Cosmic Glow Discovered —"Radiates More Light than All the Known Galaxies in the Universe"

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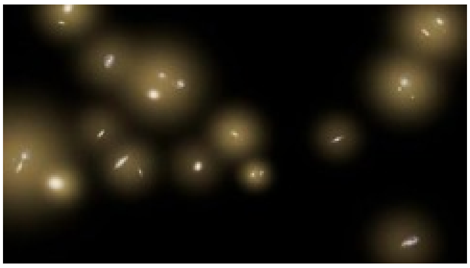

Image Credit: NASA/JPL-Caltech

Using an experiment carried into space on a NASA suborbital rocket, astronomers at Caltech and their colleagues have detected a diffuse cosmic glow that appears to represent more light than that produced by known galaxies in the universe. Initially some researchers proposed that this light came from the very first galaxies to form and ignite stars after the Big Bang. CalTechresearchers say that the best explanation is that the cosmic light originates from stars that were stripped away from their parent galaxies and flung out into space as those galaxies collided and merged with other galaxies.

The discovery suggests that many such previously undetected stars permeate what had been thought to be dark spaces between galaxies, forming an interconnected sea of stars. "Measuring such large fluctuations surprised us, but we carried out many tests to show the results are reliable," says CalTech Fellow Michael Zemcov, who led the study.Although they cannot be seen individually, "the total light produced by these stray stars is about equal to the background light we get from counting up

individual galaxies," says Bock, also a senior research scientist at JPL. Bock is the principal investigator of the rocket project, called the Cosmic Infrared Background Experiment, or CIBER, which originated at Caltech and flew on four rocket flights from 2009 through 2013.
In earlier studies, NASA's Spitzer Space Telescope, which sees the universe at longer wavelengths, had observed a splotchy pattern of infrared light called the cosmic infrared background. The splotches are much bigger than individual galaxies. "We are measuring structures that are grand on a cosmic scale," says Zemcov, "and these sizes are associated with galaxies bunching together on a large-scale pattern."

CIBER was designed to help settle the debate. "CIBER was born as a conversation with Asantha Cooray, a theoretical cosmologist at UC Irvine and at the time a postdoc at Caltech with [former professor] Marc Kamionkowski," Bock explains. "Asantha developed an idea for studying galaxies by measuring their large-scale structure. Galaxies form in dark-matter halos, which are over-dense regions initially seeded in the early universe by inflation. Furthermore, galaxies not only start out in these halos, they tend to cluster together as well. Asantha had the brilliant idea to measure this large-scale structure directly from maps. Experimentally, it is much easier for us to make a map by taking a wide-field picture with a small camera, than going through and measuring faint galaxies one by one with a large telescope."

Cooray originally developed this approach for the longer infrared wavelengths observed by the European Space Agency's Herschel Space Observatory. "With its 3.5-meter diameter mirror, Herschel is too small to count up all the galaxies that make the infrared background light, so he instead obtained this information from the spatial structure in the map," Bock says.

"Meanwhile, I had been working on near-infrared rocket experiments, and was interested in new ways to use this unique idea to study the extragalactic background," he says. The extragalactic infrared background represents all of the infrared light from all of the sources in the universe, "and there were some hints we didn't know where it was all coming from."

In other words, if you calculate the light produced by individual galaxies, you would find they made less than the background light. "One could try and measure the total sky brightness directly," Bock says, "but the problem is that the foreground 'Zodiacal light,' due to dust in the solar system reflecting light from the sun, is so bright that it is hard to subtract with enough accuracy to measure the extragalactic background. So we put these two ideas together, applying Asantha's mapping approach to new wavelengths, and decided that the best way to get at the extragalactic background was to measure spatial fluctuations on angular scales around a degree. That led to CIBER."

The CIBER experiment consists of three instruments, including two spectrometers to determine the brightness of Zodiacal light and measure the cosmic infrared background directly. The measurements in the recent publication are made with two wide-field cameras to search for fluctuations in two wavelengths of near infrared light. Earth's upper atmosphere glows brightly at the CIBER wavelengths. But the measurements can be done in space—avoiding that glow—in just the short amount of time that a suborbital rocket flies above the atmosphere, before descending again back toward the planet.

CIBER flew four missions in all; the paper includes results from the second and third of CIBER's flights, launched in 2010 and 2012 from White Sands Missile Range in New Mexico and recovered afterward by parachute. In the flights, the researchers observed the same part of the sky at a different time of year, and swapped the detector arrays as a crosscheck against data artifacts created by the sensors. "This series of flights was quite helpful in developing complete confidence in the results," says Zemcov. "For the final flight, we decided to get more time above the atmosphere and went with a non-recovered flight into the Atlantic Ocean on a four-stage rocket." (The data from the fourth flight will be discussed in a future paper.)

Based on data from these two launches, the researchers found fluctuations, but they had to go through a careful process to identify and remove local sources, such as the instrument, as well as emissions from the solar system, stars, scattered starlight in the Milky Way, and known galaxies. What is left behind is a splotchy pattern representing fluctuations in the remaining infrared background light.

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