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Sonia Fernandez

Mapping space: Largest map of the universe announced

In the name of open science, the multinational scientific collaboration COSMOS on Thursday has released the data behind the largest map of the universe. Called the COSMOS-Web field, the project, with data collected by the James Webb Space Telescope (JWST), consists of all the imaging and a catalog of nearly 800,000 galaxies spanning nearly all of cosmic time. And it's been challenging existing notions of the infant universe.

"Our goal was to construct this deep field of space on a physical scale that far exceeded anything that had been done before," said UC Santa Barbara physics professor Caitlin Casey, who co-leads the COSMOS collaboration with Jeyhan Kartaltepe of the Rochester Institute of Technology. "If you had a printout of the Hubble Ultra Deep Field on a standard piece of paper," she said, referring to the iconic view of nearly 10,000 galaxies released by NASA in 2004, "our image would be slightly larger than a 13-foot-tall by 13-foot-wide mural, at the same depth. So it's really strikingly large."

The COSMOS-Web composite image reaches back about 13.5 billion years; according to NASA, the universe is about 13.8 billion years old, give or take one hundred million years. That covers about 98% of all cosmic time. The objective for the researchers was not just to see some of the most interesting galaxies at the beginning of time but also to see the wider view of cosmic environments that

existed during the early universe, during the formation of the first stars, galaxies and black holes.

“The cosmos is organized in dense regions and voids,” Casey explained. “And we wanted to go beyond finding the most distant galaxies; we wanted to get that broader context of where they lived.”

A 'big surprise'

And what a cosmic neighborhood it turned out to be. Before JWST turned on, Casey said, she and fellow astronomers made their best predictions about how many more galaxies the space telescope would be able to see, given its 6.5 meter (21 foot) diameter light-collecting primary mirror, about six times larger than Hubble’s 2.4 meter (7 foot, 10 in) diameter mirror. The best measurements from Hubble suggested that galaxies within the first 500 million years would be incredibly rare, she said.

“It makes sense — the Big Bang happens and things take time to gravitationally collapse and form, and for stars to turn on. There’s a timescale associated with that,” Casey explained. “And the big surprise is that with JWST, we see roughly 10 times more galaxies than expected at these incredible distances. We’re also seeing supermassive black holes that are not even visible with Hubble.” And they’re not just seeing more, they’re seeing different types of galaxies and black holes, she added.

'Lots of unanswered questions'

While the COSMOS-Web images and catalog answer many questions astronomers have had about the early universe, they also spark more questions.

“Since the telescope turned on we’ve been wondering ‘Are these JWST datasets breaking the cosmological model? Because the universe was producing too much light too early; it had only about 400 million years to form something like a billion solar masses of stars. We just do not know how to make that happen,” Casey said. “So, lots of details to unpack, and lots of unanswered questions.”

In releasing the data to the public, the hope is that other astronomers from all over the world will use it to, among other things, further refine our understanding of how

the early universe was populated and how everything evolved to the present day. The dataset may also provide clues to other outstanding mysteries of the cosmos, such as dark matter and physics of the early universe that may be different from what we know today.

“A big part of this project is the democratization of science and making tools and data from the best telescopes accessible to the broader community,” Casey said. The data was made public almost immediately after it was gathered, but only in its raw form, useful only to those with the specialized technical knowledge and the supercomputer access to process and interpret it. The COSMOS collaboration has worked tirelessly for the past two years to convert raw data into broadly usable images and catalogs. In creating these products and releasing them, the researchers hope that even undergraduate astronomers could dig into the material and learn something new.

“Because the best science is really done when everyone thinks about the same data set differently,” Casey said. “It’s not just for one group of people to figure out the mysteries.”

For the COSMOS collaboration, the exploration continues. They’ve headed back to the deep field to further map and study it.

“We have more data collection coming up,” she said. “We think we have identified the earliest galaxies in the image, but we need to verify that.” To do so, they’ll be using spectroscopy, which breaks up light from galaxies into a prism, to confirm the distance of these sources (more distant = older). “As a byproduct,” Casey added, “we’ll get to understand the interstellar chemistry in these systems through tracing nitrogen, carbon and oxygen. There’s a lot left to learn and we’re just beginning to scratch the surface.”

The COSMOS-Web image is available to browse interactively; the accompanying scientific papers have been submitted to the Astrophysical Journal and Astronomy & Astrophysics.

Media Contact
Sonia Fernandez
Senior Science Writer
(805) 893-4765

sonia.fernandez@ucsb.edu

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