SCIENCE NEWS of the week

A Cold Eye on the Hot Sky

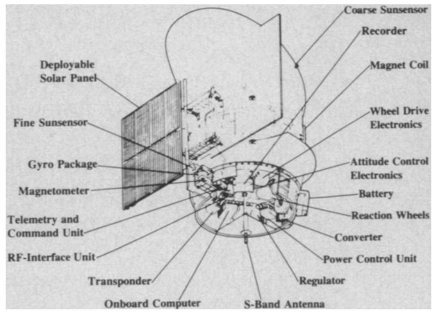
The sky, to an observer in the infrared region of the spectrum, is a panorama of life and death. Stars a-borning, too young for the process of gravitational collapse to have yet triggered the thermonuclear reactions that will one day make them visible beacons in the heavens, already are sources of heat. Dying stars, near-exhausted of the self-fuel that has sustained them for billions of years, eject large clouds of dust that mask their fading fires; yet that same dust is also warmed by the ebbing energies, forming at least a transitory epitaph in the infrared.

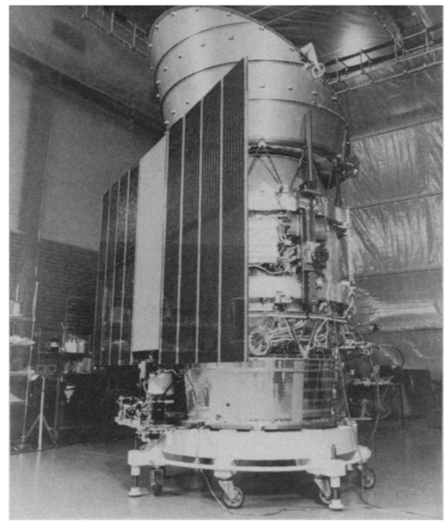
Virtually everything, in fact — except truly empty space — emits infrared radiation. Sources completely invisible to even the sensitive eye, as well as to detectors of ultraviolet light, X-rays and gamma rays, nonetheless send forth at least minute amounts of heat.

For infrared astronomers studying such tiny traces, the problem is twofold: to build a detector whose own warmth will not obscure the very radiations that are the whole reason for looking, and then to set that detector free of earth's atmosphere, which filters out most of the thermal message before it ever reaches the planet. Observations have been made from high mountains, from aircraft, balloons and sounding rockets, but all have been limited either in the coldness of sources they can see, or in the amount of sky they can cover in their brief time aloft, or both.

On Jan. 25, however (if the present schedule holds), a satellite is to be launched on what is planned as the first survey ever of the entire sky at infrared wavelengths. And according to the National Aeronautics and Space Administration, U.S. participant in the complex, trinational venture, the Infrared Astronomy Satellite (IRAS) should be able to detect "all important infrared contributions in the universe."

The development of IRAS has been a frustrating, demanding challenge. Launching it is straightforward enough, but the goal of its planners ever since its inception





Illustrations: NASA

Above photo shows IRAS on the ground in Holland; diagram details components.

a decade ago has been to provide an observing device capable of studying IR sources so faint that its detectors must operate at a temperature of only 2° Kelvin (−455°F) — two degrees above absolute zero. And do so, unattended, in space.

The heart — and most of the guts — of IRAS is its telescope, which comprises 810 kilograms of the satellite's 1,076-kg weight. A significant portion of the telescope's baggage allowance, however, is devoted to ways of keeping it cold, a necessity if its subjects are to include such faint beacons as embryonic stars. Enclosing the instrument is a cooling vessel, or dewar, in the form of a cylinder or high-sided doughnut whose hollow walls are filled with 475 liters of superfluid helium coolant (at 2K), which is also a heat conductor 1,000 times more effective than silver, the best metallic candidate. Even in orbit, with essentially zero gravity, the helium will form a thin film, clinging to the inside walls of the dewar and maintaining an even temperature throughout. Even a few degrees of heat, however, will cause some of the helium to vaporize, and it is the expected rate at which that helium is lost (vented through a specially developed, sintered stainless steel plug) that has determined the satellite's expected maximum operating lifetime of about seven months.

But the helium is not enough. Keeping the detector temperature low enough meant limiting the heat flow to the telescope's focal plane to less than a tenth of a watt. Thus the helium tank is in turn mounted within an evacuated main shell, and kept from touching it by a harness of fiberglass-epoxy straps. Also between the tank and shell are 57 layers of aluminized Mylar and Dacron netting, with the whole thing cooled additionally by vaporized helium vented from the tank. Yet another insulating blanket separates the dewar's bottom from the heat of the satellite's electronics boxes, which are further wrapped with insulation.

Past IR observations from space have used detectors cooled down to about 12K, says Peter Mason of California Institute of Technology, noting that the 2K at the IRAS focal plane offers about a 90-fold improvement in signal-to-noise ratio. Without that gain, he says, trying to achieve the demanding goals of the IRAS scientists "would be like trying to do visible-light observations with a telescope made of fluorescent tubes, with glowing mirrors."

IRAS even has to be careful where it looks. A glance at the sun would be fatal, vaporizing all the helium and bringing the observations to an abrupt halt. To be sure the sun stays out of view, the satellite will be placed in an orbit that keeps it circling over the earth's day-night dividing line, so that the telescope can always point 90° away from the sun while allowing IRAS's solar panels to keep facing in a sunward direction.

But light reflected from the earth and moon is off limits as well. Even Jupiter is bright enough, which means warm enough, to ruin observations in its vicinity, says program scientist Nancy Boggess of NASA, so "we hope to avoid it."

This does not mean that IRAS will avoid everything in the solar system, however. It may very well detect "thousands upon thousands of asteroids that have never been seen before," according to Boggess, and Dennis Matson of Jet Propulsion Laboratory says the IRAS may enable sizes and albedoes to be determined for many of the almost 3,000 asteroids already known. The satellite is not expected to yield orbits for the newly discovered ones, but it will provide spectral data about their surfaces.

The telescope carries detectors in four IR spectral bands: 8.5-to-15, 19-to-30, 40-to-80 and 83-to-119 microns. An additional instrument package provided by the Netherlands (builder of the satellite itself) will include a low-resolution spectrometer (7.4-to-23 microns); a two-channel (41-to-62.5 and 84-to-114 microns) photometer for both absolute and differential photometry; and a short-wavelength (4.1-to-8 microns) photometer provided to measure the distribution of stars in regions where they are densely packed.

The results from IRAS are expected to bear on a wide range of astronomical questions, from the birthrate of stars in our Milky Way to the total mass of the universe. Quasars are particularly bright IR

TYPICAL IRAS ORBITS

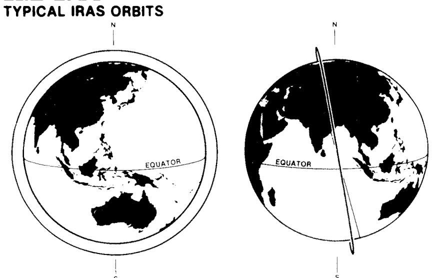


Diagram shows IRAS orbit initially (left) and 3 months later, when orbit's slow precession has kept telescope's view 90° from sun with sunlight on solar panels.

emitters, and many astronomers associated with the program are anticipating the discovery of IR sources of as yet unknown varieties.

The telescope was built and provided by the United States, where JPL is the project manager and is responsible for most of the data processing. (NASA will also handle the launching, using a Delta rocket.) The Dutch-built satellite will be controlled from the United Kingdom, whose Rutherford and Appleton Laboratory at Chilton, about 30 km south of Oxford, will also be the site of the principal tracking facility and of preliminary data-analysis activities.

Hopes for IRAS are high. Project officials do not boggle even at suggestions that the number of discrete sources discovered by IRAS could be so large as to significantly increase the total number of known sources at all wavelengths in the universe. And IRAS seems likely to represent the beginning of the explosive development of IR astronomy from space. The European Space Agency is considering an IR satellite of its own (with three times IRAS's lifetime); the Shuttle Infrared Telescope Facility is under development for the space shuttle; and planned for about 1988 is a NASA satellite called the Cosmic Background Explorer, designed for wavelengths from infrared to radio, looking at remnant emissions from the universe's origins. That one, Boggess says, is likely to be "the most exciting venture into space that I will probably see in my professional lifetime." *—J. Eberhart*

Phosphate ban stays

In a 4 to 2 decision issued Jan. 5, the Michigan Supreme Court upheld the state's right to ban phosphate-based household laundry detergents. Michigan banned the detergents six years ago in an effort to improve Great Lakes water quality by lowering the phosphorus levels in wastewater entering the lakes. (Eutrophication, a process that can lead to oxygen starvation of water life, is promoted by the overloading of nutrients — especially phosphorus—into lakes.)

Whether the ban was justified or effective was not at issue, notes Susan Peck Iannotti, the attorney who successfully defended the state law in an earlier contest before the state appellate court (the current ruling reaffirms that earlier decision). The plaintiffs — mainly detergent manufacturers — had challenged only whether the state constitution allowed the governor to transfer authority for regulating the phosphorus content of detergents from the Water Resources Commission to the Natural Resources Commission, and whether the state could legally set a more restrictive phosphorus-content standard — 0.5 percent phosphorus by weight — than the 8.7 percent level contained in the state's Cleaning Agents Act. □

Soviet nuclear spacecraft fragments, falls

Pieces of a Soviet, nuclear-powered spy satellite are circling the earth and may reenter the atmosphere late in January. The impending crash threatens to spread hazardous radioactive debris over a wide area. The reentry of a similar satellite in 1978 contaminated a sparsely populated region of northern Canada and cost several million dollars to clean up.

The troubled spacecraft, Cosmos 1,402, was launched Aug. 30, 1982. Its nuclear reactor used about 100 pounds of enriched uranium fuel to provide the electrical power necessary for its radar ocean surveillance system. Normally such a satellite operates for six months. Then the reactor is shut down, separated from the rest of the spacecraft and boosted into a higher orbit where it should be safe for at least 500 years. However, a malfunction prevented Cosmos 1,402 from ejecting the reactor section, and on Dec. 28, observers noted that the satellite had separated into three pieces, all in the original, low, 155-mile orbit.

Last week, after intelligence sources at the Department of Defense revealed that the satellite was in trouble, the Soviet official news agency, Tass, confirmed that the satellite was in fragments, but insisted that the pieces would burn up in the atmosphere as they fell. The North American Aerospace Defense Command predicted that the bulk of the spacecraft, including the reactor, could reenter the atmosphere between Jan. 23 and Jan. 25. Later, a Defense Department source reported that the smallest piece had already entered the atmosphere and burned up.

Maj. Douglas Kennett, a Defense Department spokesman, says, "We will not know, nor be able to make a prediction, as to when [the spacecraft] will reenter until just a few days ahead of time, as we continue to watch the decay of its orbit. It'll probably be only a few hours ahead of time that we'll be able to make any sort of guess as to exactly where that debris, if it does not burn up, might impact."

The spacecraft's 65-degree orbital inclination means that the satellite may reenter anywhere between 65° north and south latitude. Most of the world's population lies within this band, but the debris is more likely to fall in an ocean than on land. *—I. Peterson*

NRC sets safety goals for nuclear reactors

The Nuclear Regulatory Commission, by a 4 to 1 vote, approved this week a policy statement on safety goals for the operation of nuclear power plants. The statement focused on acceptable levels of risk to public health and safety and the tradeoffs between cost and safety involved in making regulatory decisions. The NRC also approved a two-year plan for evaluating the usefulness of specifying safety goals for future regulation and licensing of nuclear reactors.

The statement was a response to recommendations from a presidential panel that investigated the 1979 accident at the Three Mile Island nuclear power plant (SN: 12/15/79, p. 405). The panel called for an explicit statement of the NRC's safety philosophy. Commissioner John F. Ahearne said the new policy was a test to see if a few easy-to-understand goals and numerical standards could be used to establish with confidence the safety of nuclear reactors. However, Victor Gilinsky, who voted against the policy, complained, "I don't think it's a well thought-out program."

The policy statement specifies that risks from operating nuclear power plants should be comparable to or less than the risks of generating electricity by "viable competing technologies," namely coal-fired plants. The risk to the population in the area near a nuclear power plant of cancer fatalities that might result from reactor operation should not exceed 0.1 percent of the sum of cancer fatality risks from all other causes.

As one consideration in its decisions on safety improvements, the NRC also adopted for trial use a cost-benefit guideline of "$1,000 per person-rem averted." This means that each reduction in potential radiation exposure of 1 person-rem (a measure of the average radiation dose per person multiplied by the total population affected) justifies the expenditure of $1,000 for safety improvements. (The average person receives a radiation dose due to natural "background" radioactivity of 0.1 rem per year.)

In addition, for the benefit of NRC staff evaluating nuclear power-plant risk assessments, the NRC set a limit on the allowable probability of a serious nuclear accident. The statement specifies that the likelihood of a nuclear accident that results in large-scale melting of a reactor's core should normally be less than one in 10,000 years of reactor operation. Of 13 plants already studied, three do not meet the requirement.

In a letter to the NRC, the Advisory Committee on Reactor Safeguards, a group of senior, outside experts that advises the NRC, criticized the policy statement and urged tighter standards. The committee noted that the final statement no longer contained the idea of making operating risks "as low as reasonably achievable." The group argued that the omission of this concept "fails to recognize a general, societal trend to aspire to improve safety." *—I. Peterson*