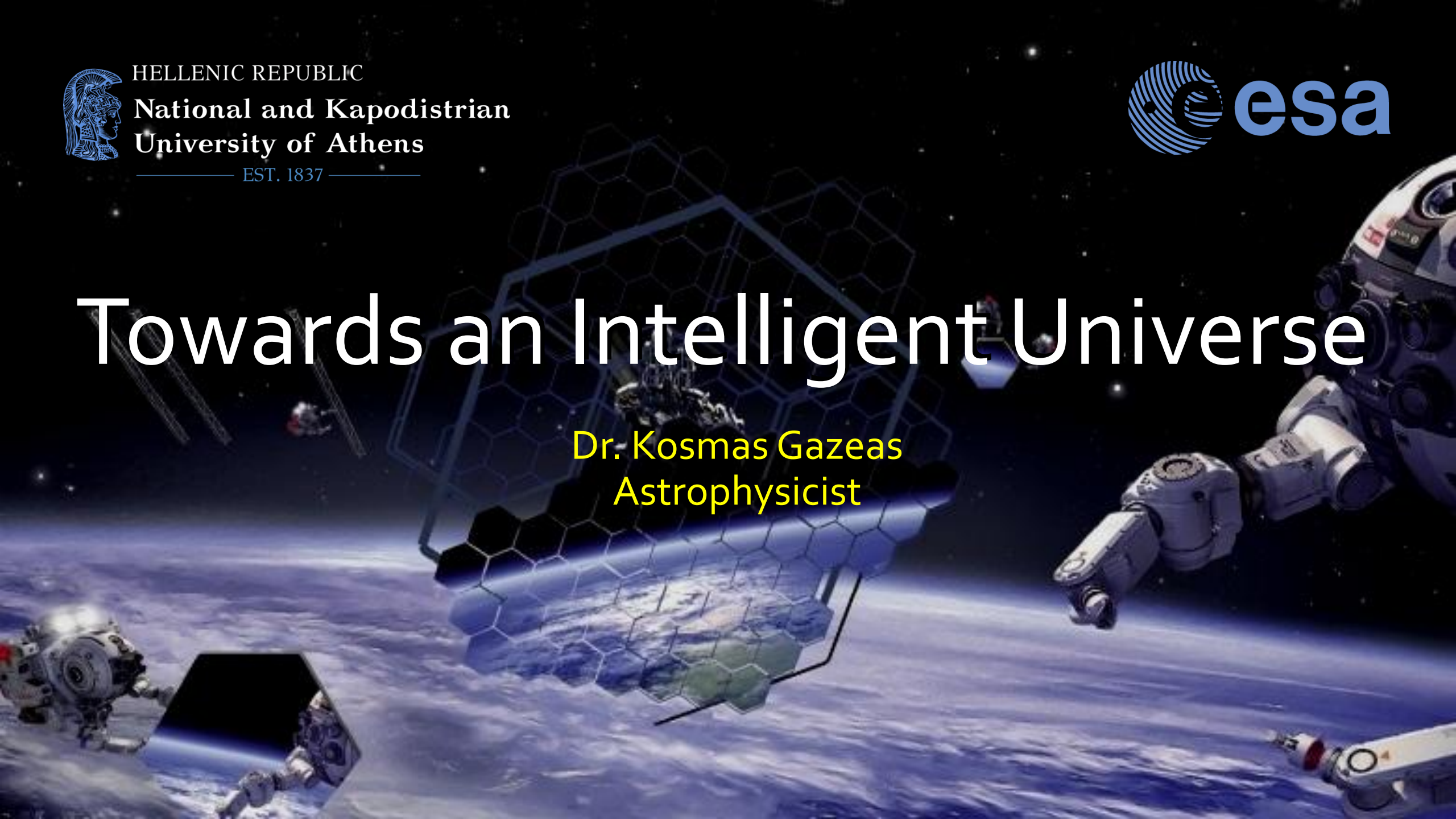

HELLENIC REPUBLIC
National and Kapodistrian
University of Athens
EST. 1837
esa
Towards an Intelligent Universe
Dr. Kosmas Gazeas
Astrophysicist

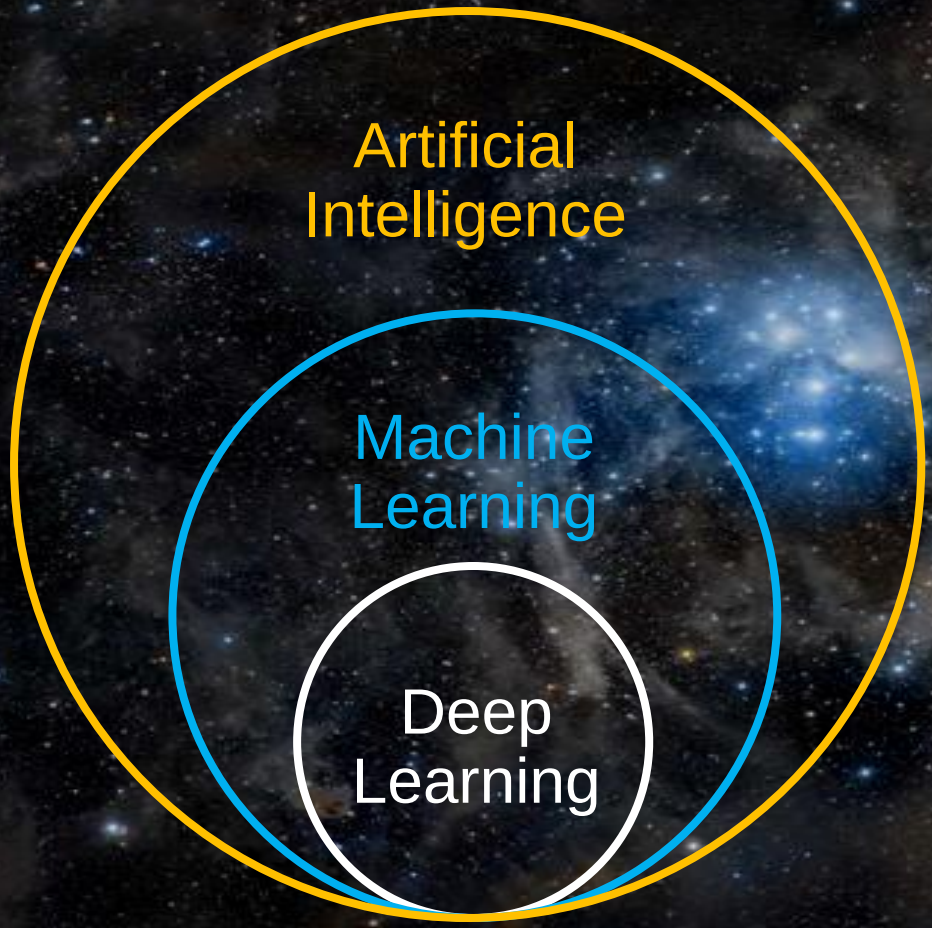
Understanding Artificial Intelligence

AI is the science and engineering of developing systems that can carry out tasks typically requiring humanly thinking.

These tasks cover an enormous range, such as pattern recognition, problem-solving, and much more.

A key component of AI is ML, which enables systems to improvise their performance by learning from data without explicit programming.

Within ML, deep learning (DL) represents an even more specialized subset that leverages artificial neural networks to process and extract patterns from large datasets.



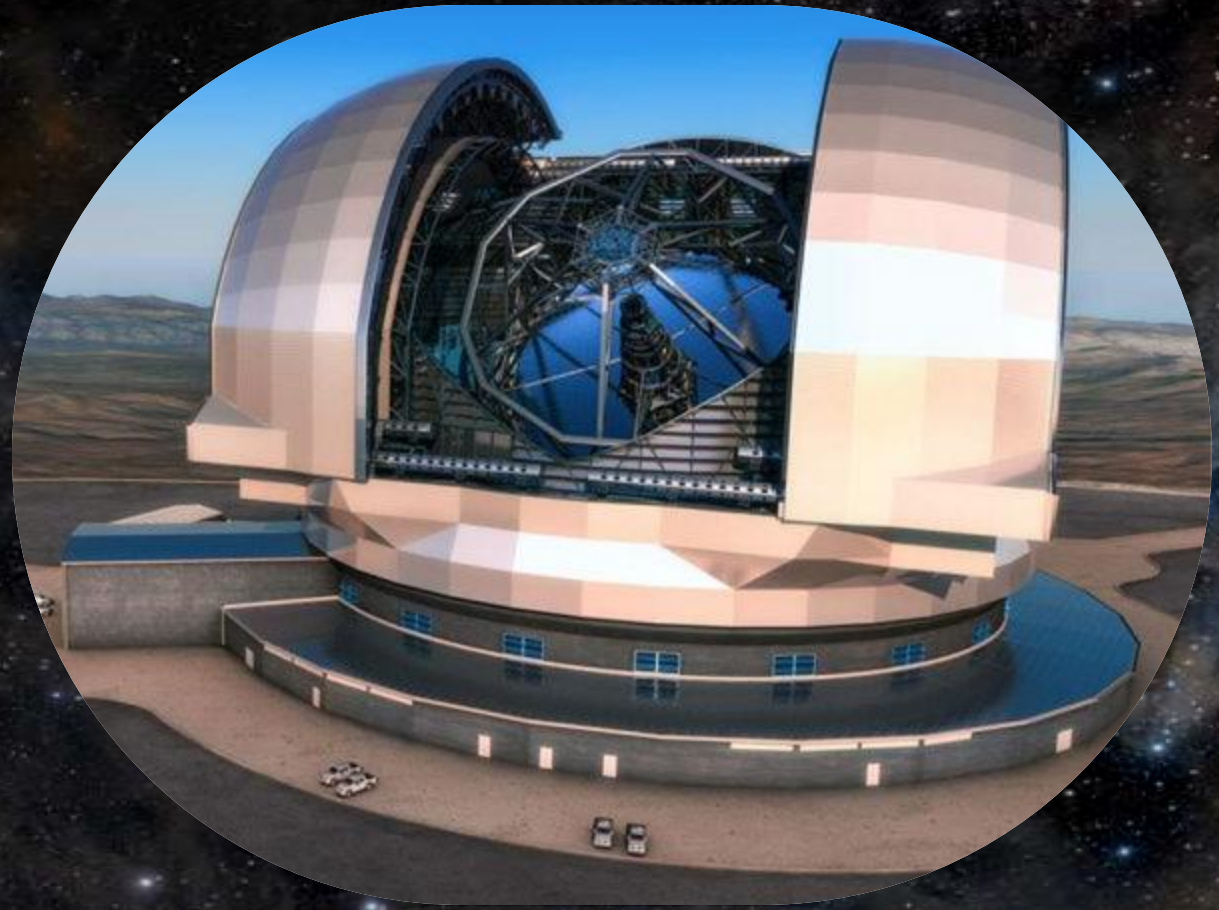
R. Barnwal, A. Kumar, Kala S. and S. Rajendran, 2025

AI in Observational Astronomy

With the exponential increase in the quantity and complexity of data generated by modern telescopes, traditional methods of analysis are no longer sufficient.

AI has become a game changer, enabling astronomers to efficiently process vast datasets, uncover hidden patterns, and automate the discovery process.

From real-time analysis of astronomical phenomena to the classification of galaxies and exoplanets, AI is revolutionizing how telescopic data are interpreted.



AI in Observational Astronomy

- AI-Powered Image Processing in Astronomy
- Real-Time Data Processing and Automated Observations
- AI in Telescope Data Compression and Storage

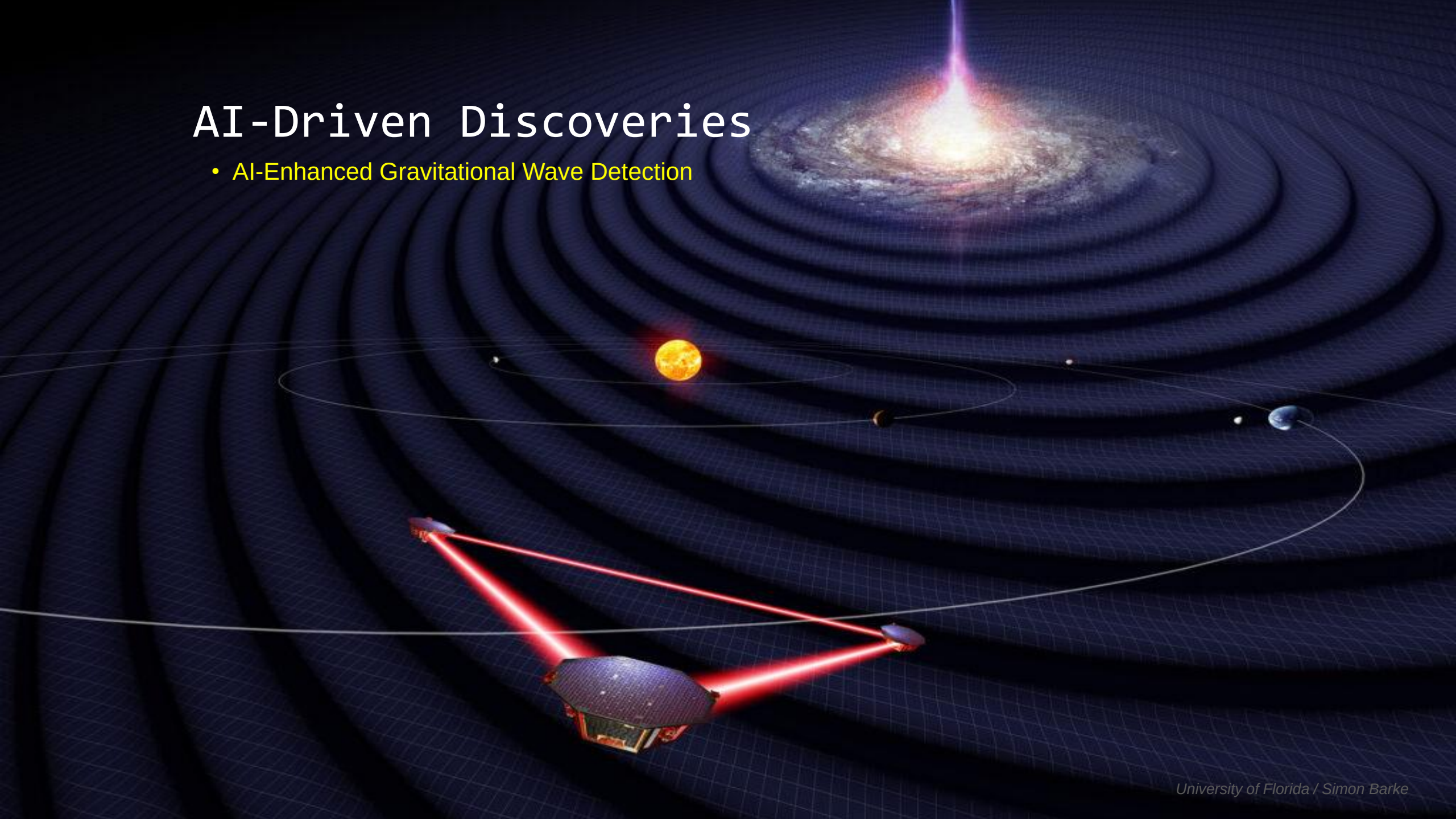
AI for Space Exploration

- Harnessing AI for Space Exploration **and Planetary Science**
- AI-Driven Autonomous Navigation for Deep Space **Missions**
- Autonomous robots for constructing lunar habitats


AI
AI
AI
AA

AI-Driven Discoveries

- AI-Enhanced Gravitational Wave Detection



University of Florida / Simon Barke

AI-Driven Discoveries

- AI-Driven Meteor Shower Mapping

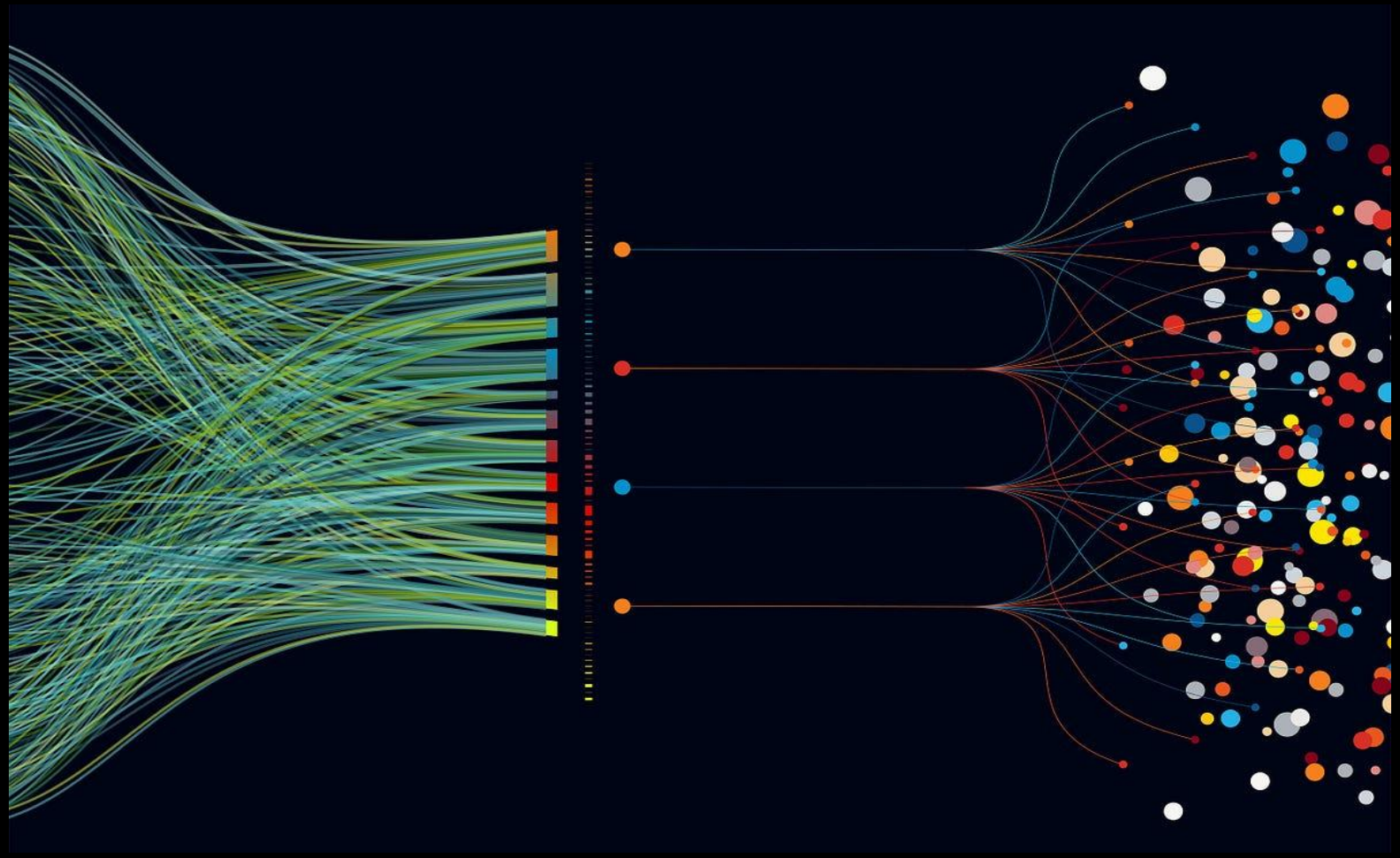
AI-Driven Discoveries

- AI for Exoplanet Discovery and Characterization

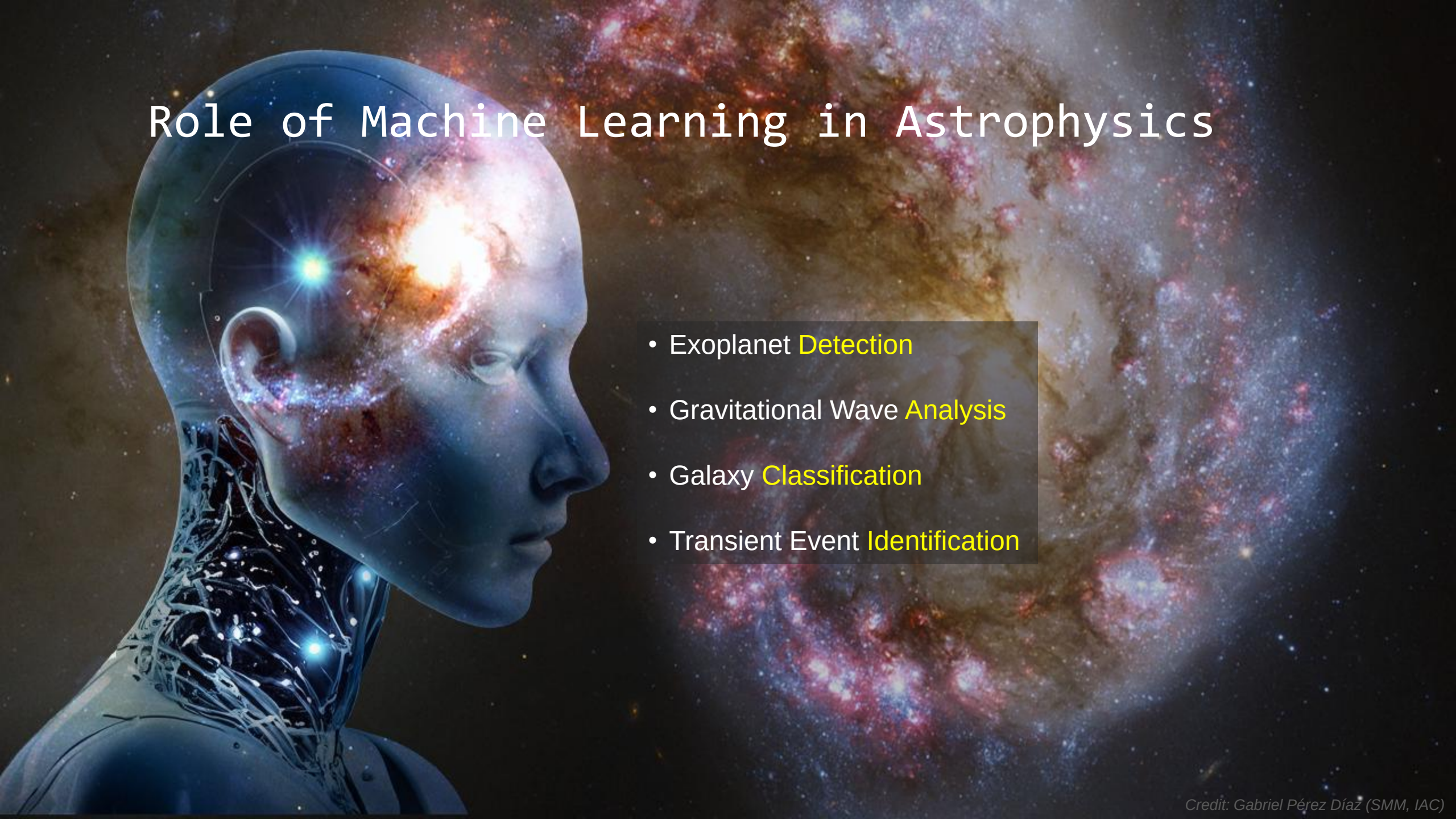
Machine Learning Applications in Astrophysics

Classification: (e.g., stars, galaxies, quasars) based on their spectral and photometric properties. Techniques like support vector machines, random forests, and artificial neural networks (ANNs) are commonly used.

Regression: Predicting continuous values such as stellar mass, temperature, or redshift using algorithms like K-nearest neighbors, decision trees, and Gaussian process regression.

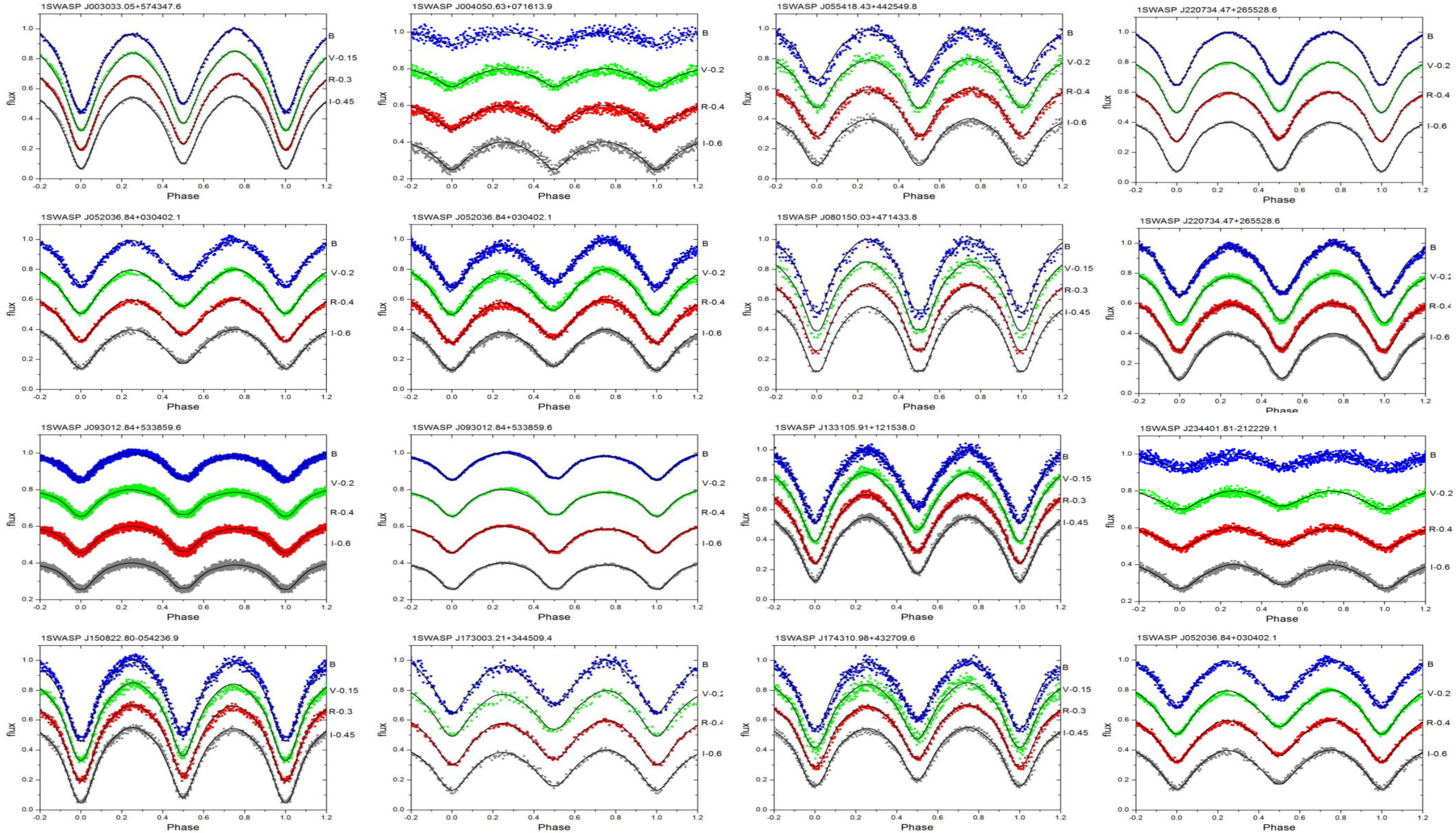


Role of Machine Learning in Astrophysics



- Exoplanet Detection
- Gravitational Wave Analysis
- Galaxy Classification
- Transient Event Identification

Credit: Gabriel Pérez Díaz (SMM, IAC)


1SWASP J003033.05+574347.6
1SWASP J004050.63+071613.9
1SWASP J055418.43+442549.8
1SWASP J220734.47+265528.6
1SWASP J052036.84+030402.1
1SWASP J052036.84+030402.1
1SWASP J080150.03+471433.8
1SWASP J220734.47+265528.6
1SWASP J093012.84+533859.6
1SWASP J093012.84+533859.6
1SWASP J133105.91+121538.0
1SWASP J234401.81-212229.1
1SWASP J150822.80-054236.9
1SWASP J173003.21+344509.4
1SWASP J174310.98+432709.6
1SWASP J052036.84+030402.1
flux
Phase
B
V-0.15
V-0.2
R-0.3
R-0.4
I-0.45
I-0.6

Challenges in the Era of Big Data

Managing Vast Data Volumes

Addressing Observational Noise

Discovering New Astrophysical Phenomena

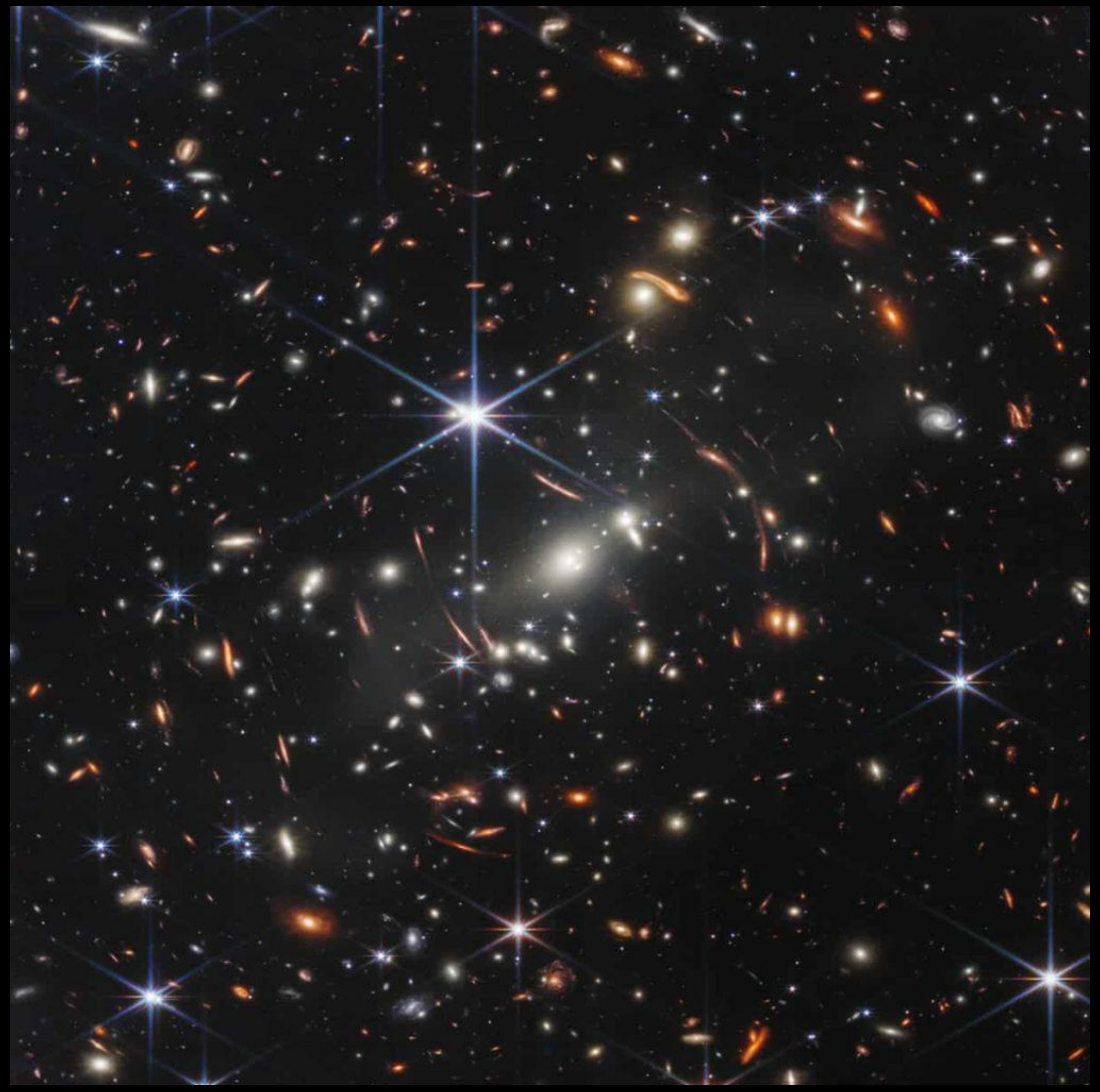
Enhancing Theoretical Simulations with Observational Data

The Future: Robotic and Autonomous Observatories

Real-Time Event Detection and Response

Predictive Modeling in Astrophysics

Towards a New Era of Astrophysical Discovery



Robotic Telescopes

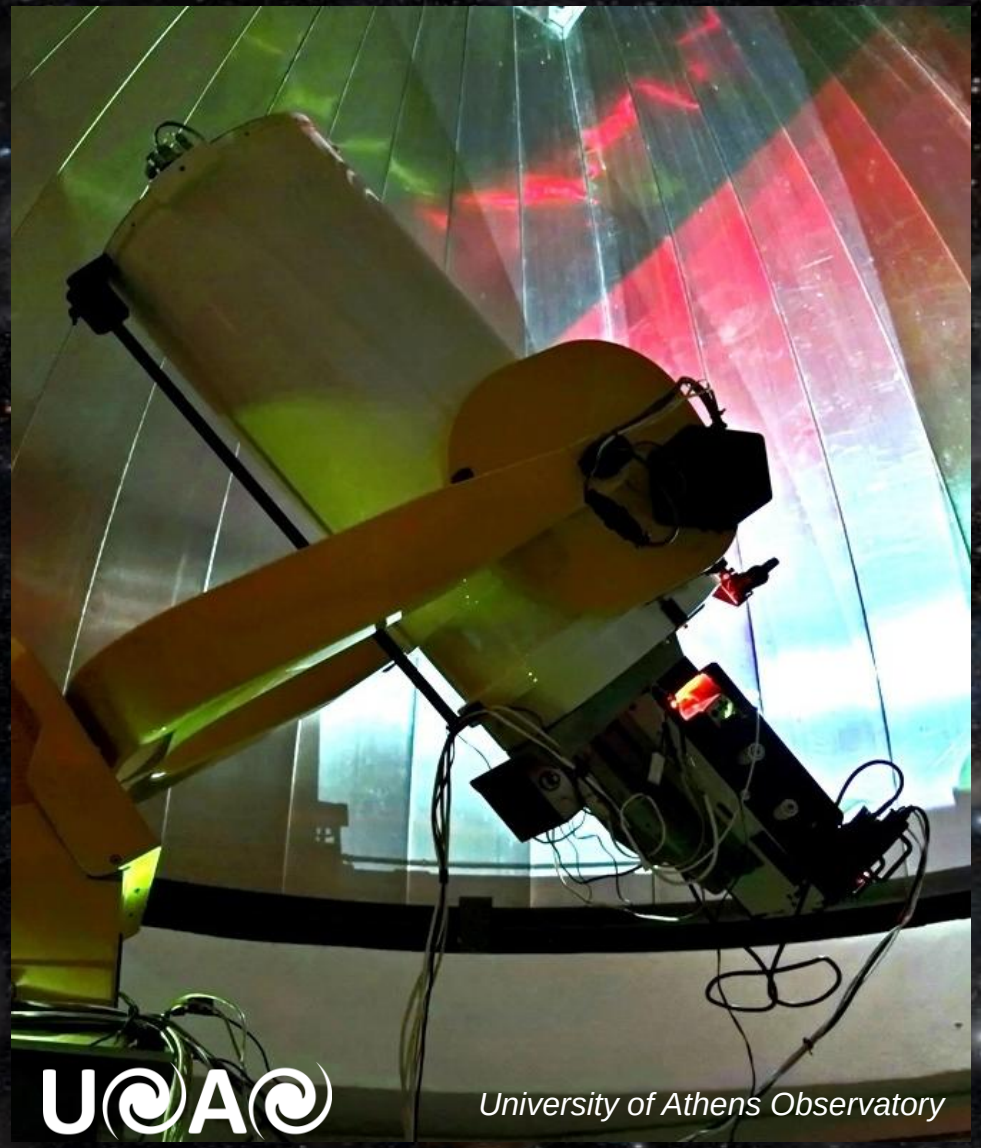
A robotic telescope can make observations without hands-on human control.

Robotic telescopes usually run under the control of a scheduler, which provides control by selecting astronomical targets for observation.

Some robotic telescopes are scheduled by a human astronomer at the start of each night. They are only robotic in the sense that individual observations are carried out automatically.

Advantages of Robotic Telescopes

- Removing humans from the observing process allows faster observation response times and begin observing within seconds.
- Automation in a telescope's observing program eliminates the need for an observer to be constantly present at a telescope. This makes observations more efficient and less costly.
- Many telescopes operate in remote and extreme environments such as mountain tops, deserts, and even Antarctica.
- Under difficult conditions like these, a robotic telescope is usually cheaper, more reliable and more efficient than an equivalent non-robotic telescope.



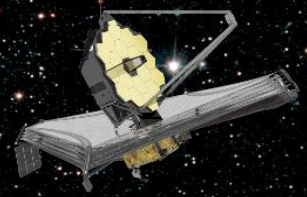
University of Athens Observatory

→ ESA'S FLEET ACROSS THE SPECTRUM

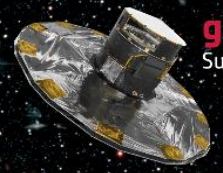
esa

Thanks to cutting edge technology, astronomy is unveiling a new world around us. With ESA's fleet of spacecraft, we can explore the full spectrum of light and probe the fundamental physics that underlies our entire Universe. From cool and dusty star formation revealed only at infrared wavelengths, to hot and violent high-energy phenomena, ESA missions are charting our cosmos and even looking back to the dawn of time to discover more about our place in space.

jwst
Observing the first light

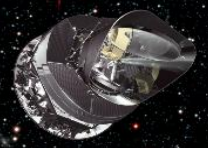


gaia
Surveying a billion stars

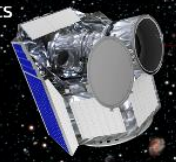


herschel
Unveiling the cool and dusty Universe

planck
Looking back at the dawn of time



cheops
Sizing and first characterisation of exoplanets

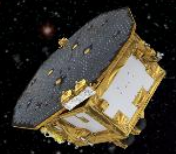


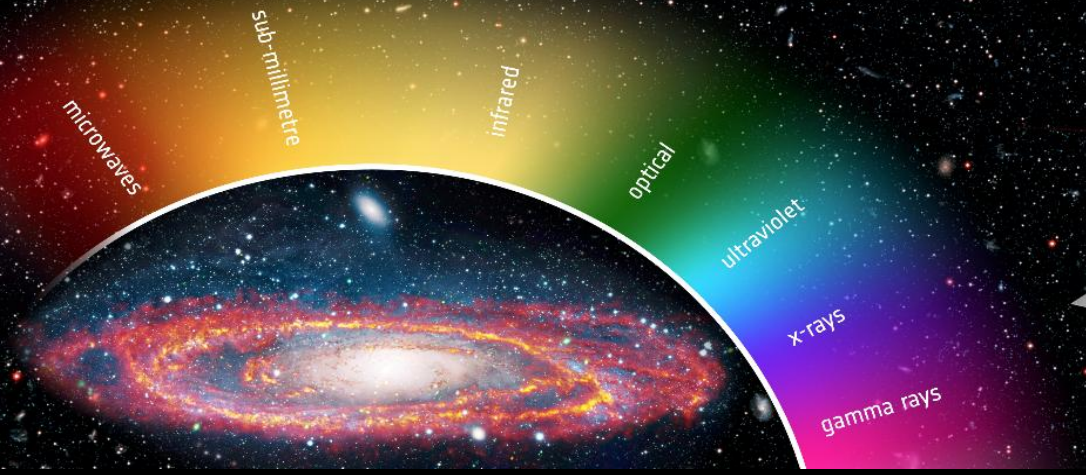
euclid
Exploring the dark Universe

hst
Expanding the frontiers of the visible Universe

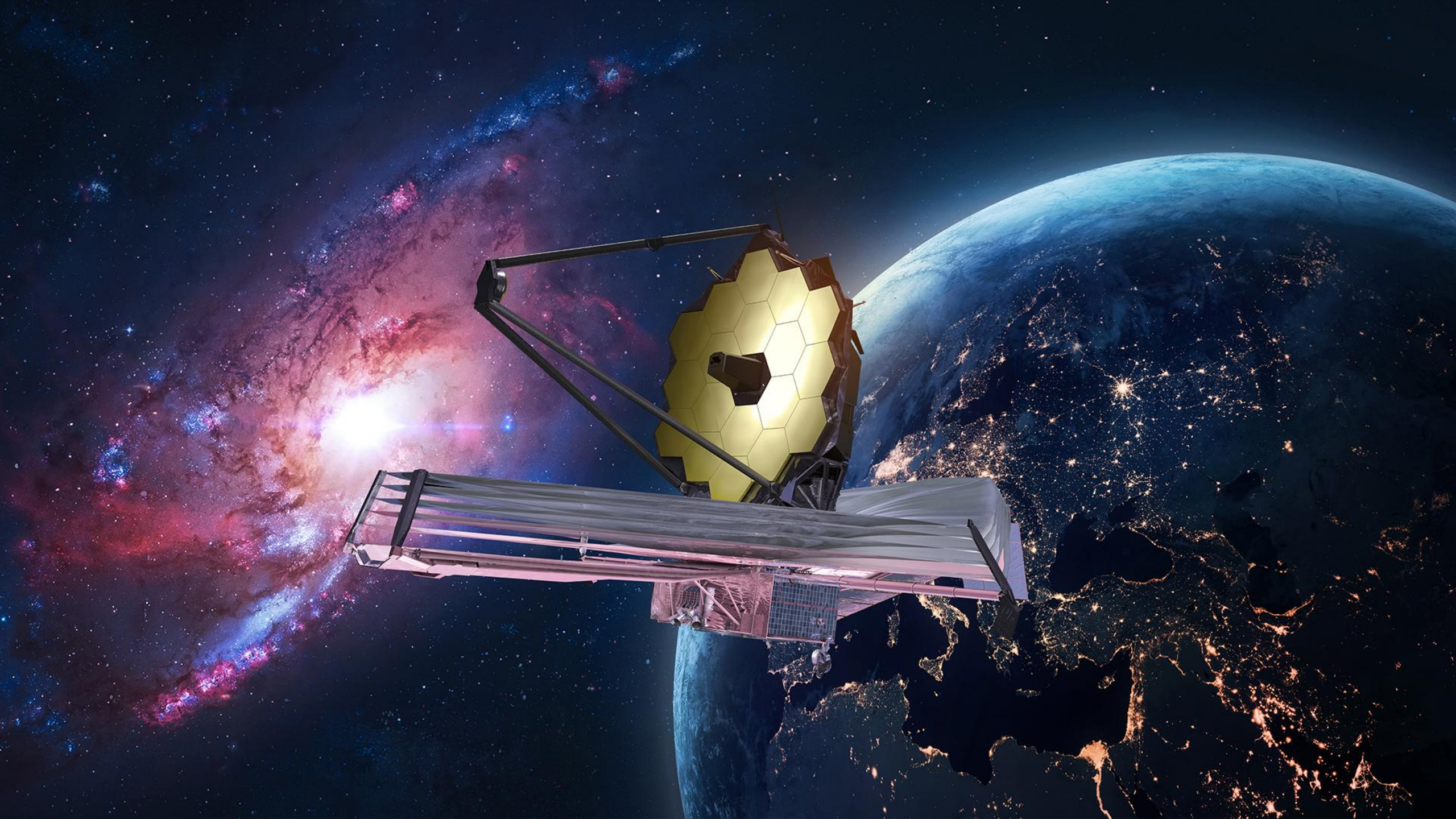
xmm-newton
Seeing deeply into the hot and violent Universe

lisa pathfinder
Testing the technology for gravitational wave detection

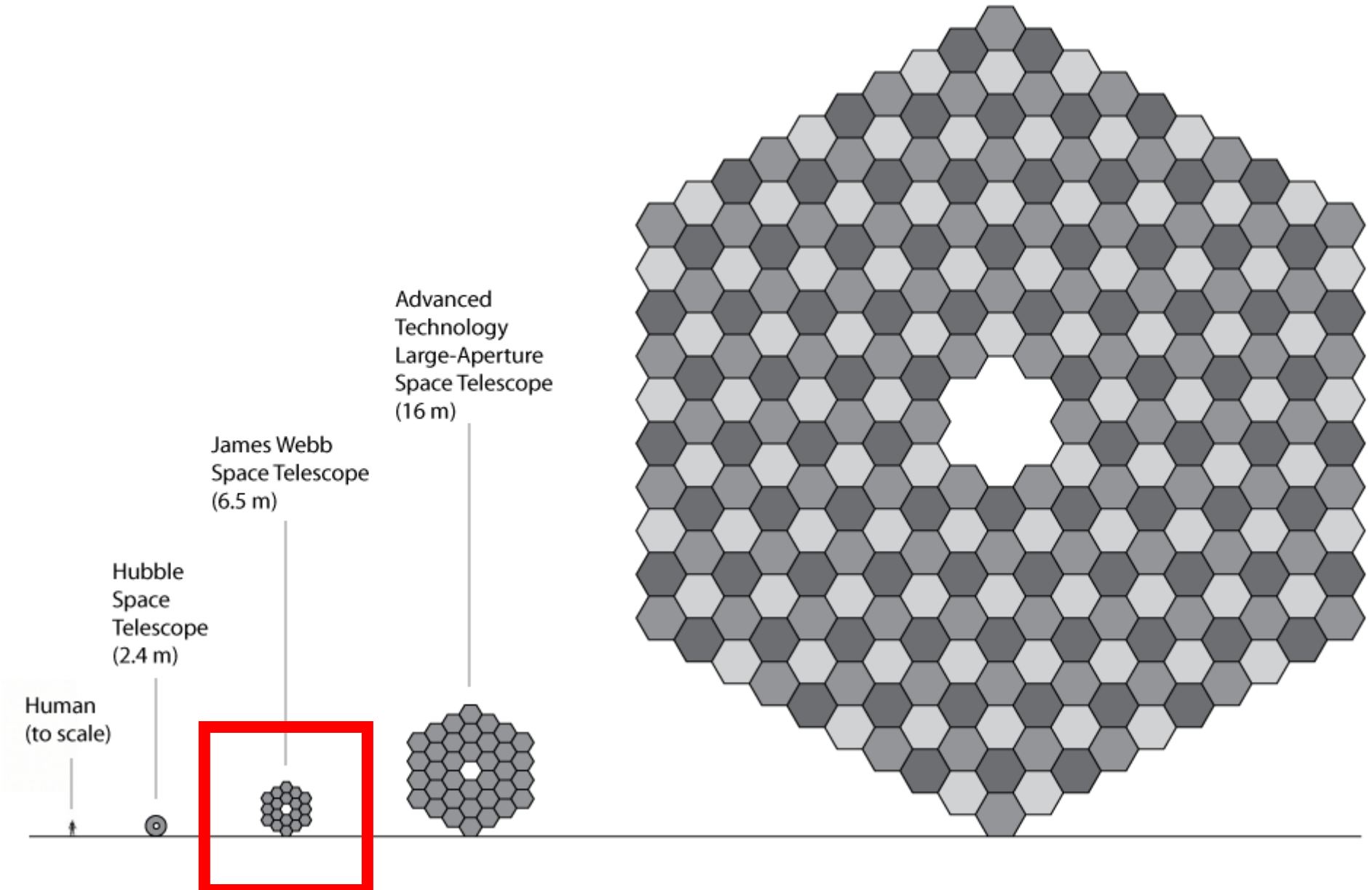




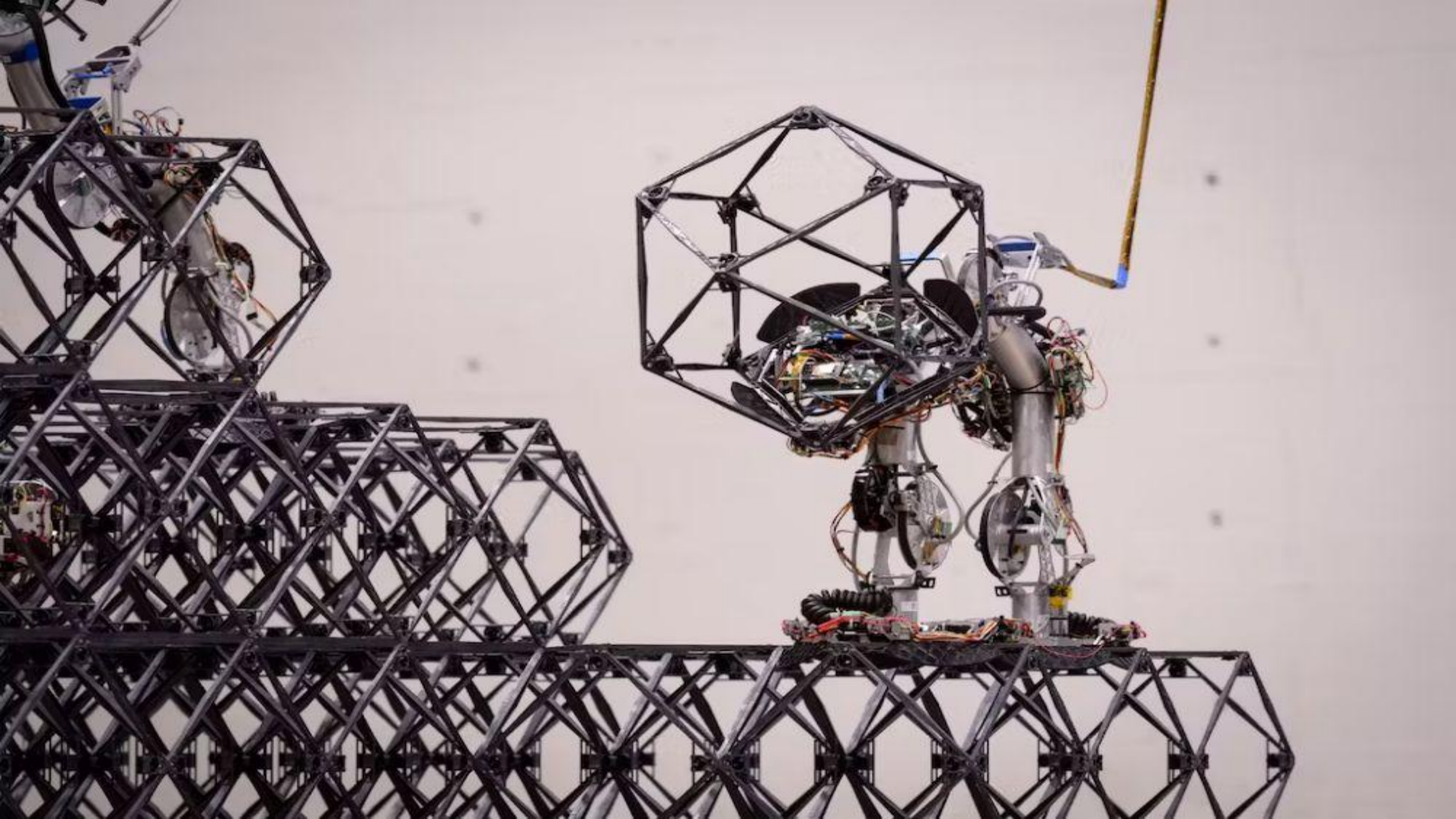
integral
Seeking out the extremes of the Universe



Current and future space telescopes



Fox et al. 2016



Future Space Telescopes

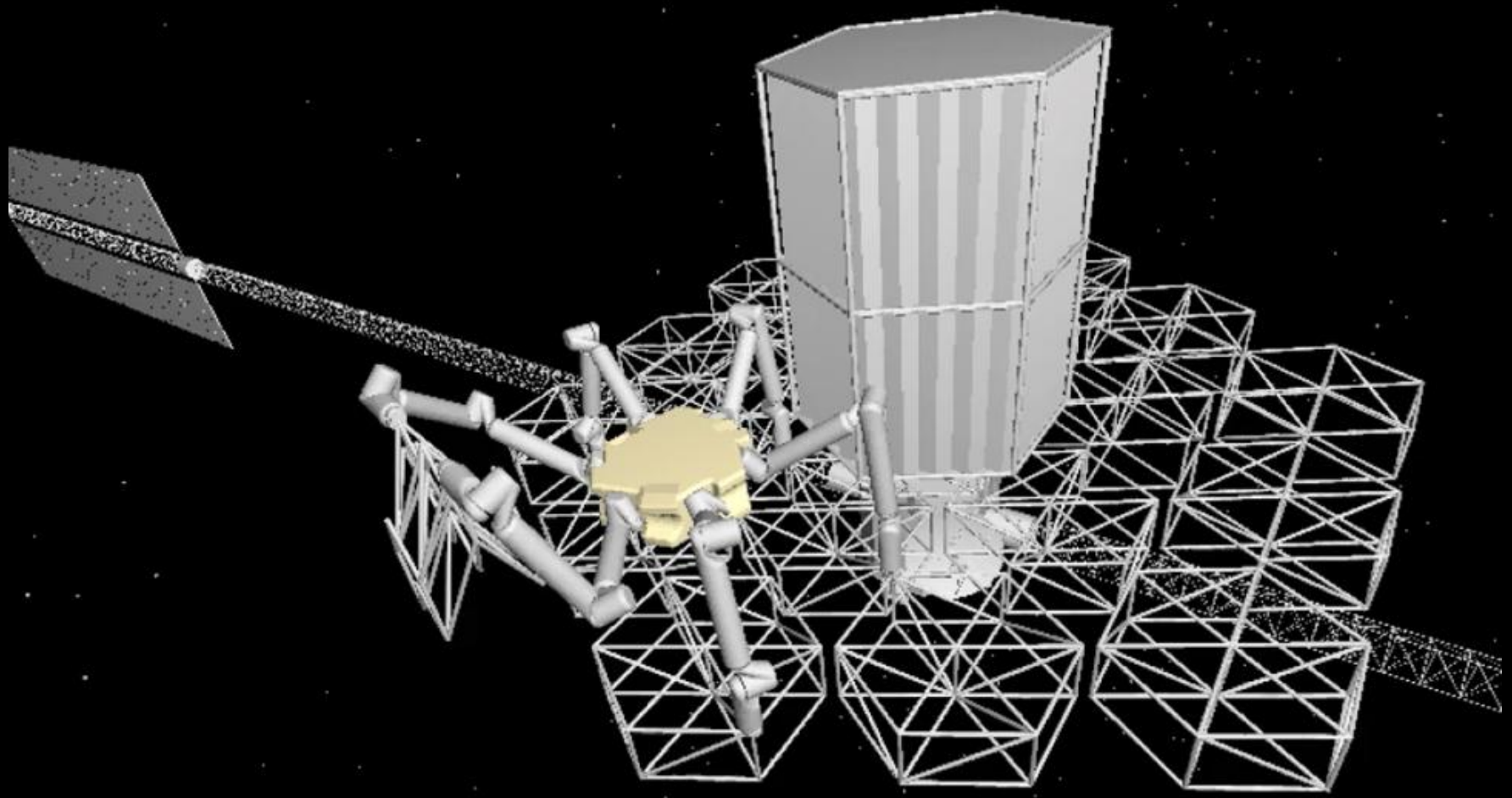
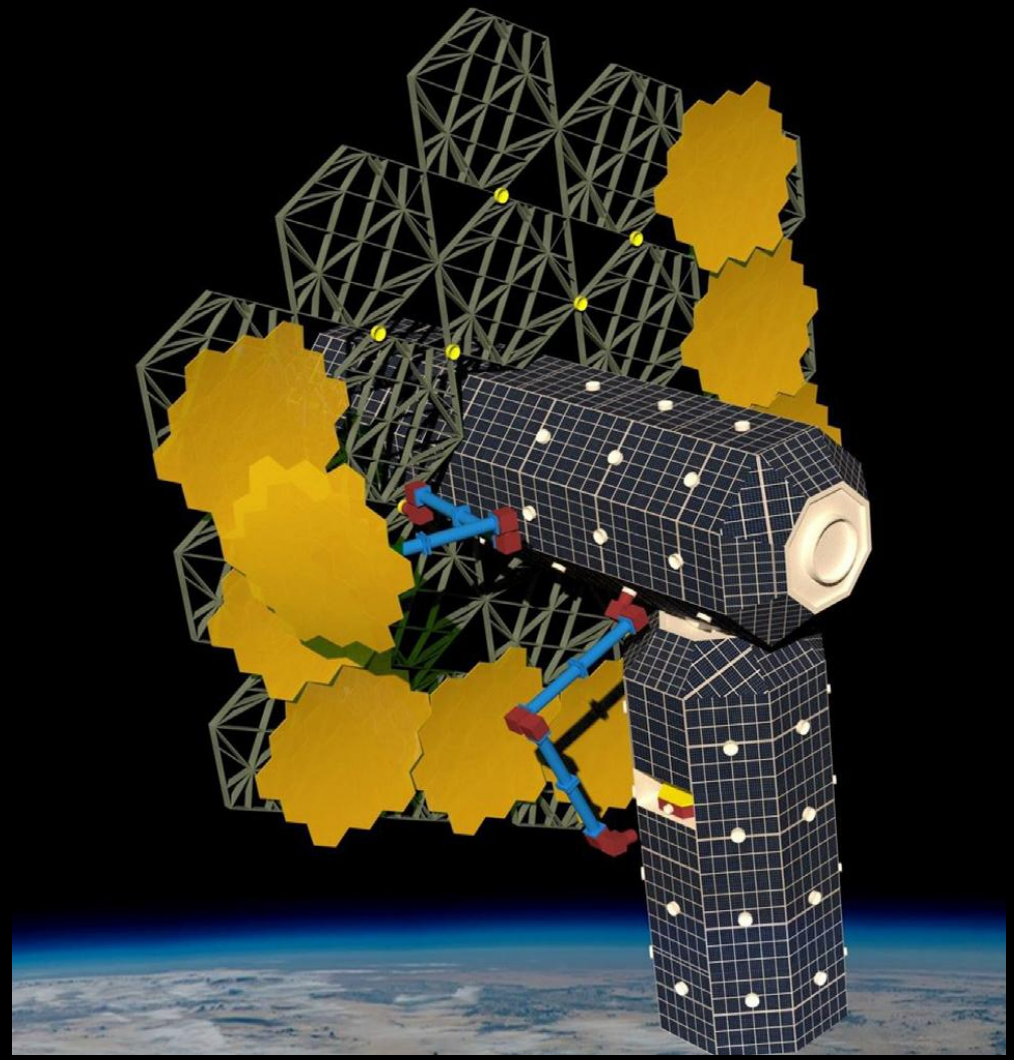


Image courtesy the Society of Photo-optical Instrumentation Engineers

Future Space Telescopes



Nair et al. 2022

Towards an Intelligent Universe

The development of autonomous observatories, powered by AI and ML, has the potential to revolutionize the way we collect and analyze data.

This way we enable real-time decision-making and paving the way for new discoveries.

As these technologies evolve, they will not only enhance our understanding of the Universe but also open new frontiers in cosmology, astroinformatics, and astrobiology.

Machine learning and AI are reshaping the landscape of astrophysics, offering new ways to analyze complex data, uncover hidden patterns, and accelerate scientific discovery.