Physics

First X-ray pattern of hydrogen solid

Very high pressures can turn a free-wheeling gas into a highly structured solid. Decades ago theorists began to predict the effects of pressure on solids made of condensed gases, but only recently have experimenters developed the tools to observe many of these effects firsthand.

At last week's meeting of the American Physical Society in New York City, researchers from the Carnegie Institution of Washington (D.C.) reported the first X-ray diffraction patterns from single crystals of hydrogen under high pressure. Obtaining the patterns was somewhat of a technical feat because hydrogen atoms have only one electron with which to scatter the probing X-rays. "Many people thought this couldn't be done," notes Carnegie's Russell Hemley. The group has also studied deuterium, xenon and neon.

Using a synchrotron to produce intense X-rays, Hemley and his co-workers have shown that hydrogen retains a hexagonal, close-packed structure at up to 260 kilobars pressure. Until now, says Hemley, theorists didn't know whether hydrogen at these pressures would have a hexagonal or a cubic structure.

The researchers also found that the ratio of distances between molecules lying along two different crystal axes decreased with increasing pressure. This compression effect, notes Carnegie's Robert Hazen, is unanticipated by normal theory and suggests that the hydrogen molecules, which rotate in random directions at low pressures, are beginning to align their rotation axes in one direction.

Hemley adds that at higher pressures, the hydrogen molecules should be pushed together so much that electrons are shared by surrounding molecules and the solid becomes metallic. He says that hydrogen studies of up to 1.5 megabars using other techniques have yet to reach this transition.

Knowing the structure of hydrogen at high pressures will provide essential information for fine-tuning theoretical quantum calculations. And coupled with studies of helium and other noble gases, the hydrogen work may help physicists describe the evolution of planets by providing equations of state, which relate a gas's pressure, volume and temperature. "So far," says Hemley, "planetary physicists have had to rely strictly on extrapolations from very low-pressure data on one end, and theoretical calculations of very high pressure on the other. Very little is known about the region, from several hundred kilobars to a couple of megabars, in between."

Why the Brazil nuts are on top

When a can of mixed nuts — or powders, balls or other particles — is shaken, why does the largest nut end up at the surface, even if it is much denser than the others? That is what researchers at Carnegie-Mellon University in Pittsburgh set out to discover with computerized Monte Carlo simulations of a shaken can containing large and small balls.

In the March 9 PHYSICAL REVIEW LETTERS, Anthony Rosato and his co-workers conclude that the size difference among balls makes it more likely that a small, rather than a large, ball will fill a void that may open during the shaking process; for a large ball to move down in the can, several small balls must simultaneously move out of the way, whereas it only takes the movement of one large ball to create a void that several small balls can fall into.

The researchers write that the extent of this size-segregation depends on the relative sizes of the balls and the distance the balls are lifted during shaking. Rosato, who is now at the New Jersey Institute of Technology in Newark, says these and other studies of size-segregation (SN: 5/3/86, p.282) may help settle some problems associated with powder mixing, which is an important part of the powder metallurgy, pharmaceutical, glass and paint industries.

Science & Society

DOD wants to boost ASAT program

"The Soviet Union has the world's only operational ASAT [antisatellite weapons] system," says Brigadier General Robert R. Rankine Jr., director of the Air Force office of space systems. This leaves the United States in the awkward position of being unable to "respond in kind" if the Soviets destroy a U.S. satellite, he says. As a result, any U.S. response may be viewed by the Soviets as a harsher-than-necessary retaliation and thereby risk provoking the escalation of a crisis.

To address this ASAT imbalance, Rankine announced earlier this month that the Department of Defense (DOD) has restructured its ASAT-development program and requested that Congress rescind its ban on the testing of ASAT components against objects in space.

The revised ASAT program, which would cost $1.2 billion over two years, would continue to focus testing on its most developed weapon, the miniature homing vehicle ASAT. (Though the actual design of these weapons is classified, they are sometimes casually described as "heavy soup cans," to collide with — and thereby "kill" — satellites.) The program would also speed studies aimed at identifying the best method for boosting the operational altitude of these ASATs, such as by launching them from the ground aboard a Pershing II missile. Finally, it would begin exploring (through the Strategic Defense Initiative program) use of excimer lasers (SN: 7/21/84, p.42) as part of a potential ground- or space-based ASAT.

Though DOD hopes to produce deployable ASATs by 1989, Rankine says this timetable is jeopardized by the current, congressional ban on testing of weapons against objects in space. But congressional arms-control analysts consider it unlikely that the ban will be removed. In fact, Rep. George E. Brown Jr. (D-Calif.) has introduced a bill requesting that the ban be extended for at least another year. Brown says the Soviet Union, which has not conducted ASAT tests since June 1982, has promised to continue its moratorium as long as the United States also refrains from space testing. He argues that with the United States more dependent than the Soviets on military satellites, "if both nations develop potent ASATs, we lose."

Low-cost oil is fueling energy worries

A major report released last week by the Department of Energy (DOE) predicts that within eight years Persian Gulf countries may again supply 30 to 45 percent of the world's oil — up from less than 25 percent today. Despite oil conservation measures adopted since the Arab oil embargoes of the 1970s, petroleum still accounts for more than half of the world's energy and 40 percent of U.S. energy. The DOE report, titled "Energy Security," says the recent fall in oil prices — at one point last year they plummeted from $25 per barrel to about $11 — has encouraged greater oil use, reduced U.S. exploration for oil (by almost 40 percent last year alone) and forced marginally economic U.S. production operations out of business.

Though the report does not suggest any solutions for reducing U.S. dependencce on foreign oil, Robert L. Hirsch, vice-president of research for ARCO Oil and Gas Co. in Plano, Tex., offers some recommendations in the March 20 SCIENCE. According to Hirsch, a former assistant administrator with DOE's predecessor agency, the best options — an oil import tax, an oil import quota, tax incentives for U.S. exploration and production, and incentives for encouraging a shift to other energy sources — all require involvement of the U.S. government, "which has in the past not performed well in such matters." Moreover, he believes, "because none [of these] are simple, because people are generally happy with lower energy prices, and because the country tends to be short-term oriented," another major U.S. energy crisis should be expected soon — "probably sometime in the early to mid-1990s."