Spectacles for a sharper microscope

Currently, the world's most powerful microscopes cannot directly resolve objects smaller than 2 angstroms in size. Because atoms in most materials are spaced roughly 1 Å apart, these microscopes can observe the atomic structure of surfaces and individual atoms only under special circumstances. Several years ago, for example, Albert V. Crewe and Michael Isaacson of the University of Chicago were able to produce motion pictures of single uranium atoms dancing across a thin carbon film (SN: 5/6/76, p. 357; 10/21/78, p. 277). Crewe has now designed a new electron microscope with a resolution of 0.5 Å, three times more powerful than any existing microscope.

Crewe's instrument, a scanning transmission electron microscope, visualizes atoms by firing a beam of electrons at a material's surface. Magnetic lenses focus the electrons scattered from the target atoms to create an image of the atoms. The improvement in resolution is possible because in 1981 Crewe invented a device, called a sextupole corrector, to remove distortions in previously used magnetic lenses. This device is analogous to the pair of spectacles a person wears to correct an eye defect. Crewe says that if the sextupole corrector is successful, microscopes with resolutions even greater than 0.5 Å should be possible. During the next three years, Crewe will supervise construction of the new electron microscope.

Fusion's future depends on materials

A recent report from the National Research Council's Energy Engineering Board, "Future Engineering Needs of Magnetic Fusion," concludes that commercially attractive nuclear fusion power is at least three decades away. Of the numerous engineering problems that remain to be solved, one of the most critical is finding appropriate materials for building a fusion reactor. "The fusion environment, particularly with regard to the radiation damage produced by high-energy neutrons, is significantly different from that encountered in any other energy system—even the fast breeder reactor," the report states. "Materials have not been developed for this application, and there is no reason to believe 'off-the-shelf' materials offer optimal performance."

Much remains to be learned about the behavior and effects of the magnetically confined, high-temperature, ionized gas (plasma) in which nuclear fusion reactions occur. In these reactions, the nuclei of lighter atoms, like deuterium and tritium, are forced together at energies corresponding to millions of degrees Celsius to form heavier elements and release energy. The neutron-absorbing blanket and the "first wall," which surround the plasma, must resist radiation damage over long periods of time. Before a safe commercial reactor can be built, a fusion engineering test reactor will be needed to test and tailor advanced alloys for reactor construction. The report notes that despite significant recent accomplishments (SN: 1/8/83, p. 21), "considerably more remains for both scientific understanding and technology development before commercial applications of fusion can be identified and engineered."

Saving gas with flywheel hybrids

University of Wisconsin researchers hope to convert a conventional compact car into a "flywheel hybrid" car with double the original gas mileage. The first step will be installation of a newly developed continuously variable transmission that shifts through a continuous range of gear ratios according to the car's speed and road conditions. The second stage involves addition of an advanced flywheel, a light disk spun at 12,000 revolutions per minute, which stores energy that would otherwise be wasted. The project is an attempt to transfer extensive flywheel research done at the Lawrence Livermore National Laboratory to industrial applications.

The inconstant sun: Subtle consequences

One of the major results of solar research in recent years has been the finding that the so-called "solar constant"—the total amount of energy radiated by the sun—is not constant after all. Its variations (ups and downs on the order of 0.1 to 0.3 percent over timespans of a week or two) are largely too subtle to be monitored from the ground, but they are clearly real, well within the sensitivity of the Solar Maximum Mission spacecraft (and others) that detected them. Far more difficult to determine, however, are the effects such changes may be having on the earth.

It has been suggested, for example, that they might have had something to do with the harsh U.S. winter of a year ago. But John A. Eddy, Ronald L. Gilliland and Douglas V. Hoyt of the National Center for Atmospheric Research in Boulder, Colo., maintain in the Dec. 23 NATURE that their direct effect on the earth's surface temperature is "too small to be significant in practical weather or climate predictions," amounting to only "a fraction of a degree centigrade." Yet even if the tiny solar-constant variations do not themselves turn out to be a predictive tool, they may well have a role in earth's climate, possibly over longer periods of time or by triggering other processes that amplify their effects.

The cited measurements date back only to early 1980, when the SMM satellite was launched, so longer-term studies would seem frustratingly difficult. But scientists readily noticed that the larger dips in the solar constant always coincided with times when large groups of sunspots were passing across the sun's disk. According to Eddy and colleagues, careful measurements of the area "blocked" by sunspots at any given time (including corrections for the spots' distance away from the sun-earth line) show a remarkable correlation with decreases in the solar constant. Sunspots, in other words, provide a readily visible "signature" of the "constant's" variations—and sunspot changes have been mapped for more than a century.

Sunspots are a key indicator of the sun's 11-year cycle of activity, but researchers have long sought in vain for clear signs of that periodicity in either regional or globally averaged temperature records of the earth. Eddy's group notes that any "coherent variation" due to "sunspot-cycle forcing" would thus seem to be extremely small (if it exists at all) on a global scale, but that there are at least hints of a pattern in a few regions that are mostly land, so that their temperature changes are more orderly.

One researcher, for example, has reported evidence for such a variation in 80 years of annually averaged surface-temperature data measured at 53 stations in northeastern North America. The mean variation is only about 0.18°C, but at least it is detectable; it is "absent or undetectable" in other parts of the continent with extended temperature records. The averaged temperature varied over a cycle with a period of 10.5 to 10.7 years, during a time when the mean period of sunspot "blocking" was about 10.6 years. (In addition, the terrestrial temperatures tended to be lower when the area occupied by sunspots on the sun's disk was higher, "almost precisely what would be expected were the temperature effect due to sunspot blocking, with a reduced solar constant at times of high sunspot numbers.") This tentative example needs to be tested on other regions and in detailed climate models, Eddy et al. point out, "but a small solar constant signal, restricted to an inland region geographically removed from the thermal inertia of the oceans and downwind of a major mountain chain is not unreasonable."

Further evidence shows in an analysis of mean monthly temperatures over the 48 contiguous states during the same time span. Record high temperatures were three times as frequent during three-year periods of minimal sunspot blocking as during sunspot maxima.

Still, though the link with the solar constant is provocative, real answers may be a long time coming.