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search for the necessity of the tool themselves makes students unafraid of the mathematics used and develop confidence with it. They also begin to feel that they are the ones who have the real control over the mathematical manipulations, because it is just a tool they use. It is usually a good idea in the introductory lecture to whet the appetite of the student by relating to him some of the striking phenomena in physics and astronomy. Then one can casually bring up the need for mathematics.

GARY R. GRUBER
Hofstra University
Hempstead, New York

New Field?

I fear that, since leaving the mainstream of physics, I have fallen out of touch with some of the more esoteric new fields in our fast-changing science. My present work does, however, require me to be familiar at least with the terminology, if not the substance, of science. Thus, I was particularly intrigued by an ad in the "positions wanted" column in the April 1972 issue (page 86) for a speciality I have never seen mentioned in the help-wanted ads nor in the lists of occupations published by the various professional organizations.

Perhaps you could publish a brief article explaining what it is that a "black theoretical physicist" does and how his activities are related to those of solid-state or nuclear theoretical physicists.

HARRY M. KRIZ
Morgantown
West Virginia

CHAIRMAN OF THE APS COMMITTEE ON MINORITIES IN PHYSICS COMMENTS: We disagree with the implied criticism offered above by Harry Kriz. We feel that PHYSICS TODAY deserves congratulations for a policy that indicates it is serious about including minorities in the mainstream of physics. Under this kind of policy, an employer who really wants to be an equal-opportunity employer has a chance to validate the equal-opportunity claims. In general, when there is an ad for a position, it has been understood by all—black, white and brown alike—that the advertisement is for white prospective employees. This understanding comes from the observed practices of employers and copious disappointing experiences of blacks and other minorities. Too often when a black shows up, an excuse is made and the minority job-seeker finds he has wasted his time. This trouble can be avoided when ads like the April one give facts used by the employer. Also, it discourages the "I would hire them if I could find them" syndrome. The disgraceful situation with respect to minorities in physics can be partially envisioned (by the general physics public) when we realize that of the 17 000 physicists with a PhD, only about 60 blacks, 8 Chicanos and one Native American (American Indian) are included.

It is hoped that PHYSICS TODAY will increase and intensify the "in-course guidance corrections" begun with the ad in the April issue to aim at the moral and practical goal of justice, equality and brotherhood—the realization of the great American dream.

WARREN E. HENRY
Howard University
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More tests of QED

The article in "Search and Discovery" (October, 1972, page 17) on the current debate between supporters and doubters of quantum electrodynamics calls to mind the original arguments over Schrödinger's theory of continuous light emission as opposed to the quantum jumps of Werner Heisenberg and Niels Bohr. This letter offers a historical review of the situation.

For practical purposes the Schrödinger theory was superseded because it was inadequate to explain collision processes, and it was shown during the famous encounter between Schrödinger and Bohr in Copenhagen that the theory, as it then stood, could not produce the Planck radiation law.[1] The published form simply stated that radiation was due to oscillations of the atomic dipole moment calculated from the hydrodynamical model of the atom.[2] This is a heuristic precursor to the present theory of Edwin Jaynes.

However, even then it was clear that radiation rates would have to show a final-state amplitude dependence,[3] and an experiment was performed by E. Gaviola to test this dependence.[4] He looked at the relative intensities of 4046Å and 4358Å secondary resonance lines in mercury as he varied the relative populations of their final states by a factor of 100. As best we can tell this experiment has gone unnoticed because it appeared after the issue of Schrödinger's interpretation was dead. Gaviola himself doesn't mention it in a critical review of quantum mechanics written in 1929.[5]

Recently R. K. Nesbet has shown that the Planck radiation law can be obtained semiclassically,[6] and further experimental tests of semiclassical theory (SCT) have been performed by

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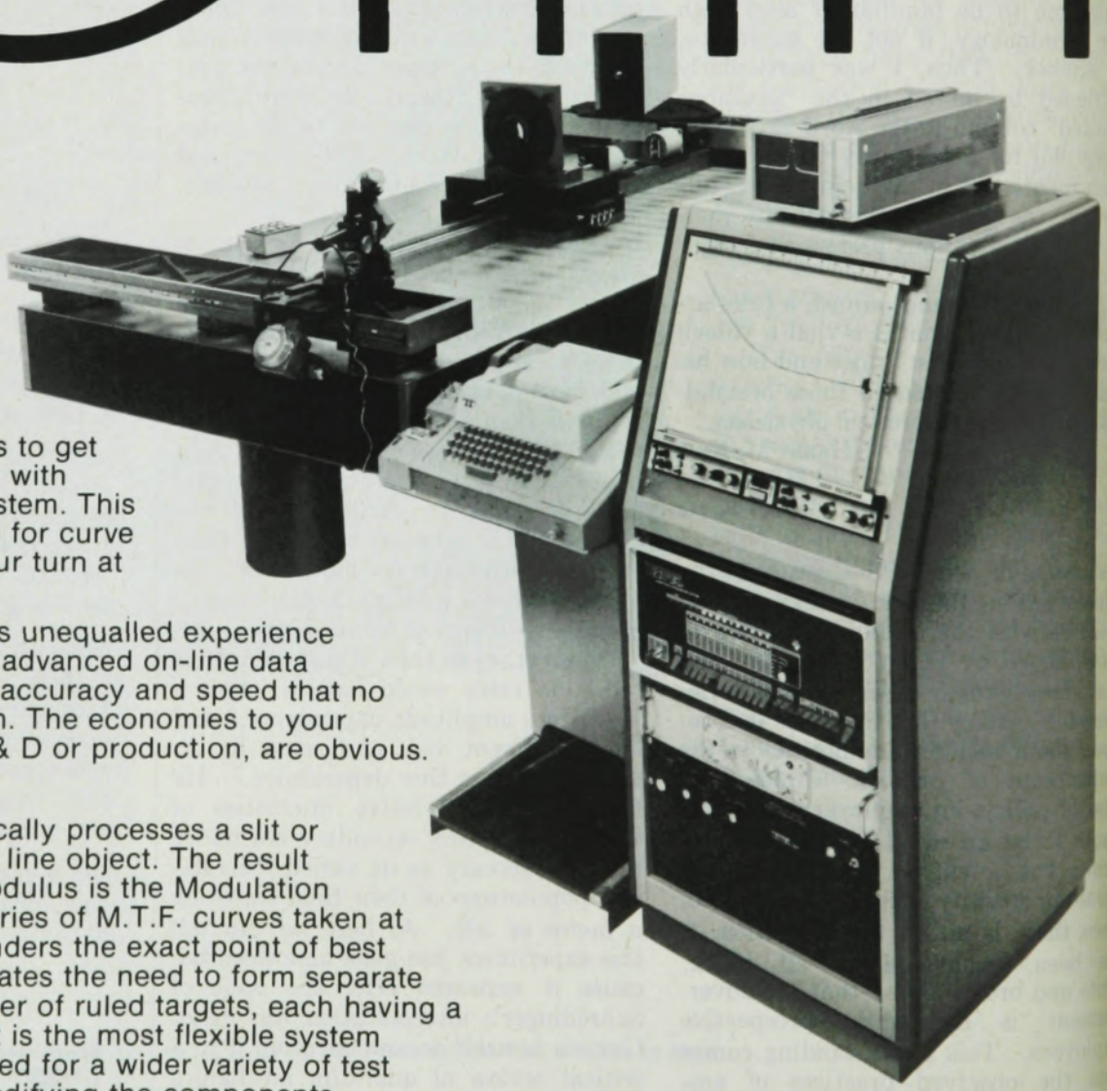

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Hyatt Gibbs[7] and by us.[8] While these lack the apparent directness of Gaviola's original test, they are more carefully analyzed in terms of the underlying assumptions of SCT. Moreover, they test a more complete theory. Each favors QED. Thus it has taken us 45 years to rediscover the inadequacy of the hydrodynamical model of the atom.

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Comparing frequencies

In the interesting news item "Absolute laser frequency measurements" (April, 1972, page 17), which described the measurement of the 88-THz frequency of cesium, a statement was made that "A chain of experiments is needed because two frequencies differing by more than a factor of 12 cannot be compared directly." Although the article otherwise was very well written, this statement is incorrect and misleading.

On 3 September 1970, S. G. McDonald, A. S. Risley, J. D. Cupp, and K. M. Evenson at the National Bureau of Standards in Boulder directly compared the 0.89-THz frequency (337-micron wavelength) of an HCN laser with an X-band frequency. This was a factor of 100 in one step.[1] On 12 August 1971 the same group directly compared the 3.82-THz frequency (78 micron) of an H_2O laser with an X-band frequency. This was a factor of 401 in one step.[2] They used a Josephson junction as the nonlinear element. Although the multiplication factor was far greater than 12, the signal-to-noise ratios obtained in these experiments were excellent, and McDonald and coworkers presently are setting up an experiment to obtain a factor of about 1100 in one step from X-band. If successful, this precedure will allow a direct comparison of a 10.7-THz (28 micron) H_2O laser frequency with an X-band frequency standard.

Their pioneering work in high-order single-step frequency multiplication should be regarded as a significant advance towards very versatile methods of infrared and visible radiation frequency synthesis that will be highly precise as well as being relatively simple, inexpensive and reliable. These desirable features are expected to be attainable partly because it is possible to compare two frequencies directly, although they differ by much more than a factor of 12. The eventual impact on technology and science may be considerable.[3,4]

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DONALD HALFORD
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KENNETH EVENSON REPLIES: Donald Halford's comments are correct. The sentence in question could be better expressed: A chain of lasers is needed when one uses the room temperature metal-metal diode because the signal-to-noise ratio decreases with increasing harmonic numbers, thus limiting the maximum useful harmonic number. The twelfth harmonic was the maximum one used in the experiments described in the April issue as well as those revised ones reported in Halford's reference 1, which resulted in the 100-fold improvement in the accuracy of the speed of light. However, signals with higher harmonic numbers from metal-metal diodes might be obtainable with longer averaging times. We presently are setting up an experiment to obtain a factor of 33 in one step from a laser with a metal-metal diode. Much higher laser harmonics might be obtainable with the Josephson junction.

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Correction

January, page 5—The cover photograph should have been credited to Ron Church of La Jolla, California. □