ASTRONOMY

Satellite Offers a View of the Coolest Objects in the Cosmos

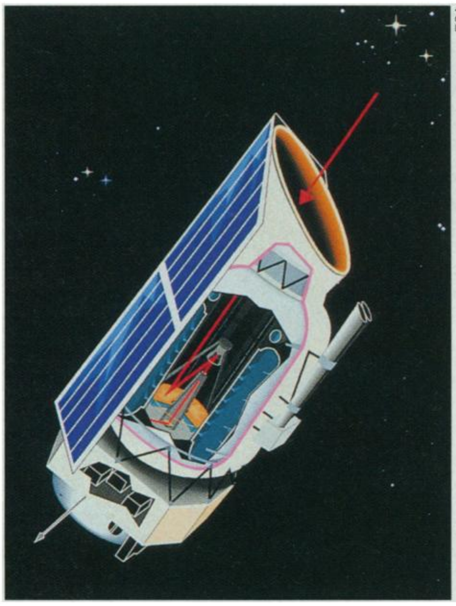
GRONINGEN, THE NETHERLANDS—To infrared astronomers, Earth's atmosphere is like a dense fog bank reflecting bright sunshine. Not only does atmospheric water vapor dim the view of objects these observers would like to study; the atmosphere itself shines in the infrared, blinding their instruments. By putting their telescopes aboard high-flying airplanes, on mountaintops, and at the South Pole, astronomers can peer through the fog. But only space offers a real escape from it. And starting on 10 November, if all goes well, astronomers will get their best view yet from this vantage point, with the launch of the European Infrared Space Observatory (ISO).

In 18 months of observations, the ISO should give astronomers a new view of cosmic birthplaces: the cool clouds of gas and dust that spawn galaxies and stars, and the dusty disks that may be the birthplaces of planets around other stars. The infrared is also the region of the spectrum where gases in the atmospheres of other planets reveal themselves, where comets can be spotted well before they display bright comas and tails, and where signals can be detected from the very cores of active galaxies. While the $840 million ISO is the second major infrared observatory to fly—the first was the U.S.-Dutch-U.K. Infrared Astronomical Satellite (IRAS), launched in 1983—the ISO far outdoes its predecessor.

Unlike IRAS, which scanned the entire sky, the ISO can track individual objects to study them in detail. "IRAS mainly ... observed stars for 1 second only when they passed by in view of the telescope," explains ISO Project Manager Johan Steinz. "ISO, on the other hand, can find a star and follow it for 10 hours." It should also be about 1000 times more sensitive than IRAS—so sensitive, managers boast, that it could detect an ice cube 100 kilometers away in space—and cover twice as wide a wavelength band, from 2.5 to 240 micrometers. "This coverage in the infrared spectrum is an entirely new adventure for us," says Thijs de Graauw of the SRON Laboratory for Space Research here, who is participating in the project.

The basic design of the 5.3-meter-long satellite, to be launched from the Guiana Space Center in Kourou, French Guiana, is much like that of IRAS: a 60-centimeter telescope to gather the light, and a battery of instruments to analyze its spectrum and polarization and focus it into images. All these components are enclosed in a large cryostat, a "thermos flask" cooled by 2000 liters of liquid helium. This arrangement ensures that the instruments are colder than anything they are measuring, so that their own infrared glow doesn't blot out the observations.

But because the liquid helium will gradually boil away, the spacecraft's observation time will be limited to 18 months. There is a lot to pack into that time. The ISO time allocation committee has approved both a set of several hundred individual research projects by outside investigators and a so-called central program, which will account for about 33% of the total observation time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A cold eye. A thermos flask filled with liquid helium encloses the telescope and instruments of the Infrared Space Observatory.

and will be carried out by members of the ISO team. "This is guaranteed time for those who have been involved for the last 10 years in putting the spacecraft and scientific instruments together," says Martin Harwit, former director of the National Air and Space Museum in Washington and a member of the ISO Science Team. "It is dedicated to projects of interest to the broader community of astronomers." Among them, says de Graauw, are the search for disks around stars and studies of active galaxies and quasars.

Data for the studies will come from four different instrument packages. The Short-Wavelength Spectrometer (SWS) will analyze light at wavelengths from 2.5 to 45 micrometers. That's where molecules such as hydrocarbons in the atmospheres of Mars, Jupiter, and Saturn radiate light. It's also the right wavelength region for detecting planet-forming disks of dust around stars. "We will look at stars that we suspect have disks with planetary condensations," says de Graauw, who is principal investigator (PI) for the SWS. "We will be looking for emission lines that will tell us about the densities, temperatures, and chemical compositions of these circumstellar disks."

To study the clouds that give birth to stars themselves, ISO astronomers will turn to the Long-Wavelength Spectrometer, which will cover the range of 45 to 180 micrometers. "Using these wavelengths we can probe into cores of molecular clouds that spawn stars," says PI Peter Clegg of Queen Mary & Westfield College in London. The high resolution of the spectrometer, he adds, should reveal "the detailed behavior of protostars," for example by registering the Doppler shifts in spectral lines that result from high-speed winds swirling through the stellar nurseries.

ISO researchers will rely on two other instruments, the Camera and Polarimeter (CAM) and the Imaging Photo Polarimeter (ISOPHOT), to make images of the objects whose light they analyze with the spectrometers. ISOPHOT, in particular, will push those imaging capabilities to wavelengths of up to 240 micrometers. "With the longest wavelengths we will cover the coldest objects in the universe," such as molecular clouds before the onset of star formation, says ISOPHOT PI Dietrich Lemke of the Max Planck Institute for Astronomy in Heidelberg, Germany.

ISOPHOT and CAM will also allow astronomers to look for sources of polarized infrared light. Polarization, in which the light waves all vibrate in the same plane, could be the signature of dust grains oriented by interstellar magnetic fields or of infrared synchrotron radiation coming from electrons in the cores of active galaxies and quasars. Polarization studies, adds Lemke, "have never been done at most far-infrared wavelengths."

In between scrutinizing particular objects, ISOPHOT will take a quick look at everything that sweeps past the telescope when the satellite is switched from one target to the next. "We measure everything it sees by accident," says Lemke. "In these 18 months, with tens of thousands of these moves, we will map a large part of the sky in this random way." This "serendipity survey" will build up potential targets for later scrutiny—either by ISO's own instruments or by the next infrared observatory to climb out of the fog.

–Alexander Hellemans

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