

UNIDAD DE CULTURA CIENTÍFICA

PRESS RELEASE

The James Webb telescope detects much more light than expected coming from the primeval universe

In a recent study led by the Center for Astrobiology (CAB), CSIC-INTA (Spain), researchers from 9 countries have analyzed the deepest images taken by the NIRCам instrument of the James Webb telescope, within the Guaranteed Time granted to the members of the team that built the MIRI instrument, and have found many more galaxies, much brighter and much smaller in size than expected to be found in the early universe.

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For 20 years, researchers from the Center for Astrobiology (CAB), CSIC-INTA, in Spain, have worked, jointly with astrophysicists and technicians of other 8 European countries and the United States, on the development of one of the instruments of the James Webb Space Telescope (JWST), MIRI. “As part of the payment for our work in the construction of MIRI, ESA and NASA awarded us with guaranteed telescope time to carry out scientific projects that we have been planning for decades,” says Luis Colina, MIRI co-principal investigator at CAB.

Guaranteed time observations began running in the fall of 2022, including what are the deepest images ever taken by JWST in the first year of science operations. Göran Östlin, MIRI Co-Principal Investigator at Stockholm University, tells us: “In December 2022 we took data in an area of the sky known as the Hubble Ultra-deep Field using MIRI, JWST spent 50 hours collecting photons of distant galaxies. In parallel, the NIRCам instrument, JWST's most sensitive camera, was also turned on, and with it we took data that allowed us to detect galaxies 10 times fainter than those that had been studied during the first 6 months of the mission. This is what we call the MIRI Deep Imaging Survey (MIDIS)”.

In an article published in *The Astrophysical Journal Letters*, the MIDIS team has presented their search for the most distant galaxies in the universe using NIRCам data. Pablo G. Pérez-González, a CAB astrophysicist who has worked on the project for 10 years, leads this work which has found 44 galaxies tentatively formed in the first 500 million years of the Universe, less than 4% of its current age, they even present some candidates formed in the first 200 million years of the universe, 1% of the age.

The main result of this work has been obtained by comparing the properties of these early galaxies with what was predicted by the most advanced galaxy formation models. Luca Costantin, a postdoctoral fellow at the CAB hired through the Madrid regional Government Talent Attraction program, and co-author of the article, tells us: “For decades, simulations of the universe developed with the most powerful supercomputers in the world have recreated how galaxies are formed, when the first stars appeared, how the primordial gas, which was only hydrogen and helium, was converted into other elements, such as oxygen or carbon, and how, ultimately, the fundamentals ingredients of life were created”.

The article compares the amount of ultraviolet photons that were created in these early galaxies discovered by JWST with what is predicted by cosmological simulations such as Illustris or EAGLE. “JWST is able to measure the amount of energy emitted in the ultraviolet by distant galaxies. Due to the effect of the expansion of the universe, today that energy takes the form of infrared photons, which are the ones that JWST and its NIRCam instrument can detect”, explains Pierluigi Rinaldi, a doctoral student at the University of Groningen and a collaborator on the project.

The first author of the article, Pablo G. Pérez-González, explains that "primeval galaxies created 10 times more ultraviolet photons than the models predicted, the key is how." Ultraviolet photons can be created by hot, young stars, much hotter than the Sun, that rapidly evolve and disappear. But those ultraviolet photons can also be created by supermassive black holes. The article describes that the primeval galaxies discovered are also very compact, 2-3 times more than expected, which could be linked to the presence of these black holes.

“Where would those supermassive black holes have come from? How could they have formed so quickly? Perhaps from primordial black holes that have been around almost since the Big Bang itself? Or from black holes that do not evolve from stars, which is how we think they normally form, but directly from the primordial gas, without going through stars, they collapsed directly? Or do we actually see more ultraviolet photons than expected because there are many more massive stars in primeval galaxies compared to the amount that is normally formed in nearby young galaxies?” says Pérez-González. "For now JWST is providing us with many more questions than answers, but these new lines of research are exciting," the authors of the article conclude.

About CAB

Centro de Astrobiología (CAB) is a joint research center of the National Institute of Aerospace Technology (INTA) and the National Research Council (CSIC) of Spain. Created in 1999, it was the world's first center dedicated specifically to astrobiological research and the first non-US associate member of NASA's Astrobiology Institute (now the NASA Astrobiology Program). It is an interdisciplinary research center whose main objective is to study the origin, presence and influence of life in the universe from a transdisciplinary approach. In 2017, CAB was distinguished by the Ministry of Science and Innovation as "María de Maeztu Unit of Excellence".

CAB has led the development of the **REMS**, **TWINS** and **MEDA** instruments, all operational on Mars since August 2012, November 2018 and February 2021, respectively; as well as the science of the **RLS** and **RAX** Raman instruments, which will be launched in this decade on board of ExoMars and MMX missions. In addition, CAB develops the **SOLID** instrument, aimed at the search for life in planetary exploration. Likewise, CAB participates in different missions and instruments of great astrobiological relevance, such as **CARMENES**, **CHEOPS**, **PLATO**, **BepiColombo**, **DART**, **Hera**, the MIRI and NIRSpec instruments at **JWST** and the **HARMONI** instrument at **ESO's** Extremely Large Telescope (**ELT**).

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The astronomers observed the Hubble Ultra Deep Field and parallels as part of the JWST Guaranteed Time Observation (GTO) Program 1283, "The MIRI HUDF Deep Imaging Survey" (PIs: Göran Östlin, Hans Ulrik Norgaard-Nielsen).

The MIDIS (MIRI Deep imaging Survey) collaboration consists of the following research institutions: Centro de Astrobiología, CSIC-INTA, Villanueva de la Cañada and Torrejón de Ardoz, Spain; Max Planck Institute for Astronomy, Heidelberg, Germany; Max Planck Institute for Extraterrestrial Physics, Garching, Germany; Physikalisches Institut, Universität zu Köln, Germany; Université Paris-Saclay, Orsay and Gif-sur-Yvette, France; Leiden Observatory, The Netherlands; KU Leuven, Belgium; Rijksuniversiteit Groningen, The

Netherlands; University of Vienna, Austria; ETH Zürich, Switzerland; Université de Liege, Belgium; LESIA, Observatoire de Paris, Meudon, France; INAF, Napoli, Italy; Dublin Institute for Advanced Studies, Ireland; UK Astronomy Technology Centre, Edinburgh, UK; University of Leicester, UK; Radboud University, Nijmegen, The Netherlands; Space Research Institute, Graz, Austria; SRON, Groningen and Leiden, The Netherlands; Stockholm University Sweden; Cosmic Dawn Center (DAWN), DTU Space, Lyngby, Denmark; Onsala Space Observatory, Sweden; Amsterdam University, The Netherlands.

The James Webb Space Telescope (JWST) is the world's leading observatory for space research. JWST is an international programme led by NASA with its partners, ESA (European Space Agency) and CSA (Canadian Space Agency). MIRI was built by a consortium involving research institutes and universities in 9 European countries and USA.

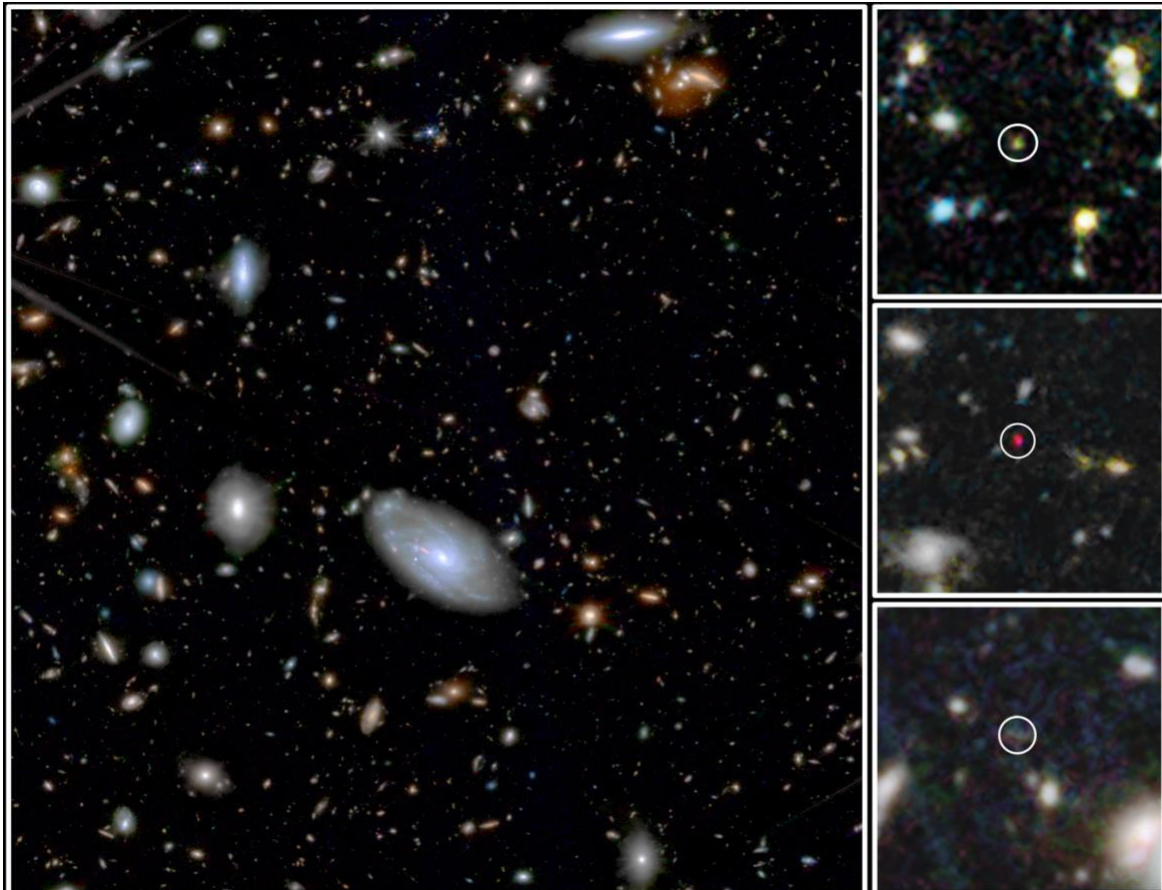


Image of the ultradeep field used by the MIRI Deep Imaging Survey (MIDIS) collaboration to search for primeval galaxies. The image combines data taken with the NIRCam camera, which operates in the near and mid-infrared spectral ranges. On the right stamps, some high redshift galaxy candidates presented in the article are shown. They would have been formed in the first 200 to 500 million years after the Big Bang, when the universe age was 1-5% of today's. Credits: Pierluigi Rinaldi, Rafael Navarro-Carrera, Pablo G. Pérez-González.

Scientific paper published in The Astrophysical Journal Letters

Reference: “Life beyond 30: probing the $-20 < M_{UV} < -17$ luminosity function at $8 < z < 13$ with the NIRCam parallel field of the MIRI Deep Survey”, Pablo G. Pérez-González et al., ApJL, , LXX <https://iopscience.iop.org/article/10.3847/2041-8213/acd9d0>

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