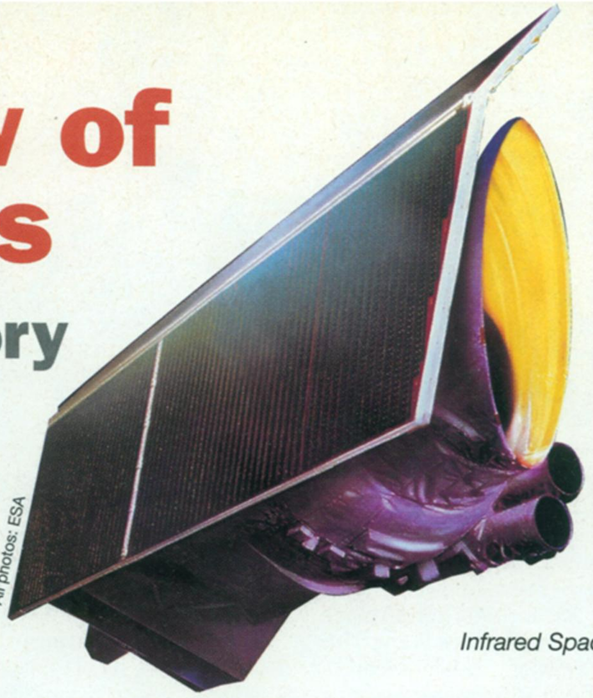
A Cool View of the Heavens

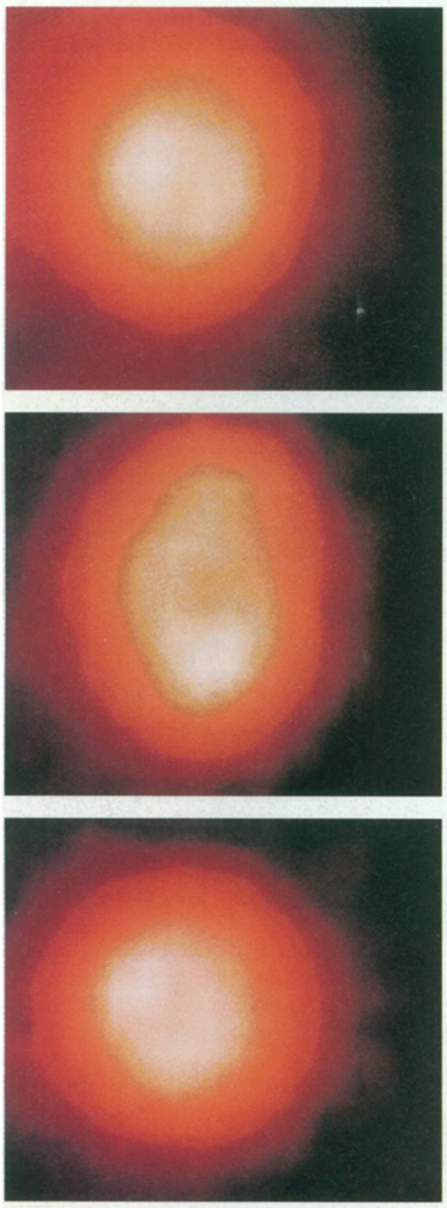
Infrared observatory spies a hidden universe

By RON COWEN



All photos: ESA

Infrared Space Observatory.



Every time the Infrared Space Observatory (ISO) slews from one target to another, it discovers new objects in the seemingly empty voids of space. This telescope, often dubbed Europe's answer to the Hubble Space Telescope, has opened a new window on the universe.

Last month in Villafranca, Spain, the European Space Agency presented the first findings from the mission, which was launched last November and still has over 18 months to run. Among the observations are spectacular images of colliding galaxies and stellar nurseries, as well as a new view of Saturn.

Although ISO has only one-sixteenth the light-collecting area of Hubble, the $1 billion observatory can see infrared emissions to which the space telescope is blind. Because these wavelengths are low-energy emissions, they reveal long-duration, subtle activity in their sources. This capability enables ISO to detect some of the chilliest objects in the universe and lay bare parts of the cosmos hidden behind dust.

The coldest bodies in the heavens—ranging from planets and failed stars to interstellar gas clouds—emit little visible light. In ultraviolet light and X rays, they're even fainter. Only in the infrared do these objects boldly announce their presence by radiating energy.

"You're looking at something which is at the temperature of dry ice, and you're measuring the heat coming from that—except that this object is millions of light-years away, and the stuff is distributed so tenuously that you can almost look through it," notes ISO mission scientist Martin Harwit, former director of the Smithsonian Institution's National Air and Space Museum in Washington, D.C.

The telescope reveals other parts of the invisible universe by penetrating the veils of dust that hide newborn stars and shroud the hearts of galaxies. Hot, young stars radiate most of their energy at visible and ultraviolet wavelengths. But the dust surrounding the newborns absorbs these emissions, reradiating their energy in the infrared.

Similarly, the telescope sees through dust that may mask a tumult of activity at the

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Dying star

When stars similar in mass to the sun grow old and run out of fuel, they cast off a cloud of gas and dust known as a planetary nebula. Recently ISO took images and spectra of the planetary nebula NGC 6543, which lies about 3,000 light-years from Earth in the constellation Draco. The pictures show a variety of features of the nebula, depending on the wavelength imaged.

At 10.5 micrometers (top), the camera detected emissions from ionized sulfur atoms. This pattern of emissions reveals the spherical shell of ejected material. A snapshot at 12.8 micrometers (middle), which reveals emissions from ionized neon atoms, shows that the nebula is elongated by oppositely directed jets of gas squirting out from the poles of the dying star. At 15 micrometers (bottom), arms of warm dust protrude in several directions, indicating regions where newly ejected matter interacts with material previously released by the star. Spectra taken by ISO's short-wavelength spectrometer, measuring from 3 to 45 micrometers, show the signature of argon atoms as well as sulfur and neon.

Galaxies in collision

This image, captured by ISO's camera, shows an act of violence 60 million light-years from Earth. Two galaxies, designated NGC 4038 and NGC 4039, but better known as the Antennae galaxies because of their streamers of stars, have smashed into each other. Other telescopes had revealed that the titanic collision crashed together clouds of gas and dust, generating intense waves of starbirth known as starbursts.

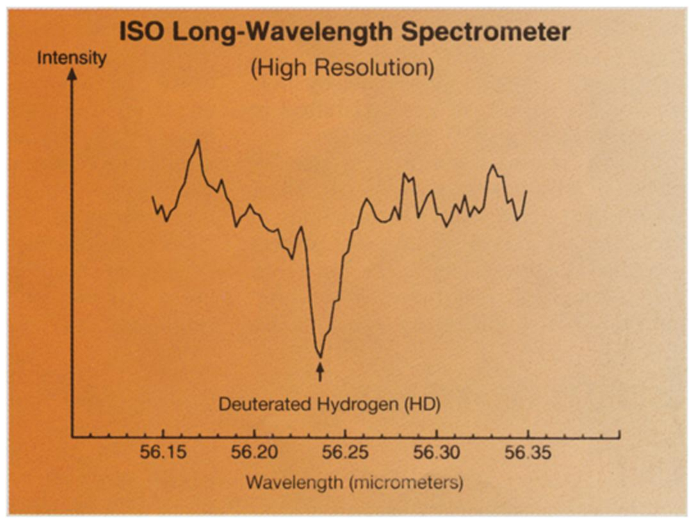
An elongated, bright region in the lower galaxy, NGC 4039, along with a hot spot at right, marks a region where the two colliding galaxies have merged. This region bore the brunt of the impact and thus has the bulk of the star formation. The image also reveals an isolated region of intense star formation near the center of the upper galaxy, NGC 4038.

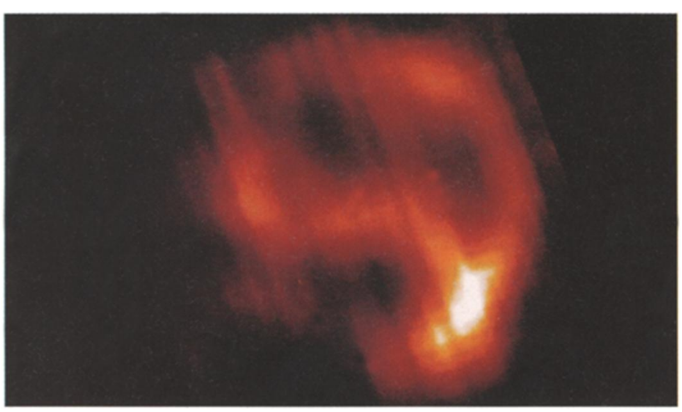
Probing Saturn's atmosphere

Lit by the sun, Saturn makes a striking image in visible light. In the infrared, however, Saturn's internal heat sets the ringed planet aglow, generating an even brighter image. By detecting narrow gaps—lines of absorption—in the planet's infrared emissions (right), ISO's long-wavelength spectrometer identified the fingerprints of several molecules in Saturn's atmosphere, some of them never before seen there.

One discovery was deuterated hydrogen, a molecule that consists of an atom of ordinary hydrogen paired with an atom of heavy hydrogen, or deuterium. All deuterium in the universe was created in the first few minutes after the Big Bang. By the time Saturn formed, stars had burned up some of that initial supply. Thus, the amount of deuterium acquired by Saturn may reveal the amount present in the early universe, as well as details about the formation of the solar system.

The long-wavelength spectrometer on ISO also detected phosphine and ammonia in Saturn's atmosphere, two molecules that previously had proved difficult to identify.





Hidden features of a remnant

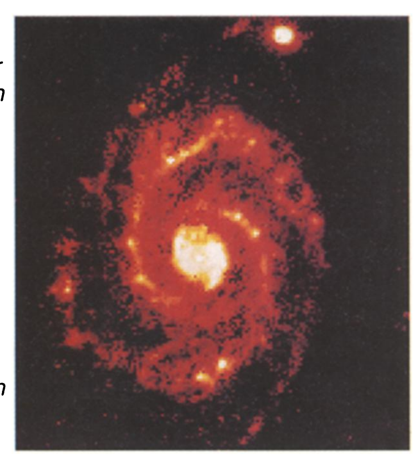
ISO's photometer took this snapshot of debris (above) left over when a star exploded as a supernova. In a supernova explosion, the interior of a massive star collapses, but its outermost layers of gas and dust are hurled into space to form a supernova remnant. The remnant pictured here, known as MSH 11-54, resides about 10,000 light-years from Earth. It has a diameter of about 7 light-years and is expanding rapidly. Although observations in visible light don't reveal the remnant, it has been well studied by X-ray telescopes in space. ISO highlights the luminous regions where material from the remnant has smashed into clouds in interstellar space.

Stellar nurseries in the Whirlpool

When ISO discarded its protective cover Nov. 28, 1995, and cast its eye on the heavens, its first target was the Whirlpool galaxy, a neighbor of our Milky Way. So named because of its spiral shape, the Whirlpool lies 20 million light-years from Earth. At first glance, the galaxy's infrared portrait (below), taken at a wavelength of 15 micrometers, resembles its appearance in visible light.

The infrared image, however, reveals heat radiated by dust and gas clouds. These clouds represent the sites of massive starbirth in the galaxy. Bright spots in the spiral arms indicate warm dust clouds where stars are forming. These spots are linked by regions of cooler dust along the arms and in the spaces between the arms, where previous generations of stars have abandoned their dusty cocoons.

At the top of the picture, the companion galaxy, NGC 5195, looks smaller in the infrared than in visible light because the older stars in the periphery don't shine brightly.



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cores of galaxies, where black holes and quasars may lurk.

The telescope has also begun a search for youngsters in the cosmos—baby planets and infant galaxies. It lacks the resolution to image directly the dusty disks around stars, widely regarded as the spawning grounds for planets. But it can identify excess infrared emissions, a likely signature of dust disks, around stars that lie within 100 light-years of Earth. Therefore, ISO may identify places likely to harbor planetary systems.

The observatory also seeks primeval galaxies—distant, young galaxies caught in the act of making their first generation of stars (SN: 2/24/96, p. 120). These stars radiate mostly in the ultraviolet, but the expansion of the universe shifts their light to much longer wavelengths, so they appear bright in the infrared.

The astronomers plan to characterize nearby galaxies in great detail at shorter infrared wavelengths. They can then investigate more distant galaxies by looking for the same features redshifted to longer infrared wavelengths.

"We're creating a template of galaxies in the nearby universe so we can know what to expect when we look deeper, at more distant galaxies," says ISO project scientist Martin Kessler of the European Space Agency in Villafranca. Noting that astronomers aren't sure what galaxies look like in the far infrared, the longest infrared wavelengths, Kessler says the ISO observations highlight "the unexplored nature of this part of the electromagnetic spectrum."

Observations such as these are all but impossible from the ground. Several gases in Earth's atmosphere—mainly water vapor and carbon dioxide—provide a double whammy in the infrared. These molecules absorb most infrared light, allowing only a few narrow bands of radiation to reach the ground. In addition, the molecules themselves radiate copious amounts of infrared light, overwhelming the faint emissions from stars and galaxies.

"It's as though you were trying to do astronomy in a snowstorm," notes Harwit.

Short-duration airplane and balloon surveys have flown above much of this atmospheric fog. Many studies have relied on the Kuiper Airborne Observatory, an infrared telescope that flew high in the atmosphere in a converted C-141 airplane. Even so, infrared emissions from the equipment itself as well as the atmosphere have interfered with observations.

Leaving the atmosphere far behind, ISO outperforms its only predecessor in space, the Infrared Astronomical Satellite. During its 1983 survey, the earlier satellite observed infrared emissions in only four broad bands, none of them at wavelengths longer than 120 micrometers. In contrast, ISO's suite of instruments—a sensitive camera, two spectrometers to analyze the components of infrared light, and a photometer to measure brightness—cover a wavelength range spanning the middle and far infrared, from 3 to 240 micrometers.

"One can now make observations across the entire infrared spectral band—perhaps that's the most important attribute of the mission," says Harwit. "Now we have this absolutely clear view of the universe at all infrared wavelengths."

Even in the chilly environs of space, most infrared telescopes would generate infrared emissions some 10,000 times as strong as the radiation they are designed to detect. That's why scientists built ISO as a cryogenic telescope, using a huge tank of superfluid helium to cool it down to 2° above absolute zero. The mission ends when the helium runs out, about 20 months from now.

By that time, if all goes according to plan, astronauts will have outfitted the Hubble Space Telescope with an infrared camera, and NASA may be 2 years away from launching a major infrared observatory know as SOFIA (Stratospheric Observatory for Infrared Astronomy). Astronomers hope that as part of its legacy, ISO will have unveiled a variety of cool bodies for these telescopes to examine further. □

Environment

Cooking—and wheezing—with gas

If preparing dinner leaves you a trifle short of breath, perhaps you should evaluate the range of cooking preparations involved. British researchers find that women who cook with gas are at least twice as likely to experience wheezing, shortness of breath, and other symptoms of asthma as those who prepare meals using electric cooktops and ovens. This association held even when the cooks regularly used exhaust fans.

Deborah Jarvis and her coworkers at St. Thomas' Hospital in London surveyed respiratory symptoms for a year among 659 women and 500 men, aged 20 to 44, living in one of three provincial towns in eastern England. In addition to describing the heating appliances in their homes, most participants also provided blood samples and submitted to tests of lung function.

The questionnaire and tests link gas cooking not only to asthma but also to slightly diminished lung function, the researchers reported in the Feb. 17 LANCET. Moreover, these effects showed up only in women—probably because they spend more time in the kitchen than men do. Small impairments in lung function also showed up among those participants who heated rooms or water with an open gas fire, again only among women. Though smokers were no more likely to develop symptoms than nonsmokers, those who did experience problems tended to develop more serious ones.

Other studies have implicated the pollutants from indoor gas appliances in the frequency and severity of asthmatic episodes in children. That link tended to be weaker, however, perhaps because children spend less time close to a gas range's flames, suggest Michael Brauer and Susan M. Kennedy of the University of British Columbia in Vancouver in a commentary accompanying the LANCET article. Jarvis and her team calculate that switching to electric ranges might cut wheezing and breathlessness among young women by up to 48 percent.

New construction: What a waste

As anyone who's hosted a major building project knows, those ugly dumpsters fill up fast—with scraps of framing lumber, drywall, and roofing shingles; bedsheet-size panels of plastic and paper; and nail-studded pallets to keep supplies flat and off the ground. Now, researchers at Cornell University have audited recyclable materials in construction waste from two houses. The 4,656 pounds of scraps tallied during the building of one four-bedroom vinyl-sided house included 1,788 lbs. of drywall, 1,338 lbs. of wood scraps (46 lbs. as sawdust), 346 lbs. of asphalt roofing, 273 lbs. of cardboard, 211 lbs. of plastic, 133 lbs. of brick pieces, and 31 lbs. of paper.

The big surprise, to environmental analyst and former building contractor Mark Pierce, was the uniform ratio of waste types among the two houses he examined and those in other studies. "Cardboard, wood, and gypsum [drywall] account for between 74 and 77 percent of all the wastes produced in a residential construction site, regardless of the size of the house or style."

While makers of particleboard and some other materials are periodically "starved" for the raw materials shed as waste during construction, he noted, "we had a real hard time finding [conservation and recycling] alternatives that would be cost-effective" for a builder putting up houses 60 miles north of New York City. Unless landfills increase their fees, Pierce found, it will remain slightly less expensive to dump most construction materials than to salvage them.