal and derivative.
Is the 2nd harmonic of your output signal a derivative? The 353 measures both simultaneously—or their ratio.
- Modulated carrier signals.
Measure carrier amplitude with linear or log response—and simultaneously measure the modulation signal or depth of modulation.

Arrange for a demonstration of Ithaco's versatile 353 lock-in.

Write or call
Don Munroe, Ithaco, Inc.,
735 W. Clinton Street, Ithaca,
New York 14850. 607-272-7640

ITHACO