

ISO Peers Into the Cool Corners of the Universe

KYOTO, JAPAN—Nearly 2000 astronomers gathered here late last month for the 23rd General Assembly of the International Astronomical Union. A special full-day session at the triennial event was devoted to the latest findings from the European Space Agency's Infrared Space Observatory (ISO). Launched in November 1995, ISO has provided unique insights into the cool and dusty corners of the universe, where stars are born and die, and the atoms and molecules necessary for life are created. The spacecraft's useful life was expected to end soon, but because the liquid helium that cools ISO's cryogenic detectors has been used up more slowly than expected, operations have been extended to next spring.

Boosting the Birth Rate of Stars

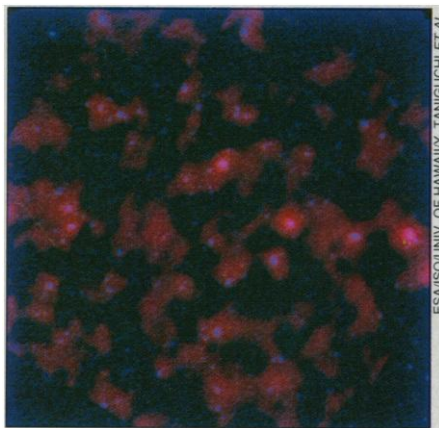
A group of infrared astronomers says it has confirmed its earlier, controversial claims that a frenzy of star formation took place in galaxies two-thirds of the way back to the big bang. Sebastian Oliver of London's Imperial College announced at the meeting that a new survey of distant galaxies carried out with the ISOCAM camera onboard the ISO satellite shows that studies at optical wavelengths had underestimated the rate at which new stars were being born in these galaxies by a factor of 4.

The group, led by Imperial's Michael Rowan-Robinson, had presented its preliminary findings last November. The researchers had measured the infrared output of a number of galaxies in the same patch of sky where the Hubble Space Telescope made its Deep Field survey of some of the faintest and most distant galaxies ever seen. Comparing the ISO measurements with the Deep Field results showed that these remote galaxies are giving out 10 to 100 times as much infrared radiation as visible light. Because the dust shrouding star-forming regions absorbs light from young stars, then reemits it as infrared radiation, Rowan-Robinson argued that the galaxies were forming stars 10 times faster than the optical observations had implied.

Researchers at France's Atomic Energy Commission in Saclay, who developed ISOCAM, raised questions about the group's data-reduction techniques, however. So the Imperial College group resurveyed the same galaxies at a different infrared wavelength in

July, narrowed the number of galaxies to 11, and scaled back the rate of star formation from the original estimate of 10 times what optical observations indicate to four times. Even at this scaled-back level, these higher rates of star formation could have implications for the current understanding of the number of stars in the universe when star-formation peaked. The bottom line, Rowan-Robinson says, is that "if you only look in the optical [wavelengths], you're missing a part of the story."

Even now, not everyone is convinced that the star-formation estimates need to be revised. Lennox Cowie, an astronomer at the University of Hawaii's Institute for Astronomy, says there are still questions about the "quite tricky" interpretation of the ISO data, which can be contaminated by signals from stray cosmic rays. What is more, Cowie's own observations of another set of galaxies point to a different conclusion. He is a member of a team that is using ISO to survey another part of the sky in search of much more primeval galaxies. The survey by this group, led by Yoshiaki Taniguchi of Japan's Tohoku University, also spotted several emission sources in the same age range as the galaxies Rowan-Robinson's team studied. Follow-up optical observations on a few of these with the Keck Telescope in Hawaii convinced Cowie that there was nothing "you have to go into very heavy starburst interpretations to understand." The discrepancy between the results could mean that such rapid star formation is confined to a few galaxies, Cowie says, or that there is some other explanation for Rowan-Robinson's observations.



Starburst stampede. ISO spots feverish star formation in distant galaxies (red).

Astronomers may be able to settle the issue soon, says David Elbaz, an astrophysicist at Saclay, because more evidence supporting Rowan-Robinson's claims is on the way in the form of soon-to-be-published results from other ISO surveys. "We can say that in the optical [wavelengths] a large fraction of star formation [evidence] is missing," Elbaz says. He is not ready to endorse Rowan-Robinson's actual numbers for the star-formation rate, however. Says Cowie: "I just think we don't quite know what the answer is at this point."

Picking Brown Dwarfs Out of a Crowd

A group of ISO researchers is turning up surprising numbers of brown dwarfs, balls of hydrogen and helium that are too small to ignite and sustain the nuclear reactions that make stars shine. Brown dwarfs have long tantalized astronomers: Although they were theoretically predicted 3 decades ago, only a handful have ever been positively identified because they glow so feebly.

Now, as Thierry Montmerle of France's Atomic Energy Commission in Saclay reported in Kyoto, a group led by Linnart Nordh and Göran Olofsson, both of the Stockholm Observatory in Sweden, carried out a survey of dim stellar objects in four well-known star-forming regions and spotted evidence for between 10 and 30 brown dwarf candidates and doubled the number of known young stars. The size of the brown dwarf collection may allow astronomers to begin estimating how common such bodies may be throughout the universe, and overall, the survey should help astronomers understand star formation in dense interstellar clouds. "It will be a significant input for those who try to model and understand the star-formation process," Nordh says. It may also have implications for estimates of the total mass of the universe.

ISO is so adept at spotting brown dwarfs and dim stars because it can observe at the midinfrared wavelengths that escape from the dust clouds shrouding star-forming regions. For this study, the group chose to survey several well-studied regions to try to find objects that previous surveys might have missed, particularly dim young stars and young brown dwarfs. When first formed, brown dwarfs glow from the gravitational contraction, later growing dimmer and harder to detect as they cool.

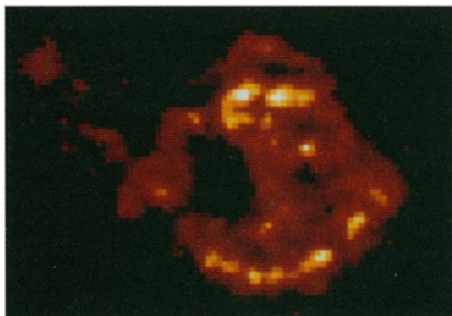
To determine whether an object is a dim star or a brown dwarf, the astronomers must determine its mass. They can deduce the mass if they know an object's age and total luminosity over the entire spectrum of wavelengths. The team made the assumption that all the objects in each region they studied were formed at roughly the same

time. Getting the luminosity was a bit trickier, as ISOCAM was only surveying the regions at 7 micrometers. To deduce an object's total luminosity, they developed a yardstick by looking at a number of stars with known total luminosities and calculating an average ratio of total luminosity to luminosity at 7 micrometers.

Astrophysicist Hans Zinnecker of Germany's Astrophysical Institute in Potsdam says this trove of dwarfs and dim objects will help astronomers understand the process through which molecular clouds fragment and form stars. For example, it might contribute to an understanding of the relationship between the mass of a cloud and the mass and number of the resulting stars. There is also the long-standing question of the unidentified "dark matter" of the universe. "This can help us estimate how many of these [brown dwarfs] form and what their contribution might be to the dark matter," he says.

Watching Dust Grains Form

None of us would be here today if it were not for supernovae. These violent explosions of old, burned-out stars are responsible for scattering the heavy elements such as carbon, oxygen, and silicon created in the star's nuclear furnace. The fireball is also thought to play a role in forming basic chemical compounds and interstellar dust, which condense into new solar systems like our own. Now, ISO is getting a



Dust storm. A ring of debris from supernova Cassiopeia A, where cosmic dust forms.

clearer picture of how and when supernovae create the ingredients of future worlds.

By training ISOCAM, ISO's infrared camera, on Cassiopeia A, the youngest supernova remnant in our galaxy, astronomers have, for the first time, identified the composition of dust grains in the remnants of the supernova. They have also detected a new addition to the list of elements found in supernova remnants: the inert gas neon. By tracing the signatures of dust and elements through the different regions of the exploded star, astrophysicists should be able to fine-tune their understanding of the processes that produce them.

Using a filter specially tuned to pick up the thermal emissions from dust, a group led by Pierre-Olivier Lagage of France's Atomic Energy Commission in Saclay reported a year ago that it had determined that dust was forming in so-called fast-moving knots,

globules of nuclear fusion products blown off from the outer layers of the exploded star. Now, as they reported in Kyoto, Lagage and his colleagues have succeeded in determining the composition of individual knots. They have found that the dusty knots are, as expected, rich in silicate, while others contain traces of argon and sulfur, together with the new addition, neon.

The knots originated in different layers of the star, and they can be distinguished because knots from outer layers move faster than knots from inner layers. Astrophysicists have wondered how much mixing occurs among these layers as the star explodes, because the mixing would affect the processes that generate elements and dust. Lagage's group is now trying to determine whether the composition of the knots varies, which would indicate that the layering of the original star was preserved when it exploded, or whether its layers got churned up, homogenizing the composition of the knots. "We think, at the moment, that there is not a lot of mixing," Lagage says, but he cautions that this is a very preliminary analysis of the rich data returned by ISOCAM.

Eli Dwek, an astrophysicist at NASA's Goddard Space Flight Center in Greenbelt, Maryland, agrees that the data are a mother lode. "In trying to work backward and see what the composition of the ejecta was at the explosion, the more elements you sample, the more of a picture you get," he says.

—Dennis Normile

AIDS RESEARCH

HIV Suppressed Long After Treatment

BALTIMORE, MARYLAND—"Anecdote" is one of the most damning things you can say about a scientific report. Still, some anecdotes are provocative, and one caused a stir when it was related at an AIDS meeting here last week: An HIV-infected German man drove the virus down to an "undetectable" level with drugs, stopped taking the drugs, and yet, 9 months later, has not had the virus return. This report comes on the heels of a paper published in the 30 August issue of *The Lancet* describing two other patients who similarly have not seen their HIV rebound after being off drugs for 1 year. Those results have drawn some skepticism, however.

The description of the German patient, a man in his 20s who lives in Berlin, came at a meeting put together by Robert Gallo, the head of the Institute of Human Virology in Baltimore. Franco Lori of the Research Institute for Genetic and Human Therapy—which is located in both Pavia, Italy, and at Georgetown University in Washington, D.C.—said that when the patient first sought treatment shortly after becoming infected, the polymerase chain reaction (PCR) assay showed that he had

85,000 copies of HIV RNA per milliliter of blood—a solid infection.

Lori says clinicians in Berlin started the man on three drugs: indinavir, ddI, and hydroxyurea. Indinavir inhibits HIV's protease enzyme; ddI jams the virus's reverse transcriptase enzyme; and hydroxyurea, an anticancer agent, boosts the effects of ddI and also suppresses the immune system. The man's HIV levels quickly dropped to those that the most sensitive PCR assays could not detect. After 27 days, he stopped taking his medication for 3 days, and the virus, as expected, quickly came back. When he restarted the drugs, the HIV again went down to undetectable levels.

Then, 144 days after beginning treatment, the man developed hepatitis A and was so ill that he could not take any drugs for 3 weeks. But before restarting his medications, his physicians checked the amount of virus in his blood. It was still undetectable—and it has remained so for 9 months. "I hate to draw conclusions too early," says Lori. "We think the virus is there. It just doesn't rebound."

Others at the meeting were equally wary. "It doesn't serve any purpose except for the person

who took the drugs," said Jacques Leibowitch of France's Hôpital Raymond Poincaré. Leibowitch and others also criticized the *Lancet* paper, which was written by Jorge Vila of France's AFAVIR and colleagues, noting that the two patients described there, who also were using hydroxyurea as part of their treatment, had such low HIV levels to begin with that they may never have been infected in the first place.

Still, many researchers, Leibowitch included, were intrigued by the possible role played by hydroxyurea, which is not an approved AIDS drug. "There must be something that we need to investigate further," says Anthony Fauci, head of the U.S. National Institute of Allergy and Infectious Diseases (NIAID). Maybe, says Fauci, the hydroxyurea suppresses the immune system cells that HIV targets. Fauci's lab reported in the August *Journal of Infectious Diseases* that a different immune suppressor, cyclosporin A, could lower levels of the AIDS virus in infected monkeys. NIAID's Lawrence Deyton also wonders whether hepatitis A might have stimulated the release of immune system chemicals that kept the HIV in check. "There are many things we have to work out," Lori says.

—Jon Cohen