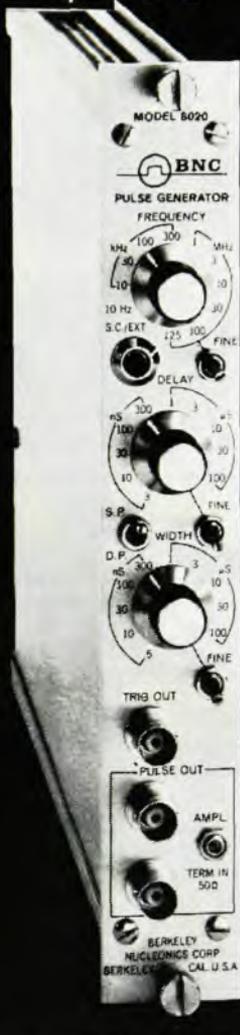


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letters

University of North Carolina student, in a class using my book, put it this way: "The book fits comfortably into the growing trend of linking science to the humanities. The basic criticism I foresee is that the book is a bit too trivial for first-year college students. The critics will perhaps believe the book to be of more benefit on the high-school level. I would not agree with the latter point."

In anticipation of Von Foerster's call for "padding" to make my text usable in a full-year course. I have prepared an accompanying collection of articles, including contributions by Arthur Koestler, John Maynard Keynes, Merle Tuve, Jean Piaget, *physics today* editor Harold Davis, I. I. Rabi, Roger Bannister, Robert Oppenheimer and Edward Teller, among others.

Robert Karplus
 University of California
 Berkeley

Fresnel and the tachyon

In connection with the recent wide interest in tachyons (May, 1970, page 13) readers of *physics today* might like to have their attention called to a case where it seems that tachyons are quite close at hand.

What one does with an imaginary proper mass, one does just as well with an imaginary component of the momentum. Fresnel's evanescent wave in total reflection is formally a plane wave with a complex propagation vector \mathbf{k} , having (in units such that $c = 1$ and $\hbar = 1$, and ω denoting the angular frequency) components $k_x > \omega$, $k_y = i(k_x^2 - 1)^{1/2}$, $k_z = 0$. That *lichtquanta* associated with such a wave will behave, in some essential respects, like tachyons is easily demonstrated. It is well known that the imaginary part k_y of the phase contributes in fact to the amplitude of the wave. Of course the corresponding real exponential factor can be expanded as an ordinary Fourier integral; the point is however that conservation of the energy-momentum with ω and k_x fixed forbids any of these Fourier components to be separately absorbed or emitted; only the whole phase-coherent Fourier integral, that is, the imaginary quantum k_y , can be absorbed or emitted.

Then it is easily verified¹ that if, say, an ion beam is sent in the evanescent wave parallel to x with exactly the appropriate velocity, it will simultaneously absorb an energy quantum ω and a momentum quantum $k_x > \omega$ by going from one eigenstate to the other, and that the transition amplitude will be proportional to the product of the x , y , z expressions of the amplitude of the ionic wave and of the evanescent electromagnetic wave. An experiment is

presently planned along these lines.

Finally we come to the question of the group velocity. It is well known that for deriving a group-velocity formula one needs a stationary phase argument *plus* another constraint. With tachyons proper, using de Broglie's constraint that the proper mass is dispersionless, one obtains a spacelike group four-velocity collinear with the four-momentum. With our tachyon photons we have dispersions $\delta\omega$ and δk_x , and we have to impose a correlation between them. Choosing $\delta[(n^2\alpha^2 - 1)^{1/2}\omega] = 0$ where, n denoting the index of the refracting medium and α the sine of the incidence angle inside it, $k_x = \eta\alpha\omega > \omega$, that is distributing our tachyon-photons with respect to their penetration depths, we obtain $\omega\delta\omega - k_x\delta k_x = 0$, which together with $\delta d\phi \equiv \delta\omega dt - \delta k_x dx = 0$ yields $dx/dt = k_x/\omega > 1$ —a reasoning and conclusion quite similar² to those applicable to tachyons proper. But neither for these tachyon proper (if they exist) nor for these tachyon-protons (that should exist) is there ground to believe that a signal velocity could be greater than one.

References

1. O. Costa de Beauregard, *Compt. Rend.* **270B**, 773 and 1004 (1970).
2. O. Costa de Beauregard, *Précis of Special Relativity*, Academic, N. Y. (1966), page 110. Equation 7 in this work should read $\beta_F \approx -\eta/n\alpha\omega \approx \beta_E$, that is, in the form of generalized Doppler effect.
3. Ch. Imbert, *Compt. Rend.* **269B**, 1227 (1969) and **270B**, 529 (1970); *Phys. Lett.* **31A**, 337 (1970).
4. F. Goos, H. Hanchen, *Ann. Physik* **1**, 133 (1947).

O. Costa de Beauregard
 Institut Henri Poincaré
 Paris

Still more on tachyons

O. M. Bilaniuk and E. C. Sudarshan have pointed out (May 1969, page 43) that it is very important to make sure that tachyons are consistent not only with relativity theory but also with quantum theory. I would like to comment on this point.

Bilaniuk and Sudarshan have studied the dependence of $E/|m_0|c^2$ versus $P_x/|m_0|c$ (their figure 1). For a given momentum P_x there are therefore always two values of the energy, $+E$ and $-E$. It is just this double sign for the energy that necessitates the use of a four-component wave function in Dirac's wave equation.

With the smallest value of $P_x = 0$ we associate two values of $E_0 = \pm m_0c^2$. The particle can not exist in the region $m_0c^2 > E > -m_0c^2$, because P_x must be

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imaginary. In a field the quantum-mechanical particle has a discrete energy spectrum. Therefore the changes of state may take place by jumping over the excluded region from m_0c^2 to $-m_0c^2$, getting from the state $E > 0$ into the state $E < 0$. This problem is known as "Klein's paradox."

We have a similar situation in the case of tachyons (see again the same figure 1). For a given energy there are also two values of $P_x/|m_0|c$. Now the particle can not exist in the region $1 > P_x/|m_0|c > -1$ because the energy must be imaginary. It may be possible that the tachyon leaps over the excluded region by a jump from a state P_x into a state $-P_x$. The momentum spectrum must be then discrete.

It appears to me that the roles of energy and momentum for tachyons are interchanged. In the usual quantum theory the Hamiltonian plays a predominant role. For tachyons the Hamiltonian (p, q) is a single-valued function of P . On the other hand for tachyons we have for both branches of the hyperbola two values of energy for the given momentum. It is possible that we must replace the Hamiltonian by another operator $\mathcal{P}(E, q)$. Then for the given energy we obtain two values of momentum, and the problem can be solved analogically to Dirac's or Klein-Gordon's theory.

Concerning this kind of reinterpretation, I should like to point out that in 1964 I showed that the annihilation operator in the negative energy state has the same form as the creation operator in the positive energy state.¹ This result has been obtained from the statistical mechanics of particles with negative energy.

Reference

1. V. Vysin, Phys. Letters 13, 217 (1964).
Vratislav Vysin
Palacký University
Olomouc, Czechoslovakia

Minority representation

While not wishing to prolong the bickering, I can not resist observing that Jay Orear's rebuttal to readers' criticism (September 1970, page 71) falls short of intellectual infallibility.

He contends that the American Physical Society does not represent the membership because it was not split in its decision concerning the Chicago meeting, while a poll of the membership indicated that almost half the membership did not agree with the Council's decision. Since the Council is elected by majority vote of the membership, one would ordinarily expect the Council to represent the viewpoint of the majority.

Certainly there is no reason to believe that all Council decisions should be divided in proportion to the various viewpoints within the membership. Orear asks how many Council members are under 40, close to students, and so forth?

The point is that the Council was duly elected by the membership. Perhaps Orear would rather have a more complicated representation in which each Council member is elected by and represents the viewpoint of a separate constituency (under 30's, military-industrial complex, New Left, and so on).

S. J. Robertson
Huntsville, Alabama

Nuclear phase transition

In connection with your recent news report on the discovery of a phase transition in magic even-even nuclei by G. Scharff-Goldhaber and A. S. Goldhaber (November, page 17), I should like to point out that such a discovery had been previously reported by the undersigned in *Physical Review Letters* 24, 1242 (1970). In addition to reporting the existence of a remarkable discontinuity between magic and nonmagic nuclei (at $E(4)/E(2) = 1.825$), this paper also shows that magic nuclei are accurately described by the "variable moment of inertia" model (or, equivalently, the Harris model).

Mario A. J. Mariscotti
Comision Nacional de Energia Atomica
Buenos Aires, Argentina

Scharff-Goldhaber comments: As was mentioned in the *physics today* report, the article in *Physical Review Letters* by G. Scharff-Goldhaber and Alfred S. Goldhaber was based on the earlier work by M. A. J. Mariscotti, G. Scharff-Goldhaber, and B. Buck, *Phys. Rev.* 178, 1864 (1969). Mariscotti's letter based on the same work appeared in *Physical Review Letters* two weeks earlier. That there are many coincidences in the two letters in spite of important differences is not surprising, since both letters start from the same idea as pointed out by Mariscotti in his footnote 10: "The possibility as an extension of the VMI model was first proposed by G. Scharff-Goldhaber (unpublished)."

G. Scharff-Goldhaber
Brookhaven National Laboratory

The Depression and World War II

Charles Weiner ("Physics in the Great Depression," October, page 31) draws a parallel between the present and previous reduction of research funds, slackening employment opportunities, and lower public esteem for physics. His last section, titled "The problem disappears," tells us that by the spring of

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