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Physics Through the 1990's

More than a thousand scientists participated in the preparation of the recently released *Physics Through the 1990's*.* Theirs was a labor of love and devotion that may or may not have much impact on federal support in the days of Gramm-Rudman. Their efforts resulted in a collection of eight volumes containing about 1900 pages that treats in great detail past accomplishments, future opportunities, and needs for federal support of the various branches of physics. Parts of the report are at a level designed for policy-makers. Much of it is at a level comprehensible mainly by physicists. However, there are portions of interest to scientists in other disciplines. One major theme of the publication is a multiplicity of examples of how past discoveries in physics have had important sequelae in the advancement of other branches of science and in a host of practical applications. Another facet of the report is the air of excitement that physicists are bringing to the study of the various branches of their science. Examples are especially observable in the volume devoted to atomic, molecular, and optical physics (AMO). This area of physics is highly likely to develop information, techniques, and equipment that affect other disciplines.

Physicists engaged in AMO research have much to be enthusiastic about. Their work has both fundamental significance and important practical applications. Developments in equipment and instrumentation have opened rich frontiers for study. As many as two score of different kinds of measuring equipment have been invented and produced. Perhaps most important are various types of lasers, synchrotrons, vacuum equipment capable of maintaining pressure less than 10^{-11} torr, and molecular beam techniques.

With a combination of these equipments and techniques it is possible to prepare virtually any simple molecule in any desired quantum state to study its structure, the physics that underlies this structure, and the dynamics of electrons moving in molecular fields.

Picosecond and femtosecond laser experiments can reveal how energy flows from one part of the molecule to another, the transition to chaotic vibrational motion, and the rates and mechanisms that determine the system's choice of a particular decay mode. Lasers provide highly selective excitation and interrogation schemes.

By using lasers sharply tuned to a frequency just below a particular vibrational mode of an atom or molecule, it is possible to cool the atom or molecule to millikelvin temperatures. In the very high vacuum it is possible to trap either individual atoms or ions and to make observations on them for hours at a time.

Another interesting topic for study are Rydberg atoms or molecules. These are neutral entities with an outer electron in a high quantum state, for example, $n = 100$. Such an atom has a very large diameter. It interacts with electromagnetic fields to an extent 10^8 greater than that for ordinary atoms and can be used to detect infrared, submillimeter, and microwave radiation.

Some synchrotrons produce intensities at least 10^6 greater than those of conventional sources, and even greater levels of radiation are on the way. Use of this source in crystallography will be especially helpful to biologists and chemists. Already, the structures of zeolite crystals ranging in size from 1 to 10 micrometers have been determined. Synchrotrons have also made accessible the complete spectrum between the ultraviolet and x-rays, much of which had been inaccessible.

One of the goals of AMO physicists is to determine physical properties with ever higher precision. An impressive result is the determination that space is isotropic to the speed of light. Laser interferometry has shown that space is isotropic to a few parts in 10^{15}. Of all the quantities in physics, time is by far the most accurately measured. The primary time standard in the United States is basically an atomic beam magnetic resonance apparatus. It has an accuracy of 1 part in 10^{13}, approximately 3 seconds in 1 million years.

These are only a few examples from the AMO volume, but they should convey a glimpse of the opportunities. If it is a good sample of the other volumes of *Physics Through the 1990's*, physicists have much to be enthusiastic about.—PHILIP H. ABELSON

**Physics Through the 1990's* (National Academy Press, Washington, DC, 1986).