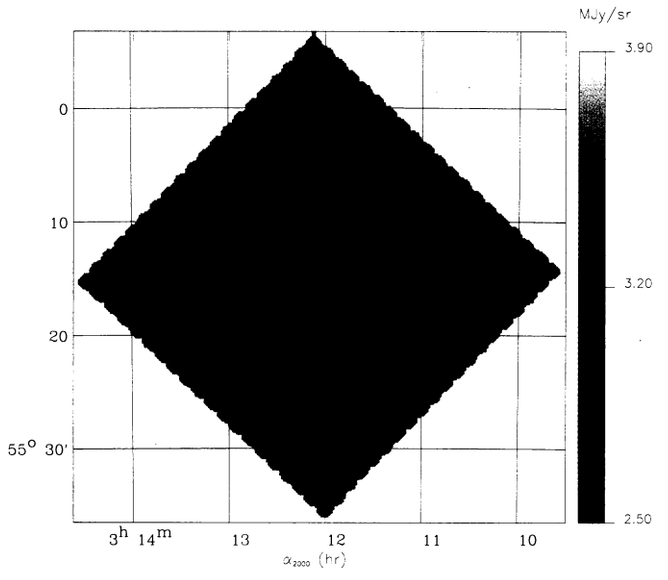

Stellar baby boom? Bumps in the infrared background of this ISOPHOT image show that the early universe was awash with star-forming galaxies.

I have no doubts," says Dietrich Lemke of the Max Planck Institute for Astronomy in Heidelberg, Germany, principal investigator for ISOPHOT, the ISO instrument involved. "Potentially this [discovery] is quite important, because we are trying to understand what the sources are of this background radiation," says Michael Hauser, deputy director of the Space Telescope Science Institute in Baltimore, Maryland.

Astronomers want to know more about the infrared background because the signal detected by COBE was much stronger than expected. The infrared glow is thought to come from primordial galaxies, full of young stars blazing within heavy shrouds of dust, which would have reradiated the starlight as heat. Hauser says observations from ISO and the SCUBA instrument on the James Clerk Maxwell Telescope in Hawaii suggest that this bright infrared background may have been caused by an early generation of "ultraluminous galaxies." Because of their cloak of dust, our only view of these early beacons may be in the infrared. "The results show that there has to have been a very strong presence of the infrared sources in the past, much more than now," says Jean-Loup Puget of the Institute for Space Astrophysics in Orsay, near Paris.

The discovery is actually a posthumous achievement for ISO, which ceased observing in May 1998 when the liquid helium coolant for its telescope ran out. Puget and his Orsay colleague Guilaine Lagache analyzed data collected during ISO's 3-year life by ISOPHOT's four infrared photometers. The photometers measured the brightness of the infrared sky as seen by ISO's 60-centimeter telescope, which has a resolving power more than 25 times that of COBE's best effort.

Puget and Lagache focused on data from small patches of sky —an area totaling 4 square degrees—that were specifically selected to avoid infrared radiation coming from dust in our own galaxy. Even so, the astronomers had to do much work to remove "foreground" radiation from within our galaxy and from point sources of infrared light elsewhere in the universe. The brightness variations that remain "are galaxies that we cannot resolve with the instrument," says Lagache.

Astronomers are now keen to learn more about these early galaxies and when star formation began. Puget says that the observations show that star formation was already intense during the first billion years of the universe's 12- billion-year life, while previous optical observations seemed to indicate that star formation started much later. For more detailed data, astronomers will have to wait until NASA launches its Space Infrared Telescope Facility (SIRTF) in 2002. SIRTF will have a slightly higher resolving power than ISO, and its detector will be much more sensitive, says Michael Rowan-Robinson of London's Imperial College. Puget adds that the Atacama Large Millimeter Array, an array of 64 infrared dishes to be built as an international project in Chile, "will allow real progress."

—ALEXANDER HELLEMANS

Alexander Hellemans is a writer in Naples, Italy.

CREDITS: (LEFT TO RIGHT) ISO; NASA

PLANETARY SCIENCE

A System Fails at Mars, A Spacecraft Is Lost

Just in time to protect the Mars Polar Lander from risking a similar fate when it reaches the Red Planet next month, NASA investigators have wrapped up their inquiry into the loss of the Mars Climate Orbiter (MCO) spacecraft in September. Confusion over units of measurement used during mission navigation set the craft on its fatal course into the martian atmosphere, investigators announced last week, but the failure of mission team members to fully follow existing checks and balances turned a correctable snafu into a disaster. Why spacecraft operators broke the rules remains unclear, but NASA's new "faster, better, cheaper" approach to planetary missions is taking some of the blame.

The investigation board confirmed that the root cause of the loss was a misuse of English units, as previously reported: The MCO's operator, Lockheed Martin Astronautics of Denver, supplied data about the firing of the spacecraft thrusters in pound-seconds. The recipients of the data, spacecraft navigators at the Jet Propulsion Laboratory (JPL) in Pasadena, California, assumed the units were the newton-seconds required by mission specifications.

Although that error was not found until later, the navigators knew the spacecraft was off course. "The navigation team realized as the spacecraft approached Mars that it was coming in lower than intended," says Arthur Stephenson, director of NASA's Marshall Space Flight Center in Huntsville, Alabama, and the head of the NASA investigation board. He adds that they did not realize the gravity of the situation. "They never saw that the spacecraft was in jeopardy. They were more worried about tuning the orbit than a catastrophic loss."

Even so, Patrick Esposito, who supervises navigation of all three current Mars missions, strongly recommended almost a week before arrival at Mars that a modest trajectory correction be made, according to an internal investigation at JPL. The suggested correction possibly could have saved the mission, but it "was denied for good reason," says Stephenson.

Mars Climate Orbiter. Off to an ignominious end.

"The [operations] team was not ready to perform it." A fifth and final tweaking of the trajectory was in the mission plan, but the operations team had done none of the planning needed to ensure that a last-minute course correction could be executed if needed.

That was just one of eight contributing factors that turned an oversight into a catastrophe, according to the NASA report. Other problems included the navigators' unfamiliarity with the peculiarities of this spacecraft's behavior, poor communication between spacecraft teams, and understaffing (the navi-

gation "team" consisted of just two people: the MCO navigator and Esposito). With these failures in mind, the board has recommended changes in the operation of the Mars Polar Lander, due to reach Mars on 3 December. They include beefing up navigation staffing and using a second, independent means of determining the spacecraft's trajectory.

NASA officials denied that their recent strategy of flying more, smaller missions at lower overall cost affected MCO. "We have to remember faster, better, cheaper includes following the rules," says Edward Weiler, NASA associate administrator for space science. "They weren't followed this time." Noel Hinners, vice president for flight systems at Lockheed Martin, begs to differ. "There is a faster, better, cheaper effect here," he told *Science*. It's a matter of sufficient staffing—perhaps 10% more—to make sure the checks and balances work, he says. "It's nothing big, but it takes time and money." **–RICHARD A. KERR**

PUBLISHING

Journals Launch Private Reference Network

Most of the world's biggest scientific publishers have so far shown little interest in participating in a U.S. government plan to provide free access to scientific articles through a Web site called PubMed Central. Now they've responded with a plan of their own. On 16 November, 12 private and nonprofit organizations unveiled a scheme designed to cross-link journal articles through their reference lists, making it easy for researchers to locate and obtain the text of a referenced article through the Internet. Unlike PubMed Central, the plan will allow publishers to retain full-text material on their own Web sites and control access to it. PubMed Central, in contrast, would turn archived texts into public property.

PUBLISHERS' REFERENCE SERVICE

Publisher	No. of publications
AAAS (*Science*)	1
Academic Press	235
American Institute of Physics	>50
Association for Computing Machinery	21
Blackwell Science	200
Elsevier Science	1200
Inst. of Electrical and Electronics Engineers	105
John Wiley & Sons	>300
Kluwer Academic Publishers	>400
Nature	7
Oxford University Press	100
Springer-Verlag	400

The lead organizers of the new project are Academic Press, a Harcourt Science and Technology company based in San Diego, California, and John Wiley & Sons Inc. of New York City. They worked with the International Digital Object Identifier (DOI) Foundation near Oxford, U.K.—established in 1998 with the help of major publishers—to devise "tags" that can be used to find and track journal articles. Others in the group supporting this venture are the American Association for the Advancement of Science (publisher of *Science*), *Nature*, the American Institute of Physics, the Association for Computing Machinery, Blackwell Science, Elsevier Science, the Institute of Electrical and Electronics Engineers Inc., Kluwer Academic Publishers, Oxford University Press, and Springer-Verlag. At press time, the sponsors had not settled on a name.

This high-profile group plans to spend an undisclosed sum to create a new, not-for-profit digital information service. Publishers who participate will send articles to the new service to be tagged with universal identifiers. The goal, according to Charles Ellis—chair of the DOI Foundation and Wiley's former CEO and president—is to enable readers to use a mouse-click to leap from a footnote in an article on one publisher's Web site to the text of the article being cited, even if it's on a different site. The mechanism will be largely invisible to readers, but access to the full text may require a password or a fee. "The beauty of the system," Ellis says, "is that it permits a kind of one-stop shopping that gives access to all the journals" participating in the scheme.

The publishers have consulted their legal advisers and concluded that they will not run afoul of antitrust laws, which prohibit collusion among competitors, as long as "we don't try to exclude anyone," says Ellis. Indeed, the founding members are eager to have many other publishers join. However, those who do so must agree to use a standard data format devised by the DOI Foundation. It requires publishers to provide summary information on every article, such as the author's name, a short description of the work, and the name of the journal. But each publisher can decide whether to make abstracts or full-text articles available for free.

Susan Spilka, a spokesperson for Wiley, says the plan is to label more than 3 million current journal articles with DOI tags immediately and to have them up and available on the system early next year. After that, more than half a million new articles will be added to the collection every year.

David Lipman, director of the National Center for Biotechnology Information, who has chief responsibility for developing PubMed Central, says this private network is very different from PubMed Central: "It in no way provides barrier-free access to the primary research literature." But, he adds, it's "great" that publishers are trying to improve access to online information, and "I hope they move forward with this." **–ELIOT MARSHALL**

SPACE TELESCOPE

Gyroscope Failure Closes Down Hubble

The stream of science data from the Hubble Space Telescope stopped last weekend after the fourth of the instrument's six gyroscopes failed. The $2 billion telescope will remain in a "safe mode" until astronauts arrive next month for a scheduled service mission to the orbiting spacecraft. Even if all goes well, however, agency officials say it will take another month to get the telescope back on line.

The gyroscopes, which keep the telescope pointed properly, have bedeviled NASA engineers since the Hubble's launch in 1990. Four have been replaced on previous space-shuttle missions. But the devices have continued to fail, and because Hubble needs three working gyros to make observations, the latest failure, on 13 November, caused NASA to suspend all scientific operations. The shuttle was slated to rendezvous with Hubble in October to replace all six gyros and conduct other maintenance tasks, but problems with the Discovery shuttle have delayed the mission. Space agency officials are eager to meet the 6 December launch date because some of the software for the Hubble servicing mission is not Y2K compliant.

Space science chief Ed Weiler says that the delay poses no danger to Hubble. And because a servicing mission is imminent, "the timing [of the gyro failure] is not so bad," Weiler notes. "We have to just sit and wait." The shutdown interrupted researchers' plans to examine the turbulent upper atmosphere of Jupiter and Saturn's rings and put on hold the search for binary brown dwarfs and a survey of galaxies with high redshifts, according to the Space Telescope Science Institute in Baltimore, which oversees the Hubble's science program. The research will be rescheduled.

On the servicing mission, the shuttle crew will install replacement gyros modified to make them more reliable. The crew will make a total of four spacewalks—replacing a host of other equipment besides the gyros—before returning to Earth. The mission should keep Hubble operating through 2003.

–ANDREW LAWLER