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JAMES WEBB SPACE TELESCOPE RESULTS AFTER 100 DAYS OF OPERATION

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ABSTRACT

From the moment the science operations begun in the summer of 2022, when it released its first collection of color images, to the most recent photo of the iconic Pillars of Creation, dense clouds of gas and dust in the Eagle Nebula, the James Webb Space Telescope has aimed at diverse targets such as galaxies 500 million light years away, the magnetosphere, the rings and satellites of the planet Jupiter, nebulae and an exoplanet with carbon dioxide in the atmosphere. Webb's innovative design combines the two main challenges for an infrared telescope, the large mirror to capture enough light as best as possible and keeping it at a low temperature. Accessible to the scientific community around the world, the James Webb Infrared Space Telescope will give scientists the opportunity to observe the evolution of galaxies, the formation of stars and planets, exoplanetary systems, and our own solar system in ways impossible before.

Key words*:* mission, infrared, innovative

Introduction

The James Webb Space Telescope is the result of an international partnership between NASA, ESA and the Canadian Space Agency (CSA). The telescope is named after NASA's second administrator, James E. Webb, who led the agency from February 1961 to October 1968 and also the Apollo space program. The James Webb Telescope is equipped with instruments that detect wavelengths longer than visible light, namely the near-infrared and mid-infrared. These features allow him to look further back in time to see the first galaxies formed in the early universe, to look inside the dust clouds where stars and planetary systems form today. It was launched on December 25, 2021 and after traveling the distance to the destination, calibrating the instruments and aligning the mirrors, on July 12, 2022, it transmitted its first photo. Webb is designed and built to give scientists the capabilities to push the frontiers of knowledge about our own solar system, the formation of stars and planets, including planets outside our solar system (exoplanets), and how galaxies are created and evolve, in ways impossible before.

Material and method

To study exoplanets JWST will use the transit method, which means it will look for the dimming of light from a star as its planet comes between us and the star.

The control module of the JWST telescope includes a set of scientific instruments, spectrographs, cameras, coronagraphs, with which the obtained data is collected. To transform JWST's raw data, scientists have to make adjustments to what the human eye can perceive, because our eyes are not made to see in the infrared, and the telescope is also much more sensitive to light than our eyes. The improved concept of the telescope gives us a more realistic representation of what these cosmic objects look like than our relatively limited eyes could. JWST can image in, up to 27 filters that capture different ranges of the infrared spectrum.

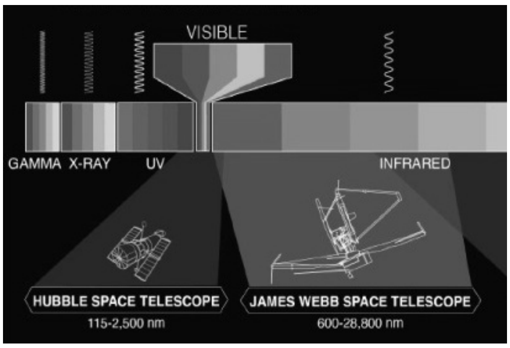

Fig. 1 - The spectrum of electromagnetic waves

Scientists isolate first the most useful dynamic range for a given image and scale the brightness values to unlock the most detailed ones. It then assigns each infrared filter a color from the visible range of the spectrum, with the shortest wavelengths becoming blue and the longer wavelengths becoming shades between green and red. Once these are added, all that's left are the necessary white balance, contrast and color adjustments to any photo.

The telescope is placed 1.5 million km away from the Sun at the L2 point, one of the 5 Lagrange

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points where the gravitational forces of the Sun and the Earth balance the effect of the centrifugal force and thus contribute to the considerable decrease in fuel consumption. In this position, Webb's solar shield will block light from the Sun, Earth and Moon, which will help keep the telescope cool, which is very important for an infrared telescope.

JWST has a primary mirror with a diameter of about 6.5 meters, which gives it a significantly larger light-gathering horizon than mirrors available on the current generation of space telescopes. Beyond the scientific importance of the photos taken by the Webb telescope, their spectacular appearance stands out.

Results and discussions

In order of distance from the Earth of the photographed subjects, follows a brief characterization at 8 different categories of objectives targeted by the telescope.

1. Neptune's rings. On September 21, 2022, the telescope photographed the gas giant planet, located at 4.4 billion km. distance from the Sun. The most recent images of the planet dated from the Voyager 2 flyby in 1989. In the images, the planet Neptune itself is no longer blue but appears in a darker color because the methane in its atmosphere absorbs both red and infrared light of the electromagnetic spectrum.

The James Webb Space Telescope "saw" the translucent rings, the high-altitude clouds that appear bright because their methane ice crystals reflect the Sun's light before they can absorb it, as well as seven of Neptune's 14 natural moons. In the image (Fig. 2) you can see the Triton satellite, in the upper left, with its reflective surface made of frozen nitrogen.

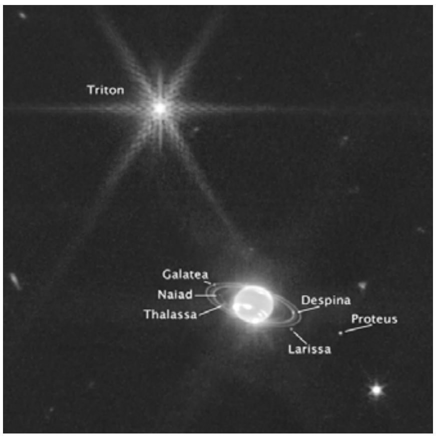

Fig. 2 - The planet Neptune and some of the satellites

2. Protostar L1527, a forming solar system, is 460 light-years away in the constellation Taurus. The protostar is the early stage of star formation and consists of the existence of a large mass of matter that is formed by the contraction of gas from a giant molecular cloud located in the interstellar medium. The image obtained by the telescope (Fig. 3) clearly shows the narrow part in the middle, which is embedded in clouds of gas and dust visible only in infrared, clouds that are attracted to the center and gradually incorporated into the future star, a process that will take hundreds of thousands of years.

Fig. 3 - Protostar L1527

These bright clouds in the T-Tauri tipe star-forming region are visible only in infrared light, an ideal target for the Webb Telescope's Near Infrared Camera (NIRCam).

The blue color indicates a high concentration of hydrogen and shades of orange are indicate different concentrations of interstellar dust. The disk, seen in the image as a dark band in front of the bright center, is about the size of our solar system. Studying such a phenomenon is very important in deciphering the stages of early formation that the Sun and its planetary system went through.

3. WASP 96-b is a gas giant exoplanet orbiting a Sun-like star about 1120 light-years away in the constellation Virgo. The planet is a hot gas giant with a mass about a quarter that of Jupiter and a diameter 1.3 times that of Jupiter.

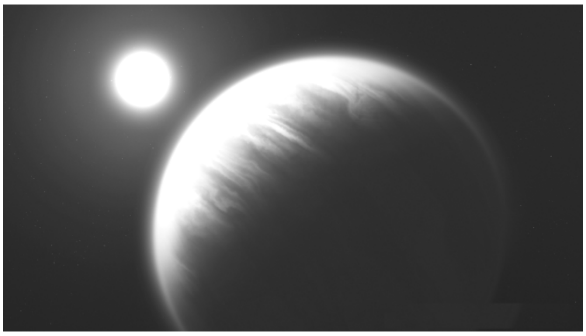

Fig. 4 - Exoplanet WASP 96-b

Its size is partly related to its high temperature of over 500ºC, but also to its placement very close to its star, making a complete rotation in almost 4 days. Data collected by Webb's near-infrared spectrograph shows clear evidence of carbon dioxide in the atmosphere after even the Hubble telescope had already detected the presence of water vapor, sodium and potassium. The planet likely has clouds and some form of climate, but may not have atmospheric bands like those of Jupiter and Saturn. This observation of a gas giant planet orbiting a Sun-like star provides important insights into the planet's composition and formation. The discovery of the planet, reported in 2011, was based on ground-based detections of the subtle and periodic dimming of light from the host star as the planet transits, or passes in front of the star.

Recent and detailed observations by the James Webb Telescope mark a giant leap in the quest to describe potentially habitable planets beyond Earth.

4. The Southern Ring Nebula, (NGC 3132), located 2,000 light years away, is a planetary nebula an expanding cloud of gas surrounding a former Sun-sized star (Fig.5).

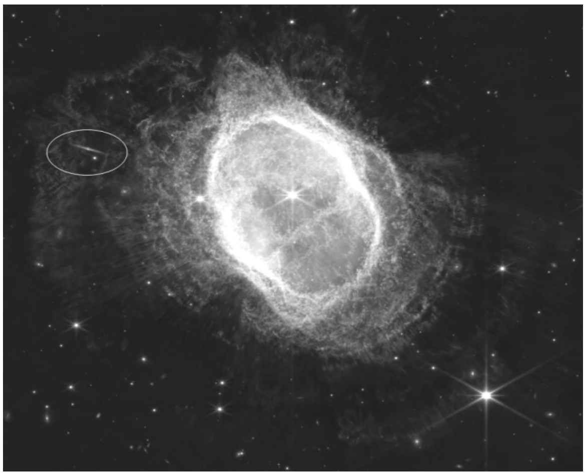

Fig. 5 - The Southern Ring Nebula (NGC 3132)

The white dwarf left over after the star exploded and the outer layers was stripped away is unimaginably hot and emits intense ultraviolet radiation, causing the gas around it to light up, over thousands of years expelling at least eight layers of gas and dust. This is not only a clear image of a planetary nebula, but also shows us objects in the vast space behind it, distant galaxies.

5. The Pillars of Creation, is a region that is part of the Eagle Nebula near the Serpent constellation, 6500 light years away.

The three-dimensional "pillars" look like majestic rock formations that sometimes appear semi-transparent in the infrared light spectrum, columns of cold interstellar gas and dust, essential ingredients for star formation.

In the background only a few tens of tiny bright white and blue stars are visible, with larger red stars and they are embedded in the columns of gas and dust.

Although this formation has been studied and photographed by other telescopes such as Hubble, the new insight provided by Webb will help researchers update their star formation models with a new method of estimating the amount of matter necessary for the formation of a star, now, but especially over billions of years (Fig.6).

Fig. 6 - The Pillars of Creation

6. The Phantom Galaxy is 32 million light years away. Delicate filaments of gas and dust are seen in the broad spiral arms. The lack of gas in the central region provides a clear view of the cluster of stars in the center of the galaxy (Fig.7).

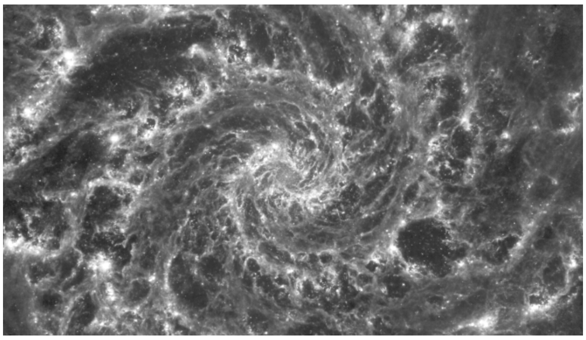

Fig. 7 - Fantom Galaxy

By studying these galaxies, we want to obtain information about the early stages of star formation. The sharp images provided by Webb at longer wavelengths will allow astronomers to identify star-forming regions in galaxies, precisely measure the masses and ages of star clusters and obtain information about the nature of interstellar dust.

7. Stephan's Quintet is a group of four galaxies, of which 3 are 290 million light years away from Earth and one is 40 million light years away. The "tails" of gas, dust and stars originating from several galaxies are the consequence of gravitational interactions. Webb captures giant red and gold shock waves around the central pair, the result of the approach of 2 galaxies. The clear color difference between dust in galaxies and shock waves between interacting galaxies can be distinguished. (Fig. 8).

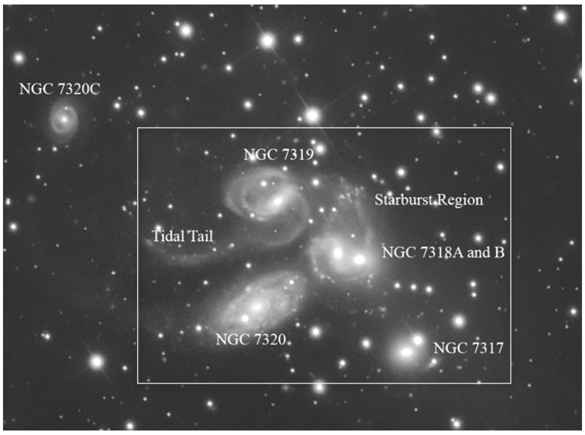

Fig. 8 - Stephan's Quintet

The stars that make up the galaxies are from all stages of stellar evolution, from newly formed stars to stars at the end of the stellar cycle, covering intervals of hundreds of millions of years of cosmic history.

Mergers and interactions between galaxies are essentials to the entire evolution of galaxies, but difficult for researchers to observe. Stephan's Quintet is a fantastic "laboratory" for studying these fundamental processes for all galaxies. Tight clusters like this may have been more common in the early universe, when their superheated, colliding material would have fueled highly energetic black holes called quasars. Even today, the northernmost galaxy in the group (NGC 7319) has an active galactic nucleus, a supermassive black hole that is constantly capturing interstellar material.

8. The first image taken by JWST was on July 12, 2022, and is the deepest and clearest infrared image of the early universe. This was the galaxy cluster SMACS 0723 as it looked 4.6 billion years ago, with thousands of galaxies, including the smallest and faintest objects ever observed.

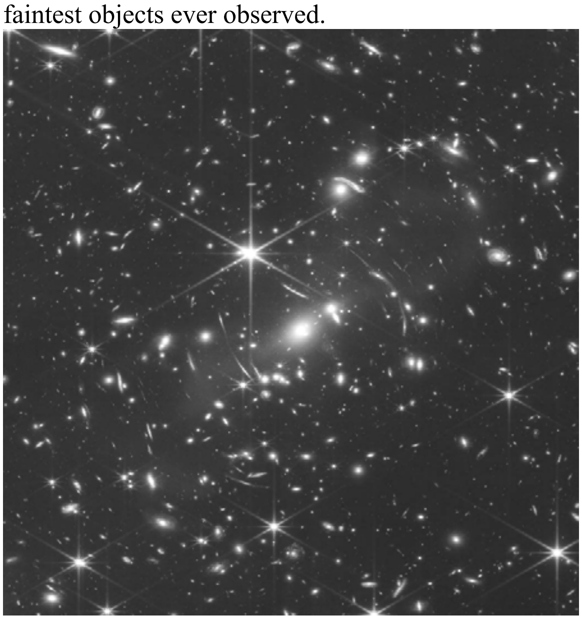

Fig. 9 - SMACS 0723

Much more about this cluster will be revealed as researchers sift through the data obtained by Webb. The image (Fig. 9) provides a kaleidoscope of colors and highlights where is located dust, a major ingredient for star formation. Blue galaxies contain stars but very little dust. The red objects in this field are shrouded in thick layers of dust. Researchers will be able to use such data to understand how galaxies form, grow and merge with each other and, in some cases, why they stop forming stars.

Conclusions

The James Webb Space Telescope is named after NASA's second administrator, James E. Webb, who led the agency from February 1961 to October 1968 and led the Apollo space program.

The new telescope's observations covering longer wavelengths of the electromagnetic spectrum allow JWST to look further back in time to see the first galaxies that formed in the early universe and penetrate the dust clouds where stars form today and planetary systems.

Looking at the universe at infrared wavelengths, Webb will show us things never before seen by any other telescope, from the first stars and galaxies formed after the Big Bang to the formation of stars and planetary systems inside dust clouds opaque to visible light.

The James Webb Space Telescope will be the next great scientific space observatory, designed to answer outstanding questions about the Universe and make groundbreaking discoveries in all areas of astronomy. It's a once in a generation mission. Since scientists have advanced various theories about the formation of the universe, especially about the Big Bang, the Webb telescope will help to confirm or clarify some of such theories and thus we will soon be able to outline a unanimous answer on this subject. Webb is designed and built to give scientists the capabilities to push the frontiers of knowledge about our own solar system, the formation of stars and planets, including planets outside our solar system (exoplanets), and how galaxies are created and evolve, in ways impossible before. Its data will be made available to the scientific community worldwide.

Rezumat

Telescopul Spațial James Webb un program internațional condus de NASA cu partenerii săi, ESA (Agenția Spațială Europeană) și Agenția Spațială Canadiană, este cel mai mare, cel mai puternic și cel mai complex telescop spațial științific construit vreodată. Conceput cu o sensibilitate mult îmbunătățită, ce poate detecta lungimile de undă în infraroșu ale spectrului electromagnetic, telescopul Webb va „privi” mult mai aproape de începutul timpului spre formarea primelor galaxii și va pătrunde în interiorul norilor de praf unde se formează astăzi stelele și sistemele planetare. Telescopul Spațial James Webb va rezolva misterele sistemului nostru solar, va cerceta planetele îndepărtate din jurul altor stele și va sonda structurile şi originile misterioase ale universului vizibil. Are o suită de instrumente astronomice de ultimă generație capabile să clarifice o gamă foarte largă de întrebări restante în astrofizică. Instrumentele, camere puternice, coronografe și spectrografe vor oferi oamenilor de știință datele de care au nevoie pentru a analiza materia din care sunt formate stelele, nebuloasele, galaxiile și atmosferele planetelor.

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