

special interest to members of the Darmstadt school.

The effect of the crystal lattice is not merely to perturb and mix the states of the free ion. Hufner gives a good account of acoustic and optical phonons, their effect in inducing the non-radiative decay of excited states, and the role they play in the transfer of energy between rare-earth ions embedded in the lattice. The specific example of TmVO_4 illustrates the Jahn-Teller effect. Hufner describes magnetic interactions between neighboring ions in considerable detail, including spin-wave sidebands. He concludes his book with a discussion of divalent rare-earth compounds and rare-earth lasers.

Throughout, the style is lucid and to the point. It is apparent that Hufner has reworked much of the material and not merely transferred it from the literature. However, it is ironic that the connection between the Slater parameters F_6 and F_6^6 , which so bedevilled the early spectroscopic term analyses, would be an example of one of the very few typographical errors. Fortunately, no misinterpretation is likely. The printing of the book is excellent and its price modest.

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Frequency and Time

P. Kartaschoff
260 pp. Academic, New York, 1978. \$24.50

During the last few decades a major revolution in the science and practice of measurement has occurred. One major component in this revolution was the change from astronomical time and the astronomical definition of *time interval* to atomic time and the definition of the *second* based on the cesium-resonance frequency at 9 192 631 770 Hz. Peter Kartaschoff has been active in the field with notable contributions to the development of cesium atomic clocks and the characterization of frequency and time stability.

Kartaschoff begins his introduction by stating: "Measurements in frequency and time are of fundamental importance for all experimental work in science and engineering. This is easily demonstrated by the fact that time as a parameter is present in most equations describing natural phenomena." I agree very much with this statement; however, Kartaschoff's attempt to cover frequency and time as a "field" in textbook fashion had to meet with difficulties. I believe that this task is not possible, because time and frequency is a topic whose *application* gives it coherence, not its *physical or technical* background. This fundamen-

tal difficulty is possibly the reason why *Frequency and Time* is, to the best of my knowledge, the first textbook attempt on this subject. The disciplines that feed into time and frequency range from fundamental quantum physics, via basic metrology, mathematical statistics, spectroscopy, circuit theory and telecommunications, to astronomy and astrophysics. The book therefore is a compendium of some of the contributions of these disciplines to the application of time and frequency.

As a textbook, *Frequency and Time* aims at the engineering student rather

than the physicist. Kartaschoff thus emphasizes statistical data analysis, time dissemination and coordination via radio signals, and electronic-measurement methods and principles. He does not focus on the underlying atomic and molecular physics, quantum mechanics and the fantastic opportunities in atomic and molecular spectroscopy opened up by and connected with atomic-frequency standards.

The most serious shortcoming of Kartaschoff's is the near-total lack of references after the year 1974, which means that its content stops at the state-of-the-



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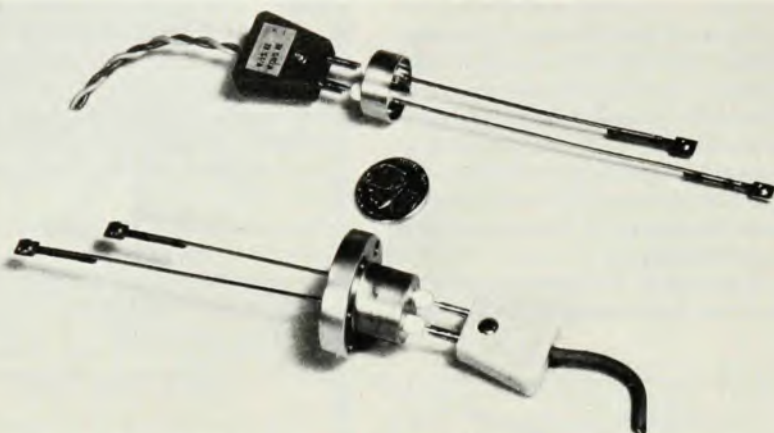
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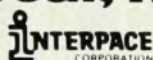


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art of 1973. In view of the important developments in time and frequency since then, the book is out of date. Kartaschoff does not mention the successful experiments in special and general relativity performed with atomic clocks in aircraft and spacecraft, the stabilities in the 10^{-16} region achieved with modern hydrogen clocks and superconducting-cavity oscillators, and sub-Doppler techniques such as two-photon absorption and trapped-ion spectroscopy. Nor does he discuss novel quartz-crystal cuts and electrodeless-resonator designs. His chapter on measurement techniques falls short of covering the low-noise circuit and measurement innovations of the last several years. The listed references are often incomplete; for example, chapter 5 has just two references, both basically unavailable from libraries.

Nevertheless, the book definitely has its value, because not only is it almost unique in its coverage of an important subject area, but also it contains a wealth of information that otherwise is difficult to find easily; in particular, this is true for the chapters on radio-signal comparison methods (ranging from radio signals to satellite techniques) and on time scales, where Kartaschoff gives an excellent historical and international perspective. The reader who is interested in time and frequency can find in this book a useful first access and a continuing reference. I encourage the interested reader to supplement his reading with the sophisticated coverage by Gernot M. R. Winkler ("Timekeeping and its Application," *Adv. in Electronics and Electron Phys.*, **44**, 33 (1977)) and James Jespersen's popularly written book *From Sundials to Atomic Clocks* (Nat. Bureau of Stds. Monograph 155 (1977), USGPO, Stock No. 003-003-01650-1).

HELMUT HELMWIG

Frequency and Time Standards Group
National Bureau of Standards
Boulder, Colorado

Science Policy: Problems and Trends

Y. Sheinin

331 pp. Progress, Moscow (US distributor: Imported, Chicago), 1978. \$4.80

The field of science studies, incorporating a variety of approaches to the study of scientific activity, has consolidated its hitherto amorphous structure during the last ten or fifteen years. Signs of this consolidation can be seen in the appearance of specialized journals (for example, *Scientometrics*, *Research Policy and Social Studies of Science*), the organization of associations (such as the Society for Social Studies of Science) and programs of specialized graduate training (such as those at George Washington

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