PROCEEDINGS OF SCIENCE

Frontier Research in Astrophysics 2024 Concluding Remarks I

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1. Introduction

The workshop is about to end and it is thus the time to take stock of the whole meeting.

Frontier Research in Astrophysics is a workshop series devoted to astrophysics (very broadly defined). The spirit of the works presented at these meetings is that we want to use our Universe as a laboratory for studying fundamental physics. The main goal of the workshop series is to provide a regular up-to-date overview of the main theoretical and experimental lines of research in astrophysics, astroparticle physics, and cosmology.

This year we are at the fourth edition. The workshop series was launched in 2014 with the plan to have a workshop every two years. The second and third workshops were thus organized in 2016 and 2018, respectively. Because of the pandemic, the workshop scheduled in 2020 was cancelled and it was not possible to organize the workshop in 2022 either. Now that the pandemic is over, we have the fourth workshop this year and we expect to have the next workshop in 2026.

2. What Is New?

Since this workshop series is devoted to review new results and trends in astrophysics, the natural question at the conclusion of every workshop is to highlight the new important scientific results with respect to the previous meeting. If I am asked to choose the three most important achievements in the past 6 years, my list is this:

1. The results of the Imaging X-ray Polarimetry Explorer (IXPE).

2. The results of the James Webb Space Telescope (JWST).

3. The application of machine learning techniques in astrophysics[1].

2.1 The Imaging X-ray Polarimetry Explorer (IXPE)

The Imaging X-ray Polarimetry Explorer (IXPE, Figure 1) is an X-ray mission led by NASA and with the collaboration of the Italian Space Agency (ASI) [1, 2]. The Italian National Institute of Nuclear Physics (INFN) and the Italian National Institute of Astrophysics (INAF) developed the X-ray polarization detectors. IXPE was designed to study the polarization of the electromagnetic radiation in the soft X-ray band (nominal energy range 2-8 keV) from the most energetic sources in the Universe, including black holes, neutron stars, and supernova remnants. The mission was launched on 9 December 2021 with a tentative duration of at least 5 years.

In this workshop, we had 14 talks to present IXPE results. IXPE represents a major advancement in X-ray astronomy, as it is the first astrophysical mission dedicated to measuring X-ray polarization since the 1970s. The "predecessor" of IXPE was the Orbiting Solar Observatory OSO-8, which operated between the end of the 1960s and the beginning of the 1970s with a sensitivity two orders of magnitude lower than IXPE. Polarization measurements are crucial to understand the geometries of astrophysical systems and their magnetic fields. Combined with spectral and timing studies, they can break parameter degeneracy in astrophysical models.

[1]This speech was given on 14 September 2024, before the announcement on 8 October 2024 of the winners of the Nobel Prize in Physics 2024, John J. Hopfield and Geoffrey Hinton, for their foundational work in machine learning with artificial neural networks.

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Figure 1: The Imaging X-ray Polarimetry Explorer (IXPE). Credit: NASA.

2.2 The James Webb Space Telescope (JWST)

The James Webb Space Telescope (JWST, Figure 2) is an infrared/optical space telescope developed by NASA and with the collaboration of the European Space Agency (ESA) and the Canadian Space Agency (CSA) [3, 4]. JWST was designed to study, among other things, the first galaxies, the first supermassive black holes, the first stars, and the atmosphere of exoplanets. The mission was launched on 25 December 2021 with a tentative duration of at least 10 years but an expected lifetime of 20 years.

JWST is the natural successor of the Hubble Space Telescope (HST), which has been an extremely successful mission in terms of scientific outputs. JWST can observe and study objects that are older, fainter, and more distant than those studied by HST. The list of its scientific achievements is already long. JWST found supermassive black holes in the first galaxies significantly more massive than what expected. It also found that the early galaxies were brighter and more structured than expected, challenging existing models of galaxy formation.

2.3 Machine Learning Techniques for Astrophysics

While the earliest applications of machine learning techniques in astrophysics started in the 1990s, it is only in the past few years that they have become extremely popular and, apparently, indispensable. In short, computational processes (very broadly defined) that were considered “impossible” up to a few years ago, are now “possible” with machine learning techniques. Either we have to analyze a larger and larger amount of astronomical data or we need to develop more and more advanced theoretical models, machine learning techniques are becoming more and more important and irreplaceable in our projects.

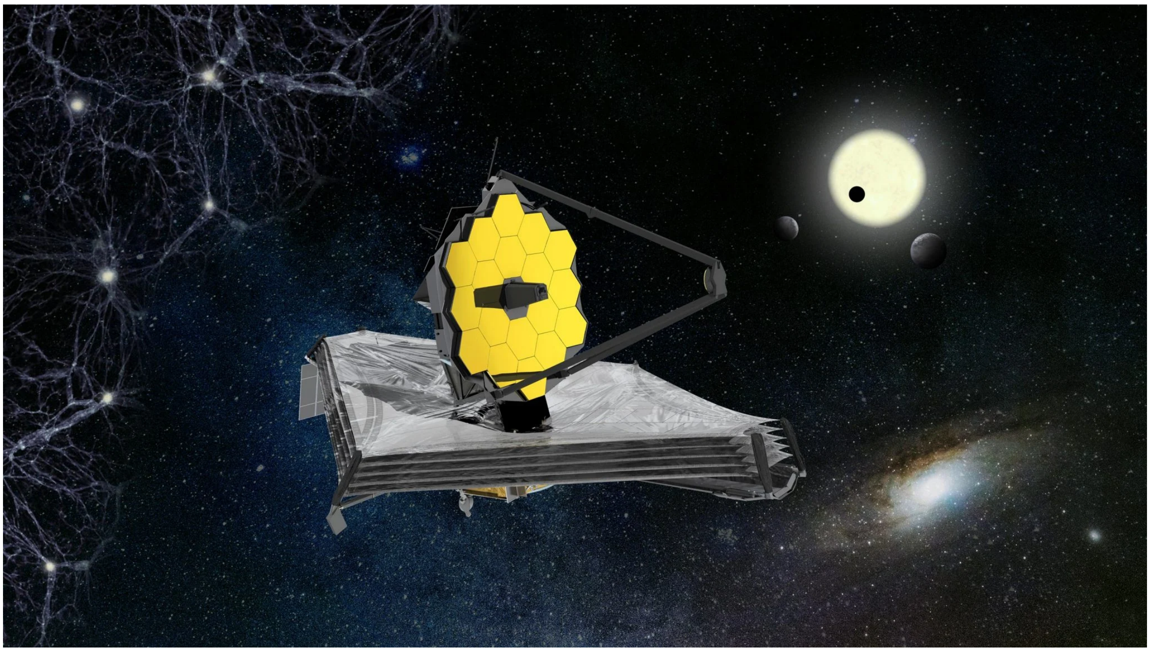

Figure 2: The James Webb Space Telescope (JWST). ESA/ATG medialab.

3. Concluding Remarks

To conclude, I sincerely believe that this meeting has achieved its main goal to bring together theorists, experimentalists, and observationalists to discuss recent key results in astrophysics, astroparticle physics, and cosmology.

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References

[1] https://ixpe.msfc.nasa.gov

[2] https://www.asi.it/en/planets-stars-universe/alte-energie/ixpe/

[3] https://science.nasa.gov/mission/webb/

[4] https://webbtelescope.org