Infrared spectrograms cause jubilation

Astronomy began with what can be seen. Modern astronomers have sophisticated techniques for extracting information from the radiation emitted by astronomical bodies, but even they still like to see a photograph now and then. It is not necessary to repeat the ancient Confucian wisdom, but a single picture does contain many thousand bits of information at a glance. And a spectrogram in which all the absorption and emission lines of a given source are laid out in order and proportion is extremely useful to astronomers.

The trouble with infrared is that it isn't visible. Some of the nearer infrared is amenable to photographic techniques, but most of what astronomers want to measure isn't. There's no way to get a "picture" of things in the infrared, and spectroscopic techniques, when possible, are extremely cumbersome. What infrared astronomy needs is an efficient upconverter, a device to translate infrared wavelengths to visible ones.

During the Memorial Day weekend an experimental device of this sort underwent a highly successful test in a special laboratory at the Optical Sciences Center of the University of Arizona at Tucson. It was developed by Thomas R. Gurski of the University of Arizona, Stephen P. Maran of the NASA Goddard Space Flight Center and Harland W. Epps of the astronomy department of the University of California at Los Angeles. In Maran's words the result was "beyond my expectations." Originally the three had intended to leave the project after the test (money being tight) and hope that they or someone could pick it up in the future for further development. The test has made Maran so enthusiastic that he is negotiating for funds to be transferred to the University of California, where he will be on a sabbatical next year, so that the project can continue without interruption.

"I hold in my hands the first infrared spectrograms in the world," Maran told Science News shortly after returning from Tucson. Well, not quite the first. In 1972 a Russian group reported some, but they used a technique that required piecemeal work, a few lines at a time. The Gurski-Maran-Epps device has the advantage that it works in real time, converting a wide range of wavelengths simultaneously. Other attempt at upconverters are under way in the United States too, but Maran says they all must do one wavelength at a time, stopping to readjust the equipment at each step. The Gurski-Maran-Epps device has the potential of taking a spectrogram or an infrared "photograph" of a celestial source at one shot.

The basic principle will be familiar to those who have worked with heterodyne radio receivers. The instrument feeds the radiation from the source under observation and light from a laser into a crystal (lithium iodate in this case) that has peculiar optical properties. The crystal is able to take the two input wavelengths, add them together and produce a signal at the sum wavelength.

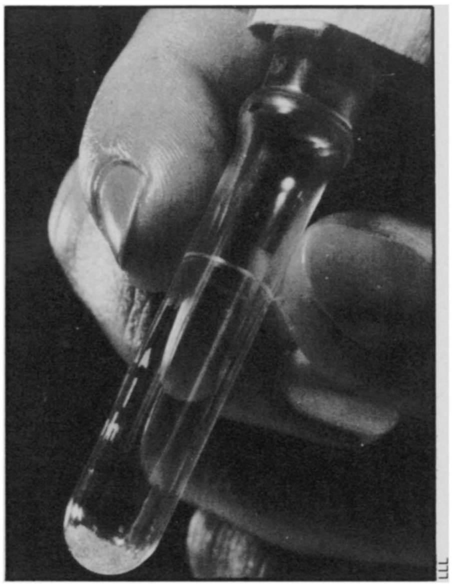
This property is, to use the physicist's term, highly nonlinear, which means that much energy has to be put into the crystal to get a usable sum signal out. The laser, designed by Gurski, that does this is itself "an innovation in laser technology," says Maran, and he expects it will find many other uses besides upconverters. It is a neodymium:YAG laser designed for maximum efficiency in a mode in which the beam cross section is a smooth curve that produces an ideally shaped wavefront for signal matching. Most laser beams have inconvenient spikes, produced, for example, by thermal and mechanical stresses induced by the supports that hold up the lasing rod. Gurski got around this by doing away with the supports. He took a second, nonlasing, neodymium:YAG rod, polished its surface and placed it against the lasing rod. The two rods are held together by atomic forces and the nonlasing rod is run out the end of the chamber and mechanically supported.

Another important point in getting the high efficiency and realtime capability is that source, laser and output are all in the same line instead of being at angles to each other.

At present the apparatus is so big it takes a pick-up truck to carry it. One of the major developmental goals is to reduce it to a more practical size.

The laser beam is 1.06 microns, and the source beams are typically between 3 and 5 microns so the output runs between 8,000 and 8,700 angstroms. This is on the verge of being red, not quite visible to the human eye, but amenable to usual optical techniques. The spectrograph, supplied by Epps, is a regular 8,000-angstrom spectrograph. The tests were run on laboratory samples of nitrous oxide, methane (loaned by Uwe Fink) and polystyrene plastic. Maran estimates it will be another year before tests can be run on astronomical sources. □

Laser-enriched uranium: Visible amount



Enriched uranium (in bottom of tube).

The battle to replace clumsy, conventional methods of enriching uranium so that is can be used in reactors has finally broken through a veil of secrecy and now is in the open. Last year, Lawrence Livermore Laboratory (LLL) made the first public announcement of uranium enrichment using lasers (SN: 6/22/74, p. 396). But now Jersey Nuclear-Avco Isotopes, Inc. claims to have performed the first successful enrichment experiment as early as 1971 and to have patented its process in 1973. Not to be outdone, LLL now announces enrichment of the first visible quantity—four milligrams—of uranium (previous microscopic quantities had to be detected and analyzed by mass spectrometer). The announcements were made at last week's Conference on Laser Engineering and Applications in Washington.

Jersey Nuclear-Avco Isotopes, Inc. is a joint venture of the Avco Corporation and Exxon Corporation. G. Sargent Janes of Avco described the experiment, which he said produced uranium with a 50 percent isotope enrichment of useful U-235 in its mixture with the naturally more abundant U-238. Tuned dye lasers selectively excited electrons around U-235 atoms in a hot uranium vapor and then a nitrogen laser was used to pull these electrons completely away from their parent atoms. The resulting ions of U-235 were then easily separated by an electric field. Janes would not talk about later work, presumably because of proprietary interests of his company.

Livermore researchers said they had made a 10 million-fold increase in the production rate of enriched uranium since their announcement last year. The new experiment produced four milligrams of enriched uranium in about two hours. The enrichment was about three percent U-235—reactor-grade fuel. In a process similar to the Janes experiment, a xenon laser was used to excite U-235 atoms and a krypton laser to ionize them. The results were reported by Livermore physicist Sam A. Tuccio, who led the experiment.

Large-scale laser uranium enrichment is still in question because of economic considerations. "This technology is in its infancy," says Tuccio, "and it would be very premature to settle on one laser method as the only way to go." □