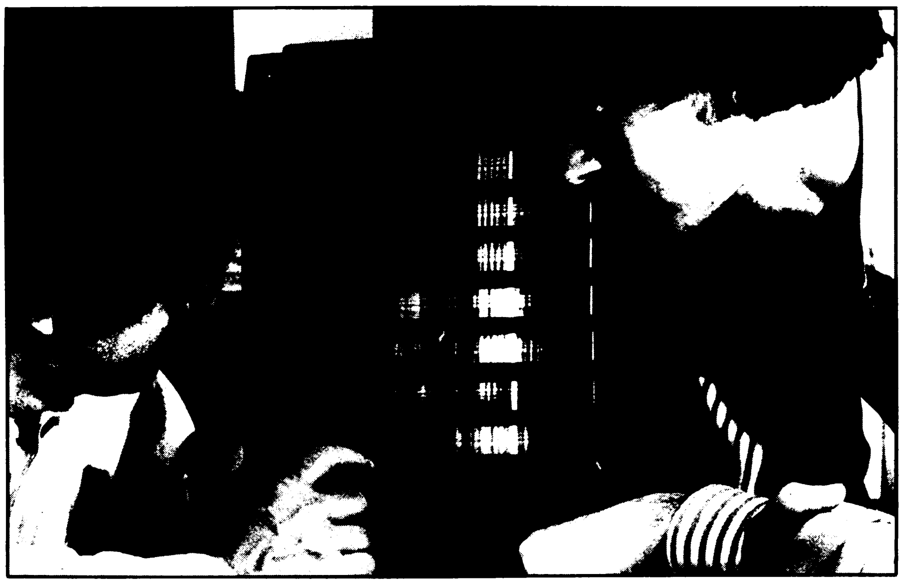
Quick look at fast reactions



IBM

Sorokin and Bethune examine "snapshots" tracing an explosive chemical reaction.

Split-second, but sophisticated, glimpses into chemistry are resulting from new laser techniques. For fast events, such as combustion in automobile engines, the action is over in a fraction of a second. One standard, but slow, technique to identify molecules and their fragments in various energy states is to observe the frequencies of infrared light they absorb. Now researchers at IBM Research Division in Yorktown Heights, N.Y., have developed a way to obtain a complete infrared spectrum from a single 5-nanosecond laser flash.

Peter P. Sorokin, Donald S. Bethune and collaborators have produced a series of infrared spectral "snapshots" that follow an explosive reaction — the molecular rearrangement of methyl isocyanide. The new technique involves two major innovations. The first is a method of generating the probe flash. The second is a way of shifting the resulting spectrum from infrared to visible light, so it can be recorded photographically.

The laser probe is a flash of infrared light with a broad, uniform range of frequencies. The sample absorbs energy from some of those frequencies, producing a characteristic spectrum. However, the infrared wavelengths of greatest interest for identifying molecules are too long to be recorded with photographic emulsion. Therefore, in the second phase of the operation the infrared spectrum is focused into a chamber filled with potassium vapor. A beam of higher-energy blue light is focused simultaneously into the chamber. Through interaction with the potassium atoms, energy from the blue light is added to the infrared, and the spectrum shifts into the visible region. The spectrum's shape, which contains the information about the sample's composition, remains virtually unchanged, the scientists report.

The IBM scientists believe that the technique, possibly using cesium or rubidium in addition to potassium, can be extended to include all of the most useful infrared spectral range. It may be applicable to studying processes in petroleum refining and other high-temperature reactions. The technique complements another recent "split-second" laser method — nanosecond X-ray investigation of the structure of biological or crystalline materials (SN: 5/19/79, p. 324). □

Uranus: Rings of gas?

On July 11, the Pioneer 10 spacecraft will cross the orbit of Uranus, some 2.9 billion kilometers from the sun. The planet, however, will be almost as far away from the probe as it can get, 172° around the sun and about 8.7 billion km across the solar system. The first spacecraft from earth to pass close to Uranus will do so no sooner than the tentatively scheduled 1986 encounter of Voyager 2.

Yet Pioneer 10 still has a contribution to make, studying the effects of the sun from greater distances than any probe before it. A major discovery would be the heliopause — the point at which the sun's influence ends, to be replaced by the interstellar medium. The 259-kilogram vehicle's nuclear power supplies are still healthy, so its radio signals may still be detectable with sensitive earth-based receivers when it passes Pluto's mean distance from the sun (nearly six billion km) in 1987. But some scientists (including some members of the Pioneer 10 team) believe that the heliopause is probably more like 15 billion km out, by which distance the spacecraft's messages may well be undetectable even if the probe survives that long.

Uranus, meanwhile, is a target of growing interest, though Pioneer 10 will not get a look at it. The planet is essentially tilted on its side — its "north" pole, defined relative to its direction of rotation, is actually pointed about 8° *south* of the ecliptic — and researchers are still puzzling over the improbable geometry of what appears to be a set of strangely dark rings discovered in 1977. Voyager 2's trip to Uranus is only a possible option (depending on the condition of the spacecraft and on the performances of Voyagers 1 and 2 during their encounters with Saturn in 1980 and 1981), but the rings have upped the project's interest.

A major issue regarding the rings is how they can exist at all. There seem to be nine of them, all extremely narrow (many of them perhaps as skinny as 1 km) and apparently less reflective than the blackest coal dust. The hitch, however, is that some seem to be elliptical while others are round — a strain on current understanding of celestial mechanics. One tentative suggestion to explain the odd arrangement has been that the rings may actually be interspersed among several small, yet-undiscovered satellites, whose gravitational effects might account for both the rings' thinness and their varied shapes.

Now another suggestion has been put forward, and it is, in a sense, as exotic as the first. Thomas C. Van Flandern of the U.S. Naval Observatory in Washington has raised the possibility that the "rings" are not rings at all in the conventional sense. Instead of being composed of numerous solid chunks, he proposes (in the June 8 SCIENCE) that perhaps they consist of gaseous material given off by an individual satellite in each "ring" orbit, much like the sulfur torus that follows the orbit of Jupiter's moon Io.

The most conspicuous difficulty with Van Flandern's proposal stems from the fact that the rings were discovered when they successively blocked off (occulted) the light from a star that was being observed in studies of Uranus itself. One of the original observers, Edward Dunham of the Massachusetts Institute of Technology, says that the star, passing behind each ring, dimmed to its minimum brightness in as little as one kilometer, seemingly a rather sharp cutoff to be ascribed to a cloud of gas. Van Flandern, however, believes that the effect is possible — not by the gas's blocking the star's light as would a solid object, but by "refractive defocusing" — essentially blurring the light until it disappears. "It is this defocusing effect," he says, "which causes the umbra of earth's shadow cast on the moon during a lunar eclipse to be more than 100 km larger in radius than earth's solid body. Even the tenuous atmosphere above 100 km, although it cannot absorb or scatter significant sunlight (nor be seen by astronauts), can still effectively defocus sunlight."

Van Flandern, then, envisions a series of small satellites around Uranus, each giving off gas molecules that concentrate in its own orbit. The individual molecules, however, would follow slightly different paths, so that the ones coming from satellites in elliptical orbits would travel in a variety of ellipses; these ellipses would precess (turn) at slightly different rates, and in time cause the gas ring's overall elliptical shape to smear out into something more like a circle. Since some of the rings are still measurably elliptical, Van Flandern suggests that the gas molecules must be sent into the ring, removed from it and replaced with new ones at a relatively rapid rate. This would mean that each molecule would spend only a short time in the ring, so that it would not have time to rotate far out of alignment with the ring's orientation.

All in all, it is an unconventional hypothesis, and there are frustratingly few data even about other solar-system objects to indicate whether it could work. A 1971 stellar occultation by Io and others by planetary atmospheres such as Jupiter's, says Van Flandern, have produced anomalies that one might interpret as defocusing effects, but it is difficult to be sure, or even confident. So the answer may depend on Voyager 2 (Voyager 1 will miss Uranus by 27° in 1984, Pioneer 11 by 9° in longitude and 16.6° in elevation the following year), unless refined earth-based techniques or the shuttle-launched, earth-orbiting space telescope shed new light on what has come to be seen as one of the solar system's most unusual members. □

Cocaine: The dangerous snort

Cocaine, the trendy means of getting high among those who can afford the costly white powder, is considered relatively safe by many — primarily because little is known about the drug's effects on the human body. But now, perhaps one of the strongest indictments to date against coke is reported by two physicians in the Dade County (Fla.) medical examiner's office.

Contrary to what much of the public and some doctors believe, cocaine can cause death, Ronald K. Wright and Charles V. Wetli report in the June 8 JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION. The physicians analyzed the case records of 24 persons who died between 1969 and 1978 after using cocaine *alone* (another 29 died after using cocaine in combination with other drugs).

The investigation indicates that cocaine can kill when injected (11 persons), swallowed (seven persons) *and* snorted (five persons) (the method of administration was undetermined in one case). Death due to snorting cocaine is particularly surprising, since many have felt that snorting is the safest way to take the illegal drug.

But, Wright and Wetli report, most of those who snorted coke before dying suffered terminal convulsions, without warning, between a few minutes and one hour after inhaling the powder. The same type of delayed seizure was seen among those who swallowed the drug — many of these people, however, had swallowed massive amounts in order to avoid detection by the police. Those who died after injecting coke usually collapsed within a few minutes after injection and died after one to three hours of coma.

Persons who died after snorting had snorted the drug at least twice during the preceding hour, report the researchers, and had average blood concentrations of cocaine somewhat higher than those who injected it; the highest levels were seen among those who swallowed large amounts. The researchers suggest, however, that there is no absolute level known to be lethal; previous studies reflect a wide range of dosages and blood levels among victims, and all those in the Dade County study fell within that range. The injectors actually had lower cocaine blood levels than the others, but they died faster — suggesting "that a relatively rapid increase in blood level may be as important in determining fatal reaction as the peak blood concentration attained," say Wright and Wetli.

"In evaluating the individual case, factors other than blood concentration of cocaine must be considered," they note. "These include tolerance and reverse tolerance, previous history of cocaine use, individual susceptibility and presence of other drugs." In addition, they point out that street cocaine is usually cut with various sugars or lidocaine; but they determined that "lidocaine plays little if any role in deaths resulting from recreational use of cocaine."

They also note that unlike other drugs, cocaine rarely seems to trigger serious nonfatal reactions — it appears as though there is little middle ground between no adverse reaction and death in coke use.

"The toxic and potentially fatal consequences of cocaine were well-known to pharmacologists and physicians during the first quarter of the century," say the researchers. "This report again demonstrates that cocaine cannot be regarded as a safe recreational drug despite current belief and legal controversy." □

Argonne makes 'heavy' move

For those missing the excitement of the space race, there's another competition to place your wagers on — the fusion race.

For the last several years, laboratories across the United States have been vying with one another to either contain a plasma or implode a fuel pellet with lasers or charged-particle beams. All are in search of the most commercially feasible method of bringing the sun's own private energy source down to earth.

The latest move toward this goal has been made by the Department of Energy's Argonne National Laboratory. Its heavy-ion fusion group recently accelerated a well-collimated beam of xenon ions to an energy of 1 MeV at a current in the tens of milliamps. Argonne researchers believe it is the most powerful beam of its kind.

Production of the beam demonstrated that Argonne now has an adequate source of ions for its fusion reactor concept called HEARTHFIRE (High Energy Accelerator and Reactor for Thermonuclear Fusion with Ion Beams of Relativistic Energy), which is designed to shoot heavy ions at tiny pellets containing deuterium and tritium. This should release immense amounts of energy as the heavy hydrogen implodes to 1,000 times its normal density.

Argonne physicist Richard C. Arnold, one of the originators of the HEARTHFIRE project, says, "The next stage in our design concept is to inject this 1 MeV beam from the pre-accelerator into a radio frequency linear accelerator where the ions will be boosted to even higher energies." Before hitting the pellets, the ions must reach an energy of 10 GeV.

With DOE funding, Argonne will be constructing the linear accelerator and two storage rings during the next three years. After various stages of testing through the early 1980s, the heavy-ion group hopes to demonstrate workable fusion (more energy out than is being put in) by 1986 or 1987.

Heavy-ion fusion is the latest entry in DOE's effort to find the most appropriate design for a commercial fusion reactor. Other concepts include magnetic confinement of a plasma and the development of powerful lasers to implode fuel pellets. But Arnold is not worried that they're the newcomers. "Over the last year, DOE has reorganized its priorities. In the future, we'll be getting much more emphasis. One main reason is that we don't have to design our equipment from scratch. Almost all of it is based on the accelerator and storage ring technology which has come out of particle physics research."

In the June 7 NATURE, Arnold commented on the question of light-ion versus heavy-ion fusion. To Arnold, light-ion use has the edge in time, whereas heavy-ion fusion will be more feasible in the long run. "The pulsed-power technology used in these light-ion experiments is relatively inexpensive.... As a consequence, fusion target experiments with light-ions will probably be done much earlier than in the U.S. heavy-ion programme. The latter technology, however, has many potential advantages for commercial reactor design." □