he says. Formenty and his assistants are now planning to trap a variety of bloodsucking insects in the Tai Forest and search them for the virus.

That's not the only search they are planning: They are also looking for a mammalian intermediary, on the assumption that Ebola employs the same modus operandi as many arthropod-borne viruses. Usually, such viruses infect an intermediate host mammal that allows the virus to reproduce en masse but is not itself harmed by the virus. That intermediate host, Formenty speculates, might be an unidentified species of rodent whose population has boomed since 1990, when Liberian refugees began streaming into camps near the park. The refugees may also have disrupted the forest ecology by illegally clearing and cultivating fields within the park, he says.

Formenty's group will search for an intermediate host by testing a wide range of the Tai Forest mammals for antibodies to the virus and for the virus itself. Other clues may come from the people in surrounding villages. Previous studies in Zaire have revealed isolated cases of Ebola among poachers and villagers who kill and eat monkeys, and any such cases near the Tai Forest could offer a glimpse of the virus's life cycle.

A close look at the chimpanzees' behaviors might also lead researchers to Ebola's mammalian host. Boesch is now reviewing the field records from the weeks preceding the epidemic, he says, "to figure out what other animals they came in contact with." Until the epidemics reduced the adult males in his study group from eight to two, Boesch's chimpanzees were well known among primatologists for their clever, cooperative hunting strategies. As a result, he plans to look into the possibility that the chimpanzees killed and ate some other species of mammal shortly before the outbreak.

Those studies, valuable as they may turn out to be, represent a sad turn for Boesch's research. Until the chimpanzees were decimated by Ebola, they were noted not only for their hunting skills, but their habit of using anvils and hammerstones to crack open palm nuts. Boesch had spent years getting the animals accustomed to people so that researchers could get close enough to observe such activities. "Sadly, now we will be studying the effect of [reduced] group size on these behaviors," Boesch says.

He suspects that his troop, lacking enough males for defense, will eventually be taken over by a neighboring group. And he worries about the long-term fate of the forest's entire chimp population, trapped in the reserve with Ebola virus and its mysterious host.

–Virginia Morell

ASTRONOMY

COBE Seeks Universe's First Blush

Three years ago the National Aeronautics and Space Administration's Cosmic Background Explorer Satellite (COBE) revealed the early moments of creation. By measuring and mapping the cosmic microwave background—a ubiquitous hiss that is a relic of the intense heat of the early universe—its detectors provided a glimpse of the nearly featureless sea of matter created by the big bang. Now COBE is flipping open the book of creation to a later page, perhaps a billion years into cosmic history, when the first stars and galaxies started to shine.

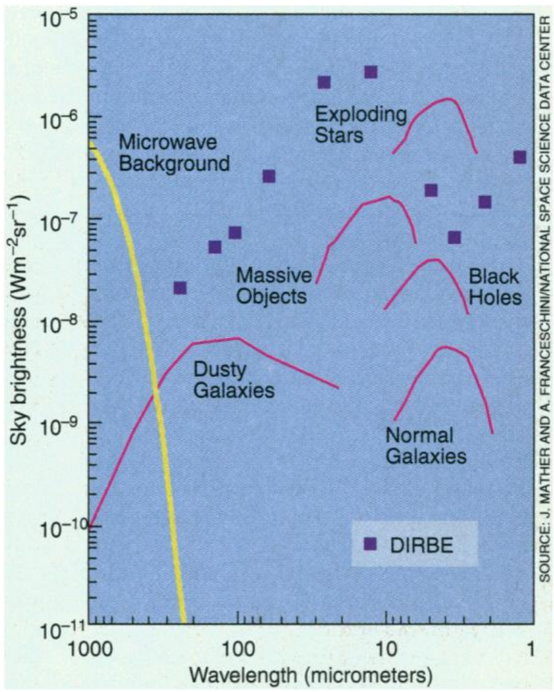
This new look at the early universe comes from another, less heralded COBE detector, one sensitive to the glow of infrared radiation known as cosmic infrared background. The infrared background, which astrophysicists believe is a relic of the universe's first light, is harder to identify and map than the microwave background because it has to be sifted from the much stronger infrared light emitted by nearby stars and dust. But little by little, investigators on COBE's Diffuse Infrared Background Experiment (DIRBE) have been uncovering the equivalent of a cosmic fossil bed, packed with clues about the galaxies and other objects in the primordial universe. "The data are starting to smell very cosmological," says DIRBE collaborator Alexander Kashlinsky, an astrophysicist at NORDITA in Copenhagen.

These cosmic fossil hunters haven't reached their goal yet, as they reported at a recent meeting.* It will be another 2 months or so before they can confidently say whether or not they have isolated an infrared signal with a cosmic pedigree. But as the background radiation's sketchy outline emerges, it is already having an impact on cosmologists' views of the first inhabitants of the universe. Gone are the massive black holes and swarms of the brilliant objects known as quasars that some theorists had envisioned in the early universe. "All those more exotic theories are in great trouble with the [DIRBE] upper limits," says University of California, Berkeley, cosmologist Joseph Silk.

DIRBE opens a window on this early era because it can detect a signal from stars and galaxies too faint to be seen by ordinary telescopes. Astrophysicists know that the most distant—and hence earliest—stars they can see directly can't be the first to have formed; they contain elements heavier than helium, which could only have been produced by nuclear fusion in a previous generation of stars. But the light from the first stars is lost in the glow of the night sky. It is dimmed not just by distance but also by the expansion of the universe, which shifts much of it into the near-infrared, and perhaps also by dust in the first galaxies, which would have absorbed light and re-emitted it in the far-infrared.

DIRBE investigators don't expect to resolve the ancient infrared glow into individual galaxies. The instrument essentially takes the temperature of wide areas of the sky, measuring the total amount of energy in the infrared background. But from that total, theorists hope to deduce how many stars populated the early universe and how bright they were. Meanwhile, the shape of the infrared background—its intensity at different wavelengths—should reveal clues to what early galaxies were like and when their first stars began to shine.

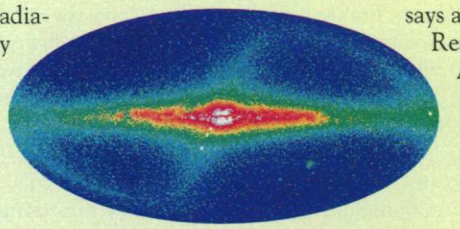
In search of these clues, DIRBE has scanned the infrared sky at 10 wavelengths ranging from 1.25 to 240 micrometers. Back on Earth, the DIRBE team at the NASA Goddard Space Flight Center and elsewhere has spent over 3 years trying to understand



Model universes meet data. Unpublished upper limits for the cosmic infrared background are now a factor of 10 lower than shown here, eliminating some scenarios for the early universe that invoke massive objects such as quasars and black holes.

* COBE Workshop on Unveiling the Cosmic Infrared Background, held from 23–25 April in College Park, Maryland. Principal Organizer: Eli Dwek, NASA/GSFC.

Infrared Detector Scopes Out the Neighborhood



Infrared sky. The afterglow of early galaxies is hidden behind the band of radiation from the Milky Way and the S-shaped signature of solar-system dust in this all-sky map at 1.25 micrometers.

NATIONAL SPACE SCIENCE DATA CENTER

Finding the cosmic infrared background radiation left over from the first galaxies is no easy task. This feeble light from the remote past is hidden behind an infrared glow from much brighter foreground sources inside and outside the solar system. In an astronomical version of the dance of the seven veils, researchers working on infrared data from the Cosmic Background Explorer (COBE) satellite are trying to peel away layer after layer of these "foregrounds" to uncover the sought-after primordial glow (see main text). But like Salome's dance, the unveiling can be interesting in its own right.

In trying to understand the relatively cool objects—dust and old stars—that act as foreground sources, scientists on COBE's Diffuse Infrared Background Experiment (DIRBE) at the NASA Goddard Space Flight Center have made some unplanned discoveries. Among them: evidence that the Milky Way galaxy, rather than having the simple spiral shape that most astronomers had pictured, actually has a cat's-eye shape known as a barred spiral.

Mapping the shape of the galaxy is difficult for optical telescopes, because our solar system lies on one of the galaxy's spiral arms and the view toward the center of the galaxy is blocked by dust. But the older, cooler stars that make up the galaxy's central bulge emit an abundance of infrared light, which is less affected by dust. That makes DIRBE uniquely suited to mapping the bulge, says astronomer Richard Arendt of the Applied Research Corporation. DIRBE data that Arendt helped analyze showed it to be shaped "more like a football" than a sphere, as expected in a barred spiral—a finding recently confirmed by a different technique that detects and counts faint stars in the bulge (*Science*, 5 May, p. 642).

Closer to home, COBE scientist William Reach and collaborators used the DIRBE data to study dust that accumulates along Earth's path around the sun. Theorists had predicted that Earth's gravity would draw dust shed by asteroids and comets into a ring tracing its orbit. Inconclusive observations by another satellite had hinted at the ring, but DIRBE clearly revealed it for the first time, as Reach and his colleagues reported in the 6 April issue of *Nature*. That, says University of Florida astronomer Stanley Dermott, who first modeled the dust ring, "was a terrific observational confirmation of theory."

These lessons from close to home are reminding astrophysicists that the cosmic background isn't the universe's only infrared mystery. Given all the new findings right in our own neighborhood, jokes astrophysicist F. Xavier Desert of the University of Paris, COBE may be a misnomer. The mission, he suggests, "should be called COFE—the cosmic foreground explorer."

–A.R.

and remove infrared signals coming from foreground sources: dust in the solar system, the visible stars and galaxies, and dust in the interstellar medium. One payoff of the effort has been a clearer picture of the nearby universe (see box). At the same time, investigators worry that no recognizable signal will be left after all this has been subtracted. As Thomas Kelsall, DIRBE deputy principal investigator, puts it: "You prune the tree and hope you leave the flower."

The success of this effort "is still unclear," says Michael Hauser, DIRBE's principal investigator. But at the meeting, NASA scientists titillated theorists with preliminary analyses revealing the infrared signal that- remains after all known foregrounds have been subtracted. This remainder sets an upper limit for the infrared background that is nearly an order of magnitude lower than the previous best limits—low enough to provide a "strong constraint on what has been going on in the universe," says Hauser. The DIRBE result, agrees Carol Lonsdale, an astrophysicist at the California Institute of Technology, "is definitely starting to limit our ideas."

Some pre-COBE microwave experiments, for example, had detected peaks in the spectrum of the microwave background, prompting cosmologists to speculate that the early universe was a far more energetic place than today, filled with astronomical powerhouses such as massive black holes, quasarlike objects, and other exotica. Most of these theories suffered a serious blow from COBE's microwave results, which failed to find the peaks. Now DIRBE has finished them off by showing that the total energy in the infrared is too small for such sources to be contributing.

At the near and far extremes of the infrared spectrum, the DIRBE results are even beginning to test more conventional models of the early universe. These regions of the infrared present fewer foreground sources to contend with, and investigators can take advantage of supporting data from adjacent regions of the spectrum—the optical and microwave bands. As a result, the near- and far-infrared wavelengths are serving as "cosmological windows," where the DIRBE investigators are more confident that they are approaching a primordial signal.

In one such window, at about 3.5 micrometers, the DIRBE limits come close to the amount of background radiation that theorists predict for a mundane early universe of galaxies like those that we see today. "This result is fundamental," says Alberto Franceschini, a cosmologist with the Padua Astronomical Observatory in Italy, because it leaves little room for anything besides normal galaxies to be emitting light in the early universe. That could rule out ideas such as the proposal that an early generation of massive stars lived and died outside of galaxies, forging the first heavy elements.

A window beginning at 100 micrometers, however, offers a hint that the early universe could have been a livelier place than today's after all. There, in the farthest reaches of the infrared, astrophysicist F. Xavier Desert and his colleagues at the University of Paris think they are seeing a signal from dust-shrouded galaxies in the early universe. The strength of the signal, they say, implies that these galaxies were burning far more brightly than those of today; the dust could explain why their light appears in the far-infrared. But Desert warns that some unknown foreground source—perhaps "some unusual galactic dust halo" surrounding the Milky Way—could be misleading his group.

Meanwhile, many other models of the early universe are following what Hauser wryly calls an astrophysical tradition: "staying about an order of magnitude ahead of the best observational limits." To catch up with them will take continuing efforts to prune DIRBE's infrared data—and perhaps another mission, says COBE chief scientist John Mather. He and his colleagues envision a probe that would travel far out into the solar system to escape some of the confusing foregrounds near Earth. In the meantime, perhaps the brightest glow in infrared astronomy comes from the heat of discussion, as astronomers contemplate what they hope is the universe's first ruddy blush.

–Antonio Regalado