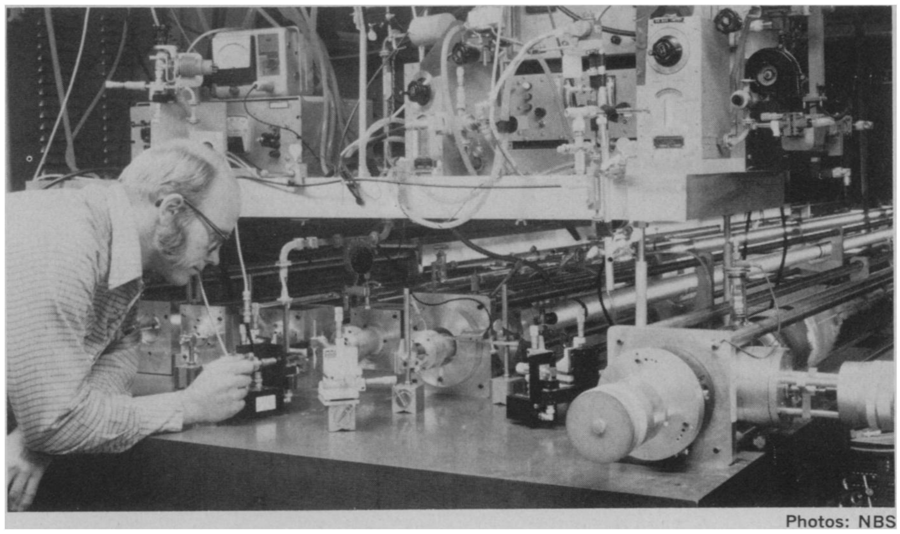
A new figure for the cosmic speed limit

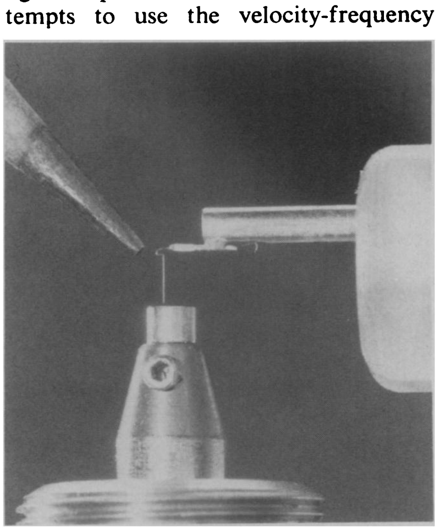


Evenson adjusts a cat-whisker diode used to measure the laser frequencies.

The speed of light is a fundamental constant of nature. According to the theory of special relativity it is a kind of cosmic speed limit: Nothing can go faster than light. Because of its unique position, physicists require a precise determination of the speed of light. In times past the usual method was to try to measure the time of flight of a light signal over some distance. (One such measurement used the distance between earth and Jupiter.)

But time-of-flight measurements with something that goes as fast as light are not very accurate. Modern attempts have concentrated on the use of the relation between wavelength and frequency and speed: Speed is the product of wavelength and frequency. A group at the National Bureau of Standards at Boulder, Colo., now reports an extremely accurate measurement using the wavelength and frequency of a helium-neon laser.

Only in the last few years has technology permitted the measurement of light frequencies. Therefore the first attempts to use the velocity-frequency relationship were done with radio waves, for which both data could be measured. But due to the low frequencies and long wavelengths there was a greater margin of error than many physicists would like.



Close-up shows how small the diode is.

The new figure for the speed of light:
299,792.4562 kilometers/second
or
186,282.3960 miles/second

Late in 1971 a group working at NBS laboratories in Boulder under the direction of Kenneth M. Evenson succeeded in measuring the frequency of a helium-neon laser to very high precision (SN: 2/5/72, p. 85). They used equipment developed at NBS and the Massachusetts Institute of Technology. The basic part of the equipment is a cat-whisker diode similar to the crystal in old-fashioned radios, which is used to compare two frequencies. The method proceeds in steps from a known low frequency (the 9.19-gigahertz cesium beam of the standard atomic clock). The low frequency is compared with an unknown one somewhat higher. The diode produces harmonics of the low frequency that nearly equal the higher one. The difference between the harmonics and the higher frequency can be measured accurately, and with that the higher frequency is known. The next step goes to a higher frequency and so on until the 88.38 terahertz frequency of the laser is reached.

Although lasers are the most monochromatic light sources ever, they are not exactly precise. The frequency of a given laser fluctuates over a narrow band from time to time, and it is only by accident that two lasers of the same kind will emit exactly the same frequency at the same time. Now the NBS team (Evenson and Joseph S. Wells, F. Russell Petersen, Bruce L. Danielson and Gordon W. Day) has succeeded in stabilizing helium-neon lasers so that two different ones always emit almost exactly the same frequency. This is done by passing the laser light through methane gas which results in the locking of its frequency to a certain very narrow absorption line in the methane. Any other laser using the same absorption gas will give the same wavelength. The high-frequency technology developed in this series of experiments could make possible the use of light or infrared frequencies in telecommunications—perhaps as much as a thousandfold increase over the present frequency span.

While Evenson and his group were measuring the frequency of a stabilized laser, John L. Hall and Richard L. Barger, working at the Joint Institute for Laboratory Astrophysics in Boulder, were measuring the wavelength of another by interferometric comparison with the krypton lamp that serves as the international length standard. The result gives the speed of light as 299,792.4562 kilometers per second plus or minus 1.1 meter per second. The new value is 100 times as accurate as the older accepted 299,792.5 km per second.

Having the speed of light defined to the present accuracy by a repeatable experiment makes possible the fulfillment of an old desire of physicists: to use the same gauge in measuring all the dimensions of special relativity (three space and one time-like). This could be done by defining the speed of light as absolutely 299,792.4562 km per second and refiguring the standard meter in terms of it. To make such a change, however, requires international negotiation so it will be some time before it happens, if at all. □