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THE MEASUREMENT OF VELOCITY WITH ATOMIC CLOCKS¹

By Dr. HERBERT E. IVES

BELL TELEPHONE LABORATORIES

ABOUT twenty-five years ago the Physical Society held a discussion of the theory of relativity, at which widely divergent views were expressed. I recollect that Professor E. W. Morley, speaking of the Michelson-Morley experiment, declared with great emphasis that this was a *physical* experiment and must have a *physical* explanation. On the same occasion a distinguished chemist, still living, declared, as his only contribution to the discussion, that the meeting would be known in history as the last time a scientific gathering treated the ether as a subject for serious discussion.

In spite of this discouragement I shall venture to discuss my subject as Professor Morley would, in terms of an ether or fixed framework. I do this partly because I know of no way to discuss the behavior of

¹ Address of the retiring vice-president and chairman of the Section on Physics, American Association for the Advancement of Science, Columbus, December 29, 1939.

variable measuring instruments, such as atomic clocks, except by comparison with real or postulated invariant instruments. Partly also I do this because of the belief, for which I shall attempt some justification, that the ether has not yet been "abolished." I hope that even if I do not convert you to this point of view, I can enlist your sympathy for my preference for it.

It is my purpose, in the next few minutes, to discuss what happens to the measurement of *velocity* when the clocks we use for the determination of time are atomic clocks, which vary in their rate, when moving, according to a relation for which experimental evidence has recently been obtained from a study of the Doppler effect in hydrogen canal rays.²

As a preliminary to this discussion we must look at the concept of velocity and velocity measurement, as it

² *Jour. Optical Soc. America*, p. 215, July, 1938.

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