

First rendered practicable by the advances in electronic and microwave techniques during World War II, atomic frequency standards of several types were developed in the following two decades. By 1967 it had become feasible to shift the definition of the second, through international agreement, from an astronomical to an atomic basis. Indeed, by that date and ever since, the precision attainable in frequency and time measurement through the improvement and proliferation of atomic clocks has far exceeded that attainable in the measurement of any other physical quantity. Consequently, other quantities (meter, volt, ohm) are increasingly redefined, by international agreement, in terms of frequency.

The interdependence of basic physics and atomic frequency standards was attested late last year by the Swedish Academy of Sciences in dividing the 1989 Nobel Prize for Physics between Norman Ramsey, "for the invention of the separated oscillatory fields method and its use in the hydrogen maser and other atomic clocks," and Hans Dehmelt and Wolfgang Paul "for the development of the ion trap technique," which technique underlies the newest and most promising approach to making still better atomic clocks. The complex interdependence of atomic clock work and the advance of basic physics is not depreciated but further displayed if we note that, the Nobel Committee for Physics notwithstanding, the method of separated oscillatory fields, which Ramsey conceived in 1948 and which found immediate application in the cesium atomic beam clock—long the most accurate as well as the most widely employed type of atomic clock—is in fact not used in the hydrogen maser. As Vanier and Audoin appropriately and perceptively emphasize, this latter device, which Ramsey invented in 1960 in collaboration with his student Daniel Klepner, relies, rather, on a principle conceived by Robert Dicke for the same purpose as Ramsey's method of separated oscillatory fields, namely reducing the frequency spread of atomic transitions—and, moreover, conceived by Dicke with its application to an atomic clock clearly in mind.

In general, the connections between basic physics and atomic clockwork prized by the Nobel Committee are nowhere developed in greater depth and detail than in Vanier and Audoin's treatise. The authors, who have for many years headed two of the very few atomic frequency standard development laboratories that have programs of graduate instruction, have evidently elaborated this treatise out of courses of lectures for students with a background in electrical engineering. Presupposing some grasp of the electronic systems, functions, and hardware,

by means of which these devices operate as devices, Vanier and Audoin provide their readers with all the physical theory—from the Bohr atom on up—necessary to understand what, physically, is going on in the atom-filled hearts of these devices and to analyze the limits on the accuracy and stability of their operation imposed by that physics.

This conception of audience and function reflects the demography of the field of atomic clock development and application: the overwhelming majority of those working in the field are electrical engineers concerned with the electronics that make the clocks work and with the systems into which these working devices are integrated. Even the majority of that small minority concerned with "the physics package" come from electrical engineering. Yet Vanier and Audoin's treatise covers its subject so comprehensively, so connects physical theory and atomic clock technology, that it will be as indispensable to the expert as to the novice.

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