

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 I¹ pointed out could serve to determine the wave function of a system.

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

$j(r)$, or, alternatively, $\nabla S(r)$ (that can be interpreted as the average momentum of the particle when it is at 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 r_0 where we wish to measure $\nabla S(r)$. The uncertainty in the momentum of the source particle is greater than $\hbar/\Delta r$; but we can carry out its positioning in such a way that its expected momentum $\langle p \rangle$ 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 $\nabla S(r_0)$.

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 r : If initially the wave function is real, $\Psi = R(r)$, then upon turning on the potential $U = S(r)\delta(t)$ the wave function becomes ($t = 0+$) $\Psi = R \exp[iS/\hbar]$. Before $t = 0$ the average momentum was zero at each point. At $t = 0$ an impulse $\nabla S(r)\delta(t)$ produces an average momentum $\nabla S(r)$.

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

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