Synchrotron Radiation Assessed

The present balance between the availability of facilities and the demand for them will last only through the end of 1984

A subcommittee* established by the National Academy of Sciences to look into the current status of U.S. synchrotron radiation facilities has found that (i) the use of synchrotron radiation has grown even faster than had been envisioned in a previous report, (ii) several new uses of synchrotron radiation that were not foreseen have emerged, and (iii) the expanding application of special devices (wigglers and undulators) can be expected to lead to new techniques possible only with the radiation from these sources. Although the subcommittee is making no specific recommendations concerning facilities, one implication is surely that an expected request from Brookhaven National Laboratory for an expansion of experimental space at its National Synchrotron Light Source should be approved.

The Academy's Solid State Sciences Committee set up the subcommittee last summer to take a rather quick look at synchrotron radiation sources, even though the newest ones at Brookhaven and at the University of Wisconsin were not yet fully operating. The timing of the study was dictated in part by a desire to have findings soon enough to have an effect on plans for expansion of existing centers, according to David Lynch of Iowa State University, who headed the subcommittee. The review is a follow-up to a more extensive study of synchrotron radiation facilities by a 1976 Academy panel. After that report there was a spurt of construction. The $24 million National Synchrotron Light Source (with two electron storage rings, one for ultraviolet light and one for x-rays) was dedicated last month at Brookhaven. A new ultraviolet and low-energy (soft) x-ray source at Wisconsin is replacing an older ultraviolet facility there. A second experimental hall has been added to the Stanford Synchrotron Radiation Laboratory. And the Cornell High Energy Synchrotron Source, which makes use of x-rays from Cornell's electron-positron accelerator, CESR, has been upgraded. There has been some concern that the United States may have overbuilt.

The subcommittee found the contrary. The number of users of synchrotron radiation has grown steadily at over 20 percent per year in the United States since 1976, when there were about 200. During 1982, the supply of x-ray experimental stations has about balanced the demand, whereas the demand for ultraviolet facilities is about 80 percent of the supply. By the end of 1984, the subcommittee foresaw, the demand for both types of radiation would exceed their availability. The projection is somewhat uncertain because funding of users is not assured.

A number of research areas were pinpointed to emphasize the belief that increased use of synchrotron radiation did not mean "just more of the same." Most of the advances have come from the development of ways to squeeze more intensity from the already very bright synchrotron radiation beams. One method for achieving this has been focusing optics for x-rays. A second has been the so-called insertion devices—wigglers and undulators. These are magnet structures placed in straight sections of a storage ring where synchrotron light normally is not emitted. The magnets in a wiggler (alternating dipoles, for example) bend the electrons through sine wave–shaped trajectories (wiggles) and thereby coax out more synchrotron light (intensity) and light of shorter wavelength (hard x-rays). An undulator acts differently. It compresses the broad synchrotron radiation spectrum from infrared to x-rays into a few, extremely intense bands. The subcommittee specifically recommended that research with these devices be pursued aggressively.

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As for the research that high synchrotron radiation intensities have already made possible, the subcommittee cited several examples. One is the use of extended x-ray absorption fine structure (EXAFS) spectroscopy for the examination of solid surface geometries. Since the EXAFS signal from a surface is swamped by that from the interior (bulk) of a sample, it has been necessary to devise a surface-sensitive detection scheme, such as the measurement of the intensity of Auger electrons emitted after the absorption of x-rays rather than the absorption itself, and to have intense x-ray beams to generate a measurable signal.

Other advances have been in crystallography. In the case of protein crystallography, researchers discovered that there is less radiation damage to the sensitive crystals when short bursts of very intense x-rays replace a more continuous but less intense beam. Not only do data come faster because of the high x-ray intensity, but crystals previously too delicate or too small to examine can now be studied. A new kind of crystallography, that of surfaces, is also opening up thanks to the high synchrotron radiation intensity. The creation of standing x-ray waves on surfaces has allowed structural studies of melting surfaces, adsorbed species, and membranes.

Finally, after years of propaganda to the effect that the pulsed nature of synchrotron light combined with its high intensity should permit time-resolved spectroscopic and structural studies, researchers are getting around to exploiting this capability. One problem has been that such investigations are feasible only when the electron beam in the storage ring consists of a single, tightly packed "bunch" of electrons, so that there is time between light pulses to observe the changes in the sample under study. Most synchrotron sources operate more easily in a multi-bunch mode or are so small that the electrons come around the ring too quickly. Another limitation has been the absence of large area electronic detectors that could record data as rapidly as it comes in synchrotron radiation experiments. However, time-resolved x-ray diffraction has been done at Cornell, and work is under way on time-resolved EXAFS.

All in all, the committee found that the promise of synchrotron radiation has not been oversold.—**Arthur L. Robinson**

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