LETTERS

Tachyons and tardyons

Murray Gell-Mann's totalitarian principle, "Anything that is not prohibited is compulsory," has guided us to a number of remarkable discoveries, as Olexa-Myron Bilaniuk and E. C. George Sudarshan pointed out in their thought-provoking May article on tachyons (Greek: *tachys*).

We applied the principle in the following situation: Since there is a Greek word meaning "swift," there is no reason why there should not also be a Greek word meaning "slow." A vigorous search for such a word was undertaken with the objective of demonstrating etymological symmetry between the hyperluminal and subluminal worlds.

The appropriate Greek prefix was found to be "brady." Tachyons and bradyons go together like tachycardia and bradycardia. Put that to music and it's a smash hit.

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Momentum after position

Willis E. Lamb Jr's illuminating discussion of measurements and state preparation of quantum systems (PHYSICS TODAY, April, page 23) is most welcome to students and teachers of quantum mechanics. One aspect of the matter, however, needs further discussion. Lamb suggests that an accurate position measurement on a particle will so disrupt phase relations that a subsequent momentum measurement on this particle will serve no physical purpose. On the contrary, it is just this sequence of measurements, which William A. Gale, Eugene Guth, and I[1] pointed out could serve to determine the wave function of a system.

If we write $\Psi = R(\mathbf{r}) \exp[iS(\mathbf{r})/\hbar]$ where R and S are real, then the experimental determination of the probability density $\rho = R^2(\mathbf{r})$ and the probability current $\mathbf{j}(\mathbf{r}) = \rho \nabla S/m$ obviously determines Ψ.

$\mathbf{j}(\mathbf{r})$, or, alternatively, $\nabla S(\mathbf{r})$ (that can be interpreted as the average momentum of the particle when it is at $\mathbf{r}$), can be experimentally determined in several ways. In particular we can use Lamb's one-bound-state short-range potential for this purpose as well as for that of determining ρ, which he discussed.

We consider the source of this potential as another particle that we center to within an accuracy Δr of the point $\mathbf{r}_0$ where we wish to measure $\nabla S(\mathbf{r})$. The uncertainty in the momentum of the source particle is greater than $\hbar/\Delta \mathrm{r}$; but we can carry out its positioning in such a way that its expected momentum $\langle \mathbf{p} \rangle$ is zero.

We now "turn on" the potential and subsequently measure the momentum of the source-plus-bound-particle system for those cases in which the particle is captured. Repeating this identical procedure for many members of the ensemble of systems whose wave function is Ψ will determine the average momentum imparted to the source by the captured particle, and a short calculation shows this to be $\nabla S(\mathbf{r}_0)$.

Lamb's procedure for the preparation of a particle in a given state provides another demonstration that ∇S has the significance of the average momentum of the particle at point $\mathbf{r}$: If initially the wave function is real, $\Psi = R(\mathbf{r})$, then upon turning on the potential $U = S(\mathbf{r})\delta(t)$ the wave function becomes $(t = 0+)$ $\Psi = R \exp[i\, S/\hbar]$. Before $t = 0$ the average momentum was zero at each point. At $t = 0$ an impulse $\nabla S(\mathbf{r})\delta(t)$ produces an average momentum $\nabla S(\mathbf{r})$.

Reference

1. W. Gale, E. Guth, G. T. Trammell, Phys. Rev. **165**, 1434 (1968).

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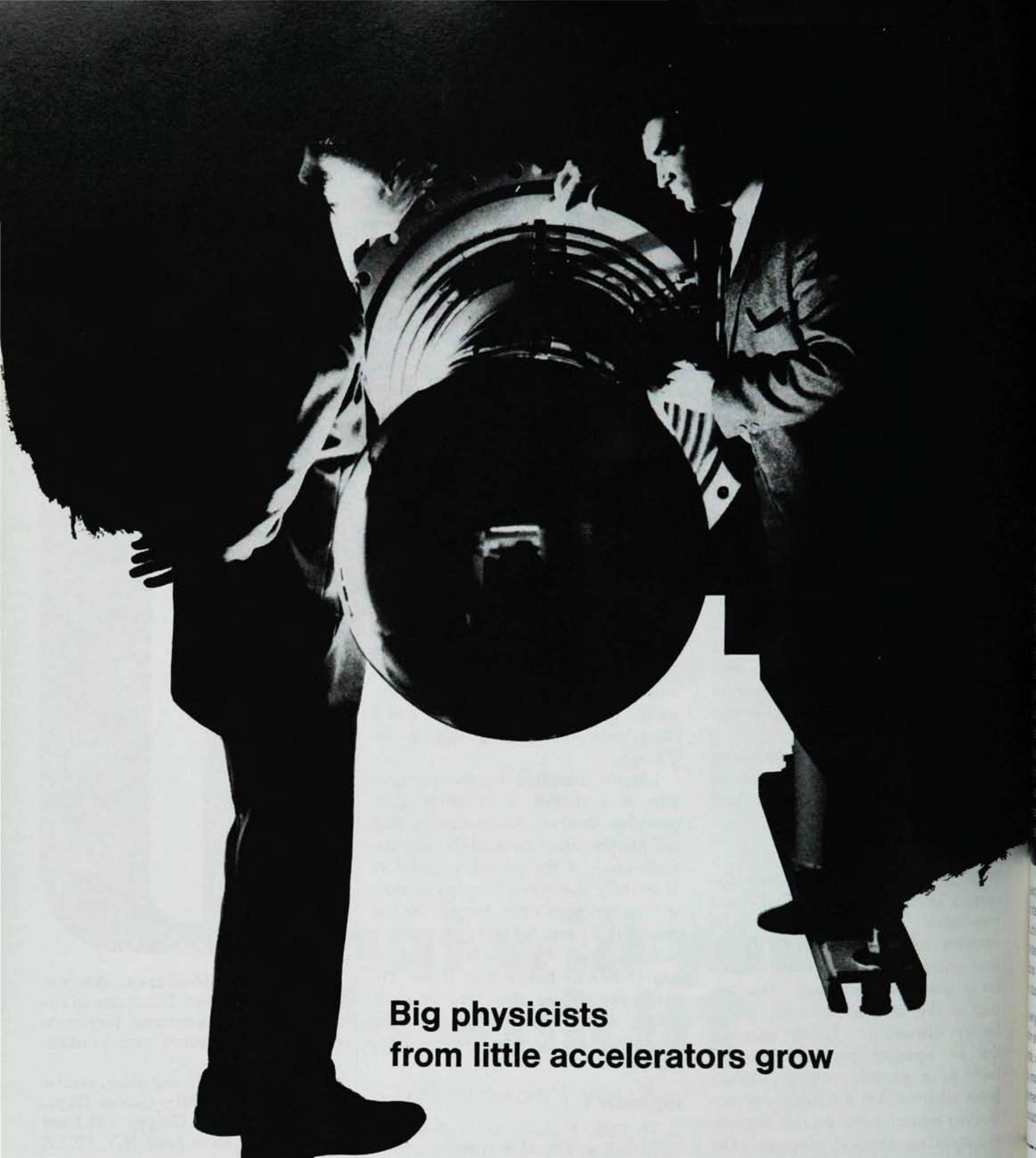
Down with nanometers

Now that my writing and your editing have combined to make a portion of the August PHYSICS TODAY article "Frontiers of Physics Today: Crystals," I have one more comment: "Nanometers" must be very strange to crystallographers, who have lived on a diet of "angstroms" since the beginning of diffraction time (for



crystals, x rays, electrons and neutrons). Whether the majority of your readers dieted differently or are ordered to do so in the future by some international clinic, I would not be able to say, but I know the crystallographers would have no interest in changing to nanometers. Not that they are not interested in unit changes! How they worked on kx units vs angstroms vs J. A. Bearden's proposed "A* unit"!

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Let students write problems

H. Richard Crane's guest editorial, "Better Teaching with Better Problems and Exams," in the March PHYSICS TODAY has stimulated some ideas about problems in a nonscience major's physics course. Although such students are disenchanted with present courses because they lack contact with pressing social problems, perhaps their interest can be stimulated by challenging them to invent problems. The effort might train them to think as scientists do and, at the same time, equip them better to attempt solutions to social ills.

At the end of the first week of class each student could turn in two or three problems that he thinks the course should enable him to solve by the end of the year. They will tell the instructor what the students think the course should be and force the student to define his own involvement. The procedure can be repeated several times during the year to show whether each student has changed his goals or defined them better or made progress toward solving his chosen problems. The instructor can change his course, and the situation might change from static to dynamic. The students might give some clues to what would make the course relevant to current problems.

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Unpublished works

In recent scientific papers I have noted that some authors tend to refer to their own unpublished work and to work they *hope* to publish later in an unspecified journal. Since several of the papers were in journals published by the American Institute of Physics or member societies, I thought to draw the matter to your attention. Allow me to give a few recent examples from a flourishing field (I apologize to those authors whose contributions I have overlooked).

1. In a paper by H. Träuble and U. Essmann (*J. Appl. Phys.* **39**, 4052, 1968), they state, "It is shown in [12]. . . . . . ." Reference 12 reads "U. Essmann and H. Träuble (unpublished)."

2. A paper by L. R. Saravia and D. Brust (*Phys. Rev.* **170**, 683, 1968) reads in part, "a method described elsewhere (see ref. 17)." Reference 17 reads, "L. R. Saravia and D. Brust (to be published)," and reference 21 further reads, "D. Brust and E. O. Kane (to be published)."

3. In a letter by D. L. Mills, A. A. Maradudin and E. Burstein (*Phys. Rev. Lett.* **21**, 1178, 1968) they state, "A microscopic theory of these mechanisms is published elsewhere[2]." Reference 2 reads, "D. L. Mills, A. A. Maradudin and E. Burstein (to be published)."

Surely such references only waste the readers' time and should read something like "We have also observed. . ." without citing a reference.

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An overly homogeneous group

The underlying problem behind the controversy on the Schwartz amendment and the American Physical Society Chicago meeting, in my opinion is that the APS Council has taken on the aspect of "the Establishment."

The APS Council is a group of dedicated, hard-working, honest and conscientious individuals. The question, however, is whether they represent the present APS constituency in approach, attitude and sympathy. Instead, I believe they have many of the characteristics of an inbred, self-perpetuating, overly homogeneous group. The manner of election helps assure this since they are selected from the scientifically elite. Note also that in the present election all of the officers are from universities, and all of the nominating group are also from universities.

Unfortunately APS officers have already acted as the Establishment. The most astonishing act of the council was to include propaganda for their side alone in the ballot for the Schwartz amendment. I am sure it