

letters

Hyatt Gibbs⁷ 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.

References

1. W. Heisenberg, *Physics and Philosophy*, page 42, Harper Torchbooks, 1962.
2. E. Schrödinger, *Ann. Physik* 79, 755 and 81, 134 (1926) and O. Klein, *Z. Physik* 41, 416 (1927).
3. J. H. Van Vleck, *J. Franklin Inst.*, April 1929, page 475.
4. E. Gaviola, *Nature* 122, 772 (1928).
5. E. Gaviola, *Z. Physik* 58, 651 (1929).
6. R. K. Nesbet, *Phys. Rev. A* 4, 259 (1971).
7. H. Gibbs, *Phys. Rev. Letters* 29, 459 (1972).
8. D. K. Anderson, R. T. Robiscoe, J. M. Wessner, *Phys. Rev. Letters* 29, 1126 (1972).

DAVIS K. ANDERSON
RICHARD T. ROBISCOE
JOHN M. WESSNER
Montana State University
Bozeman, Montana

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 H₂O 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 procedure will allow a direct comparison of a 10.7-THz (28 micron) H₂O 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}

References

1. D. G. McDonald and others, *Appl. Phys. Lett.* 18, 162 (1972).
2. D. G. McDonald and others, *Appl. Phys. Lett.* 20, 296 (1972).
3. J. S. Wells and others, *Proc. IEEE* 60, 621 (1972).
4. D. Halford and others, *Proc. IEEE* 60, 623 (1972).

DONALD HALFORD
National Bureau of Standards
Boulder, Colorado

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.

KENNETH M. EVENSON
National Bureau of Standards
Boulder, Colorado

Correction

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

Squid*

*superconducting quantum interference device



SHE SQUID instruments are used wherever ultra-sensitive measurements must be performed. Recent applications include:

geomagnetic fluctuations
superconductivity
biomagnetism
low temperature resistivity
thermopower studies
nuclear magnetism
magnetic thermometry
infrared detection
temperature dependent susceptibility
VLF detection
weak magnetic impurities
NMR
noise thermometry
remanent and induced magnetization
teaching lab experiments

Basic Magnetometer, Model MGS-20



Variable slew control unit Model VSC

Provides the extremely fast response and wide dynamic range required for sensitive magnetic measurements in an unshielded, noisy ambient.



Digital/analog output display, Model DAC. Features resolution of 1/10⁸ of full scale to enable observation of small changes on a slowly-varying, large amplitude background signal.

Contact us for details on the complete line of SHE SQUID instruments.



S.H.E. CORPORATION
3422 TRIPP CT.
SAN DIEGO, CA 92121
(714) 453-6300

Circle No. 13 on Reader Service Card
PHYSICS TODAY / FEBRUARY 1973