National Aeronautics and Space Administration

HUBBLE
SPACE TELESCOPE

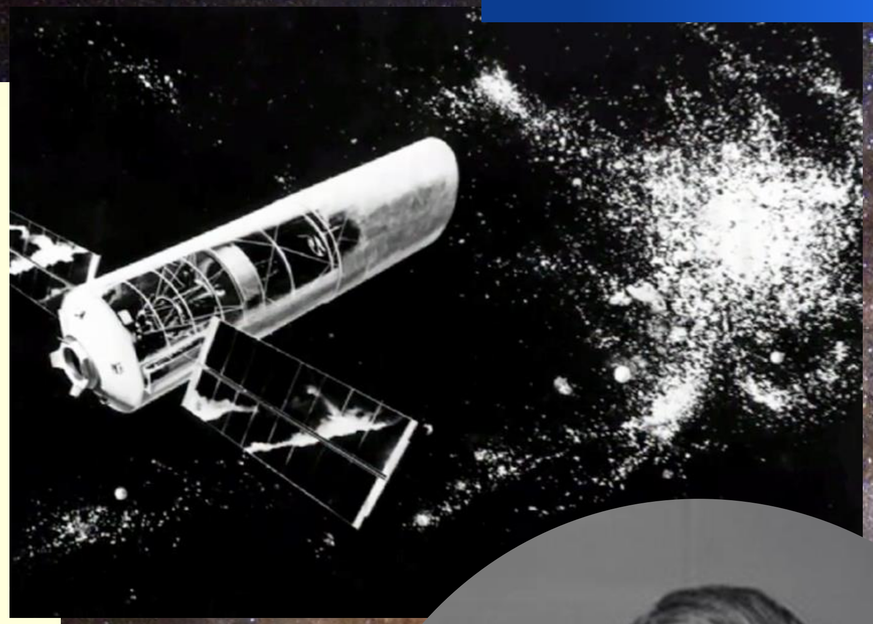
35 YEARS
OF DISCOVERY

35
HUBBLE
SPACE TELESCOPE


THE STORY
History
Launch
HP Tau, HP Tau G2, and HP Tau G3

The Beginnings

It all began in 1946 with a paper...



Initial concept illustration

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ASTRONOMICAL ADVANTAGES

OF AN

EXTRA-TERRESTRIAL OBSERVATORY

LYMAN SPITZER, Jr. [1]

This study points out, in a very preliminary way, the results that might be expected from astronomical measurements made with a satellite vehicle. The discussion is divided into three parts, corresponding to three different assumptions concerning the amount of instrumentation provided. In the first section it is assumed that no telescope is provided; in the second a 10-inch reflector is assumed; in the third section some of the results obtainable with a large reflecting telescope, many feet in diameter, and revolving about the earth above the terrestrial atmosphere, are briefly sketched.

It should be emphasized that this is only a preliminary survey of the scientific advantages that astronomy might gain from such a development. The many practical problems, which of course require a detailed solution before such a satellite might become possible, are not considered, although some partial mention is made of certain problems of purely astronomical instrumentation. The discussion of the astronomical results is not intended to be complete, and covers only certain salient features. While a more exhaustive analysis would alter some of the details of the present study, it would probably not change the chief conclusion -- that such a scientific tool, if practically feasible, could revolutionize

[1] The report re-printed here appeared as Appendix V of a larger document prepared for the Project RAND of the Douglas Aircraft Co., on 1 September 1946. At that time, Prof. Spitzer was on the astronomy faculty of Yale University; he has been affiliated with the Princeton University Observatory since 1947.

Astronomical Advantages of an Extra-terrestrial Observatory

Courtesy of Princeton Plasma Physics Laboratory

Dr. Lyman Spitzer

Astronomer who first proposed a space-based observatory

A Real Possibility

The astronomical community joins in.

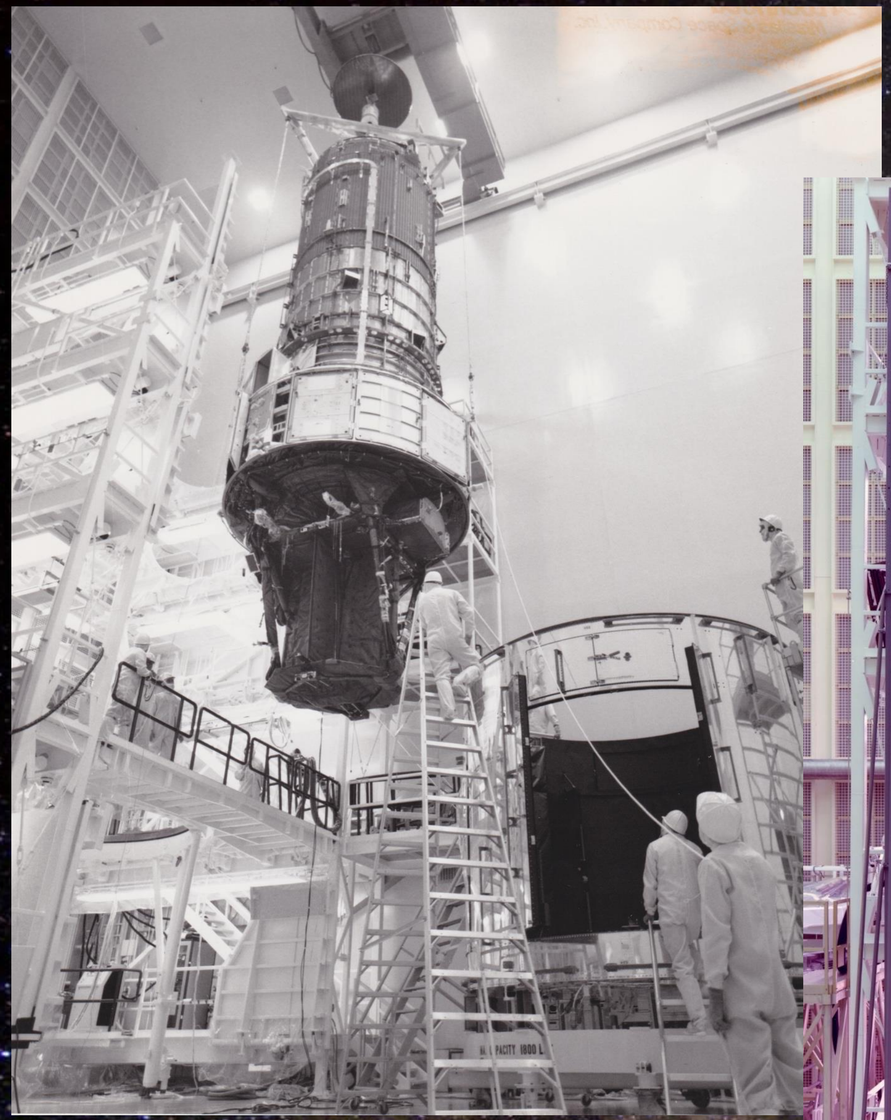
The Large Space Telescope science working group

Dr. Nancy Grace Roman

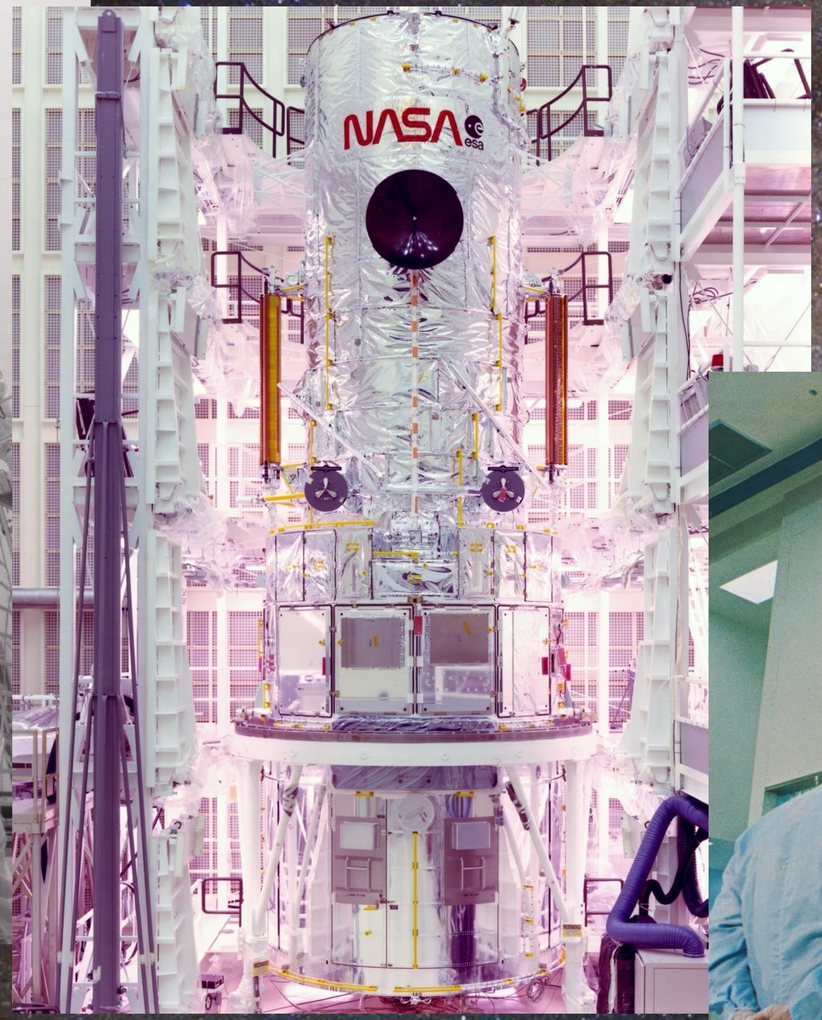
Astronomer who started NASA's space astronomy program

Official start in 1977

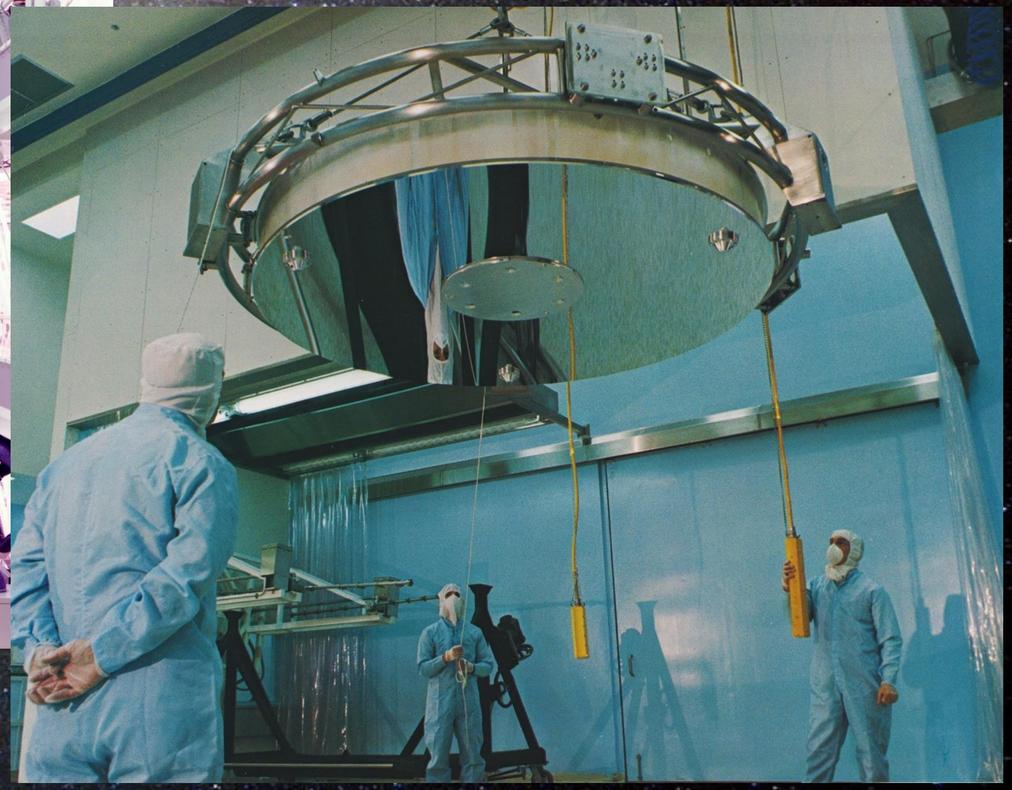
Under Development



Credit: Lockheed Martin



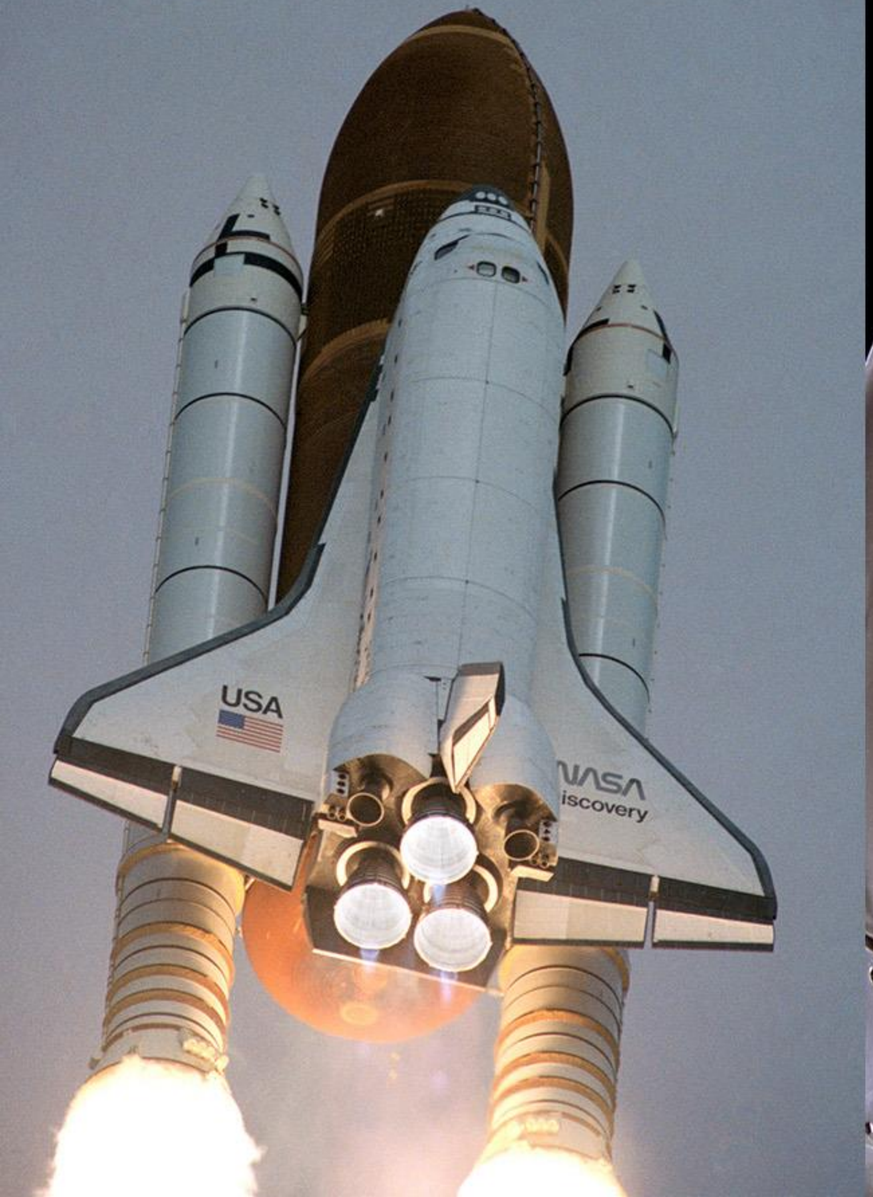
Credit: Lockheed Martin



Credit: Perkin Elmer

On Its Way!

April 24, 1990
Launch onboard space shuttle Discovery



April 25, 1990
Deployed into space

THE MISSION

Overview
Design
Servicing
Observations

Illustration of the Andromeda Galaxy and the Milky Way Collision

Hubble in Detail

INTERNATIONAL PARTNERSHIP
NASA, ESA

LAUNCH DATE
April 24, 1990

LAUNCH VEHICLE
Discovery (STS-31)

MASS
27,000 pounds (12,200 kg)
as of Servicing Mission 4

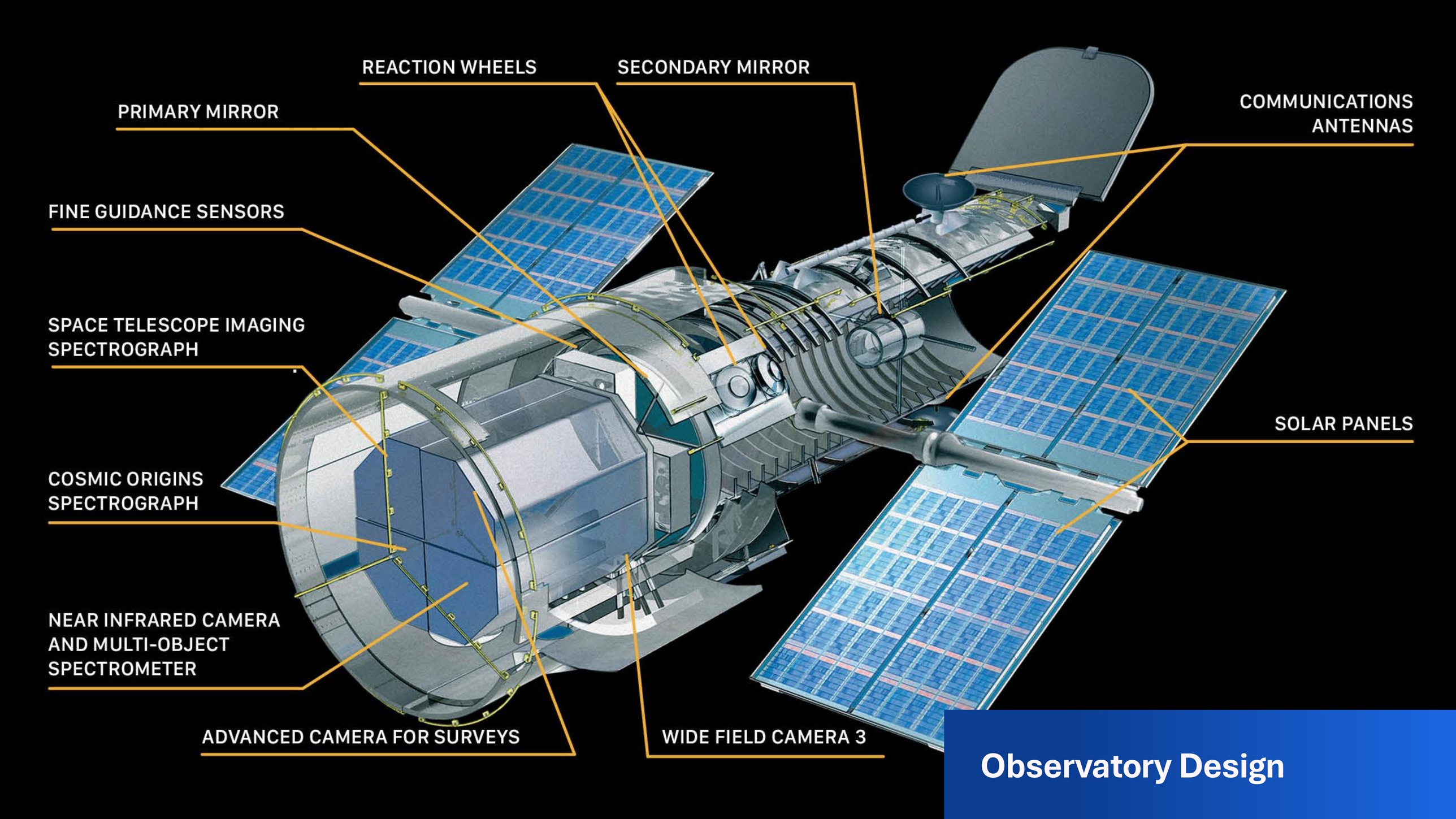
MAXIMUM DIAMETER
14 feet (4.2 m)

LENGTH
43 feet (13 m)

ORBIT HEIGHT
320 miles (515 km)

ORBIT PERIOD
95 minutes to complete one orbit around Earth

ORBIT VELOCITY
About 17,000 miles per hour (27,000 kilometers per hour)



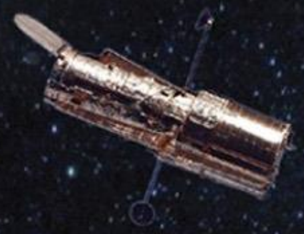
Observatory Design

Servicing

Astronauts deployed and later serviced Hubble. They installed advanced instruments, inserted new technology, repaired broken hardware, and performed standard maintenance.

Instrument repair during SM4

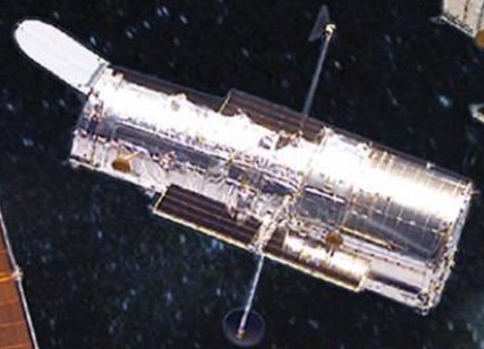
1990
Launch and deployment



1993
SM1:
- Wide Field Planetary Camera 2
- COSTAR
- Gyros
- Solar Arrays
- Magnetometers

1997
SM2:
- Fine Guidance Sensor (FGS)
- Space Telescope Imaging Spectograph (STIS)
- Near Infrared Camera and Multi-Object Spectrometer (NICMOS)
- Solid State Recorder (SSR)
- Reaction Wheel Assembly

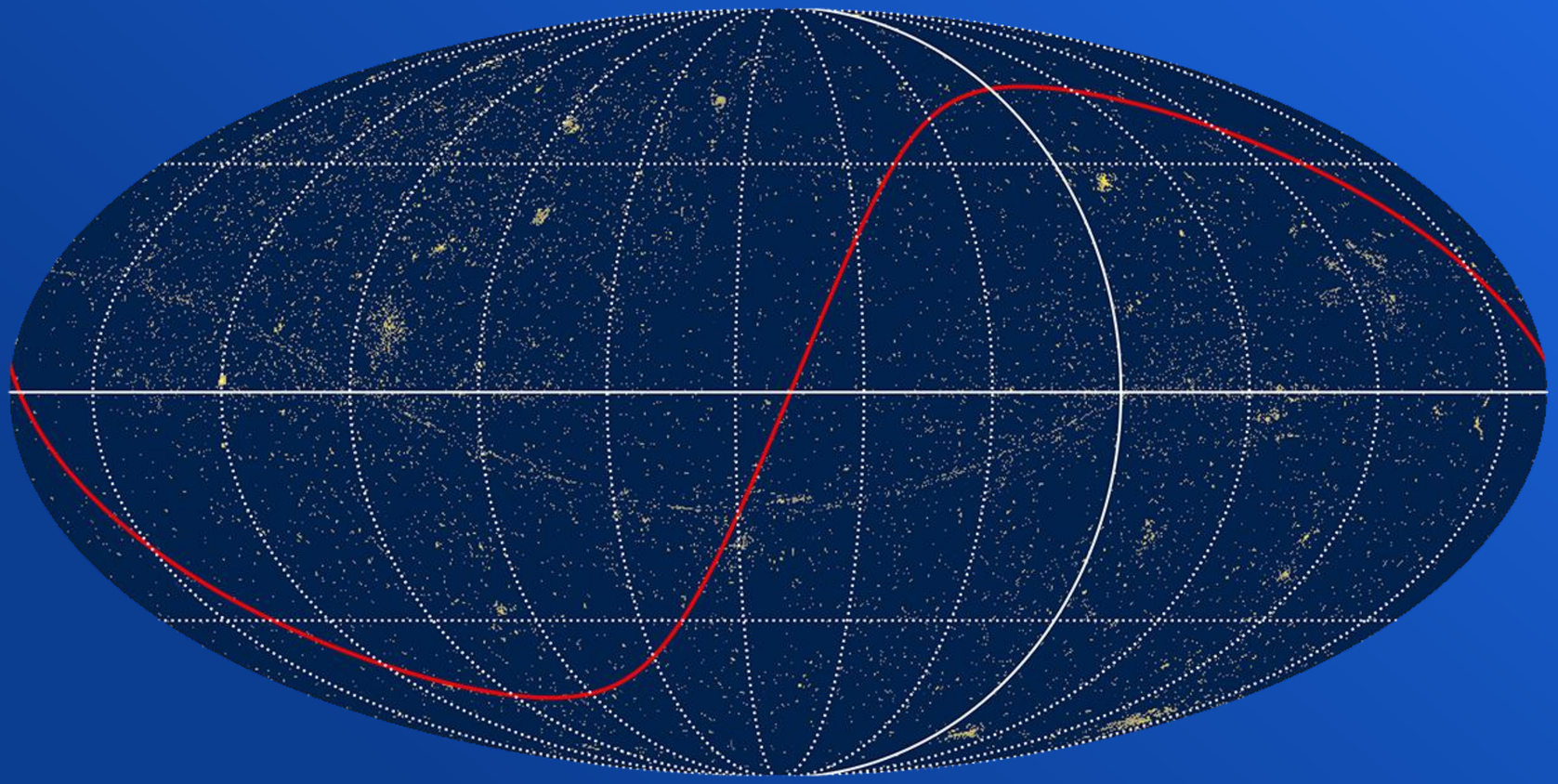
1999
SM3A:
- Gyros
- FGS
- Spacecraft Computer
- S-Band Transmitter
- SSR



2002
SM3B:
- Advanced Camera for Surveys (ACS)
- Solar Arrays
- Power Control Unit
- NICMOS Cooling System

2009
SM4:
- Gyros
- Wide Field Camera 3
- Cosmic Origins Spectrograph
- Batteries
- FGS
- STIS/ACS Repairs
- Soft Capture Mechanism
- Science Instrument Command and Data Handling Unit

Servicing Missions



Observations

NUMBER OF OBSERVATIONS TAKEN
~ 1,700,000

ASTRONOMICAL OBJECTS FOR WHICH DATA HAS BEEN COLLECTED
Over 100,000,000

PERCENTAGE OF THE SKY OBSERVED
0.1%

DISTANCE LIGHT TRAVELED FROM THE FARTHEST OBJECT (GALAXY GN-Z11) HUBBLE OBSERVED
13,400,000,000 light-years

DISTANCE LIGHT TRAVELED FROM THE FARTHEST INDIVIDUAL STAR (EARENDEL) HUBBLE OBSERVED
12,900,000,000 light-years

LONGEST EXPOSURE TIME FOR ONE POINTING
<1,000,000,000 seconds

SCIENCE HIGHLIGHTS

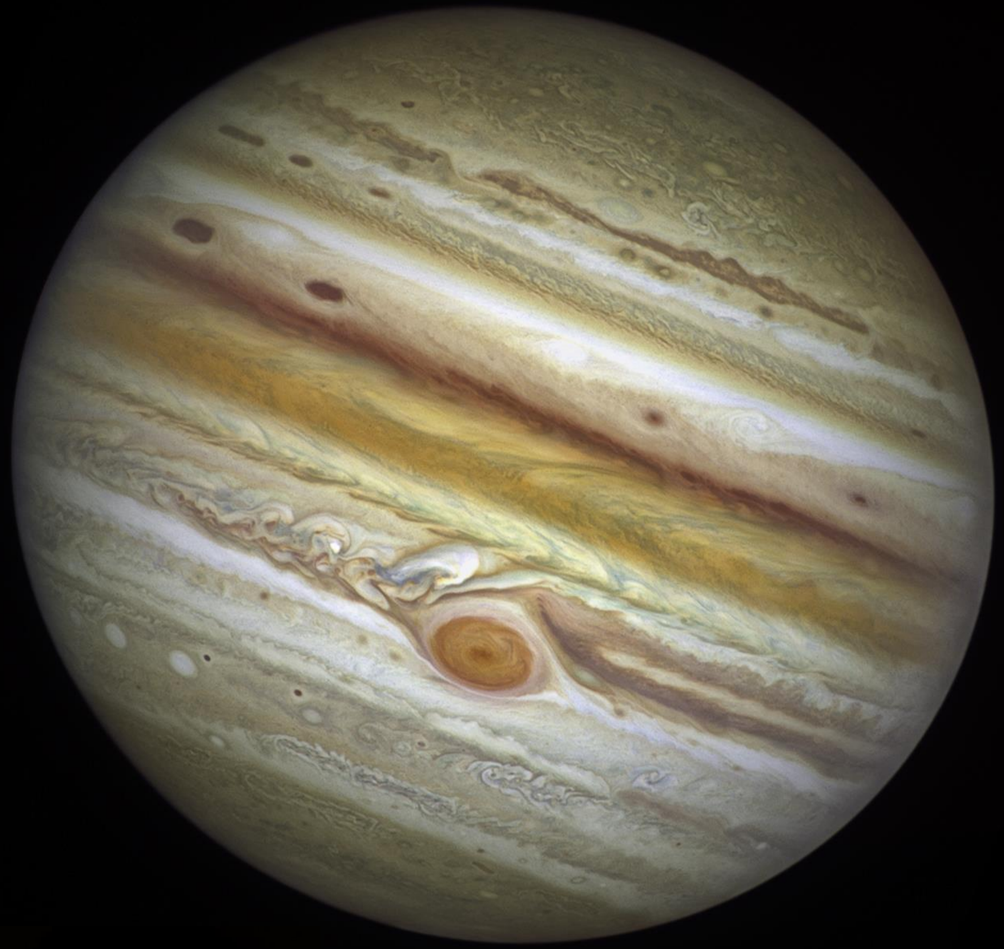
Our Solar System
Our Galaxy
The Universe

Bubble Nebula (NGC 7635)

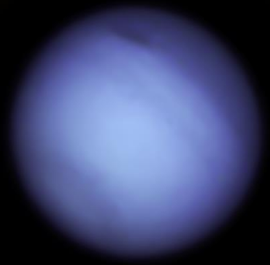
Our Solar System

SATURN

URANUS



JUPITER



NEPTUNE

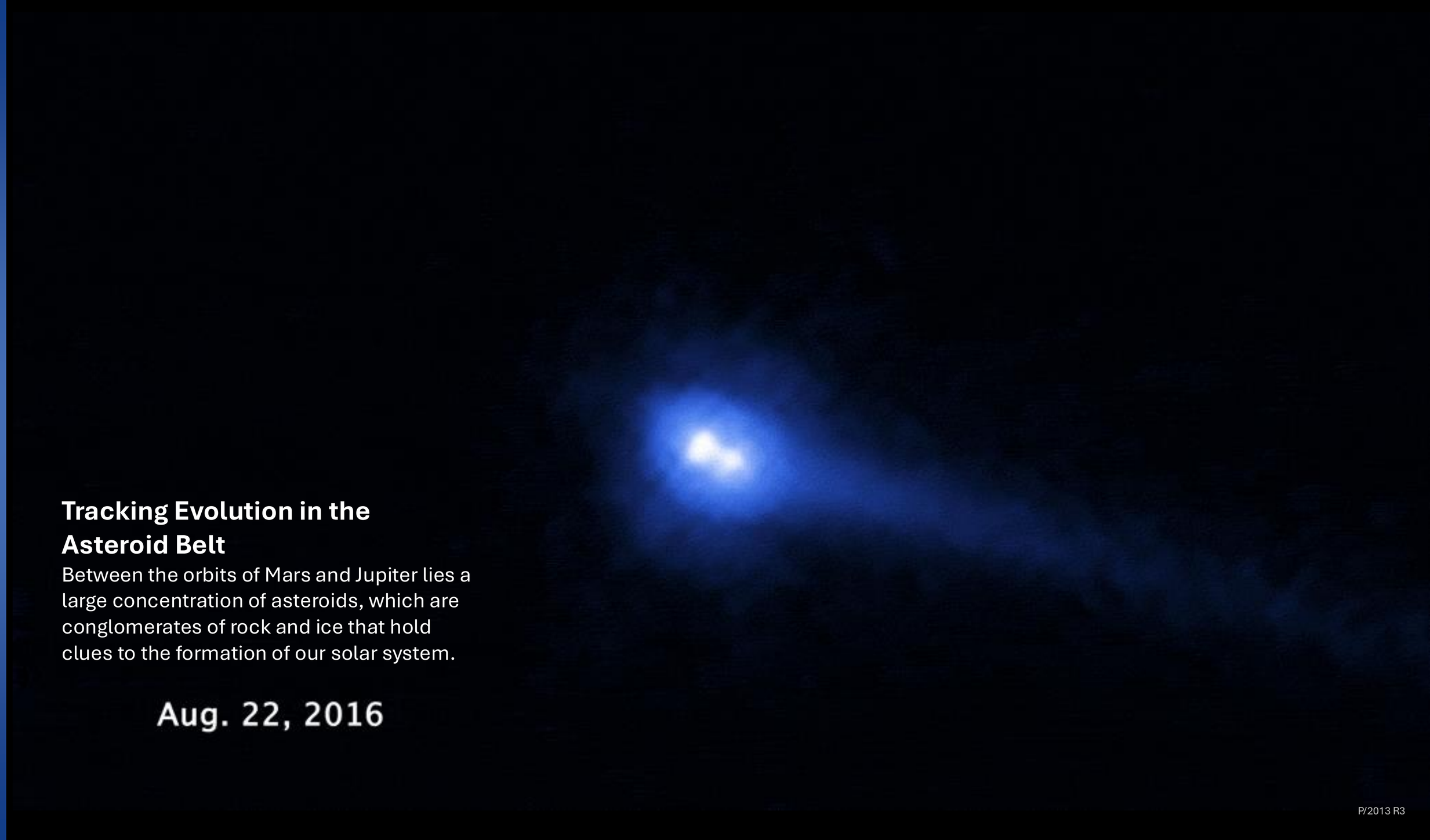
MARS

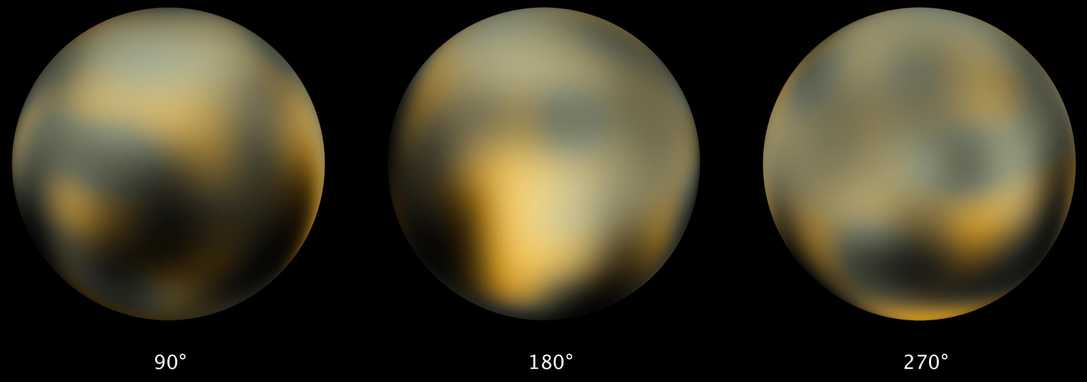
Studying the Planets and Their Moons

Hubble’s long presence in space and regular observations of the planets give researchers the opportunity to study their ever-changing atmospheres and curious moons, charting the changes of these dynamic systems.

Tracking Evolution in the Asteroid Belt

Between the orbits of Mars and Jupiter lies a large concentration of asteroids, which are conglomerates of rock and ice that hold clues to the formation of our solar system.





PLUTO

ORBITING MOON
NICKNAMED MK 2

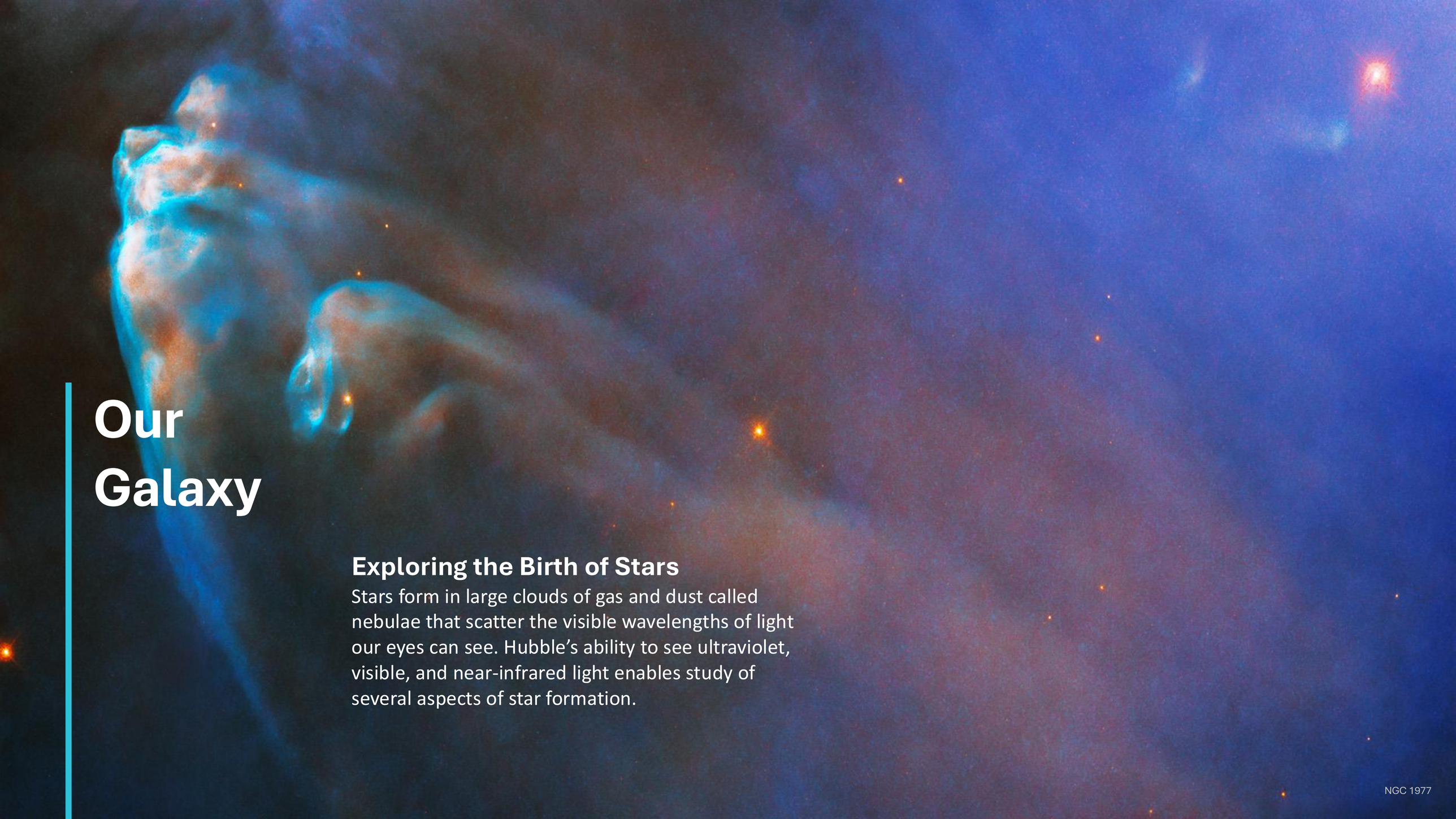
Uncovering Icy Objects in the Kuiper Belt

Hubble observations of the outskirts of our solar system found a moon around an asteroid and several new moons around Pluto.

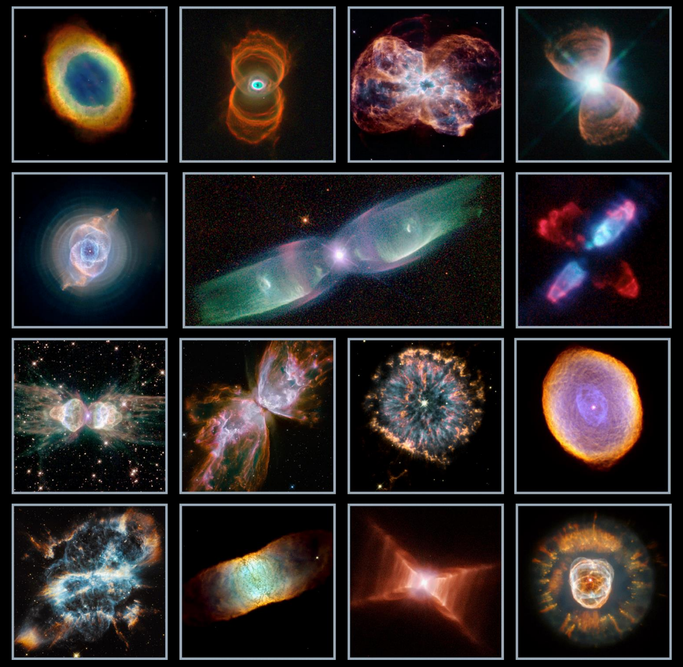
Our Galaxy

Exploring the Birth of Stars

Stars form in large clouds of gas and dust called nebulae that scatter the visible wavelengths of light our eyes can see. Hubble’s ability to see ultraviolet, visible, and near-infrared light enables study of several aspects of star formation.



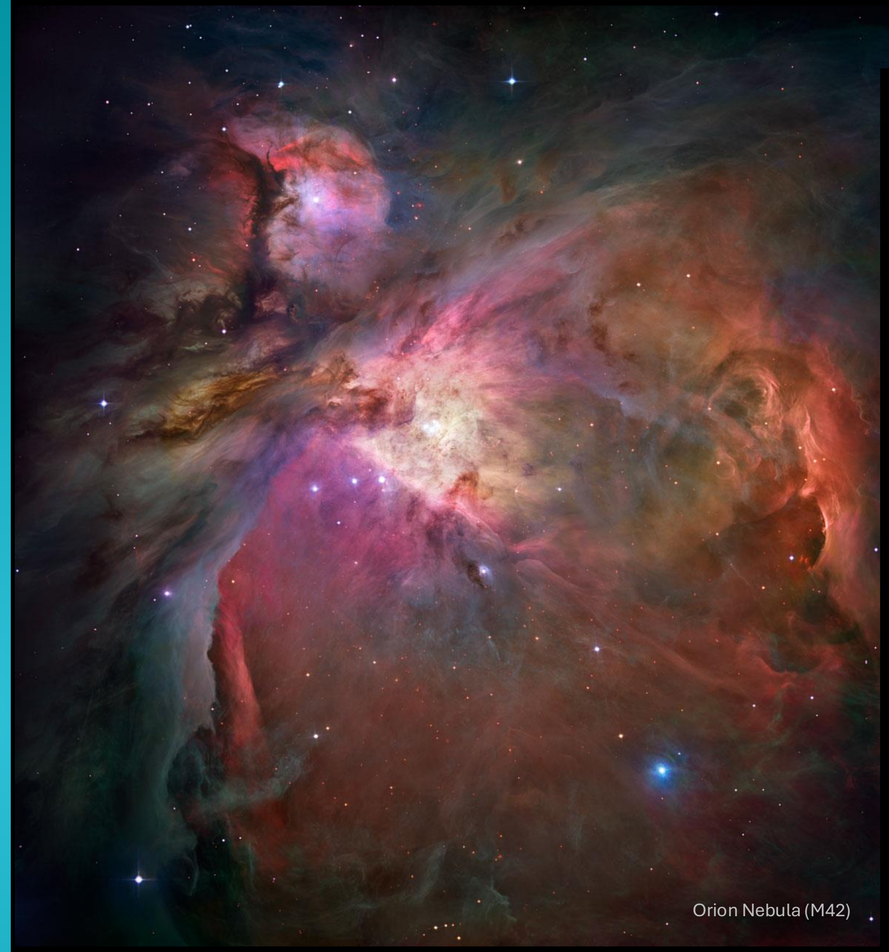
NGC 1977



The Death Throes of Stars

When a star runs out of its hydrogen fuel, the path it takes toward death depends on its size. For stars, it’s a balance between the radiation pressure of their fuel-burning cores pushing outward, and their gravity pulling inward.

Crab Nebula (M1)



Orion Nebula (M42)

Finding Planetary Construction Zones

In 1992, Hubble was the first telescope to resolve protoplanetary disks (dubbed “proplyds”) around stars in the Orion Nebula. Protoplanetary disks are dense gas and dust disks surrounding newly formed stars.

Recognizing Worlds Beyond Our Sun

Hubble's unique capabilities allow it to explore planetary systems around other stars. Scientists have since established the existence of more than 5,000 extrasolar planets.

Artist's Impression of "Hot Jupiter" Exoplanets

Seeing Light Echoes

Like ripples on a pond, pulses of light reverberate through cosmic clouds forming echoes of light. Hubble has captured some of the best images of this reverberation of light through space.

V838 Monocerotis

The Universe

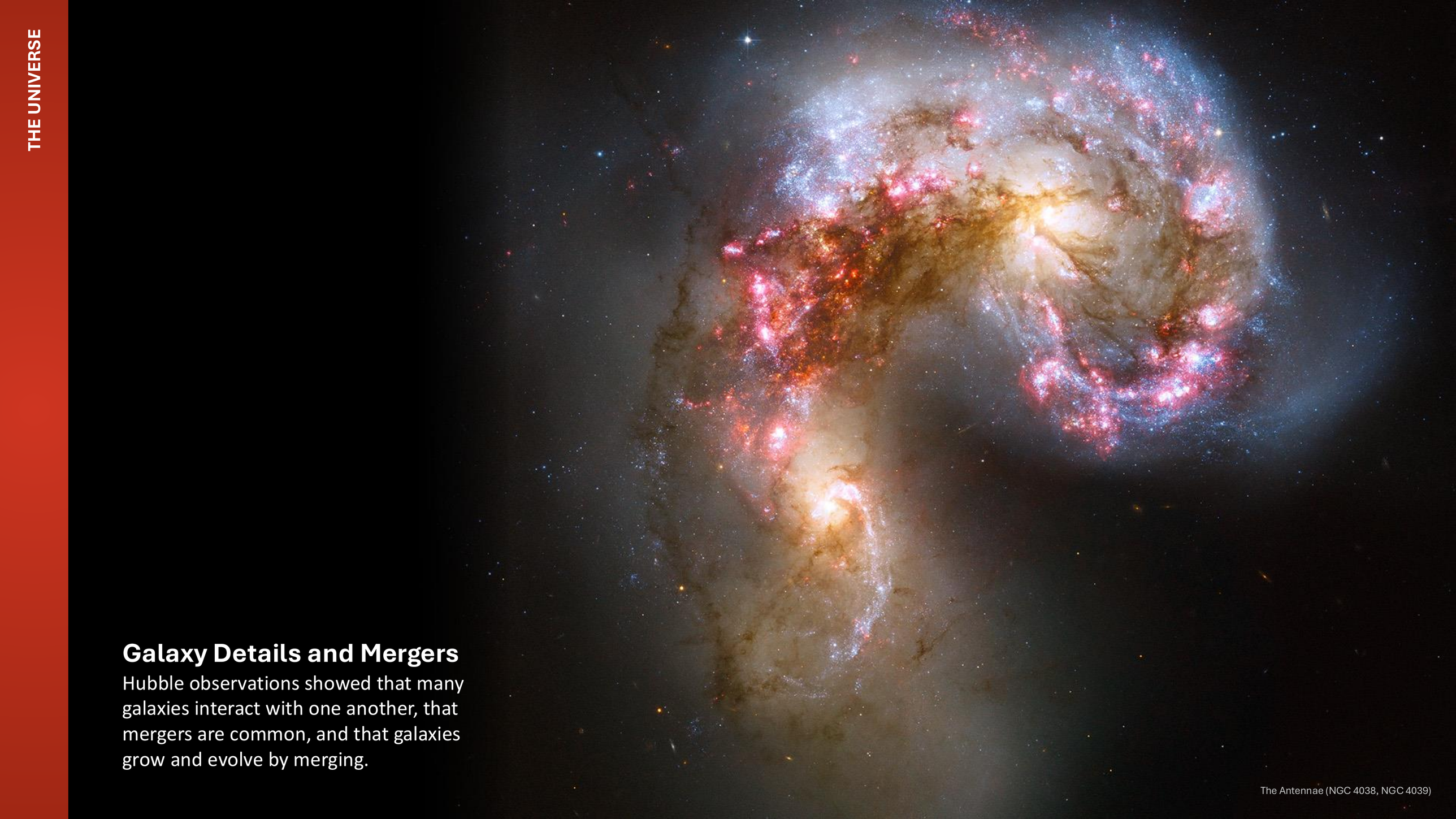
Tracing the Growth of Galaxies

Like documenting a child's development in a scrapbook, astronomers use Hubble to capture the appearance of many developing galaxies throughout cosmic time. This is possible because of the relationship between cosmic distance and time: the deeper Hubble peers into space, the farther back it looks in time.

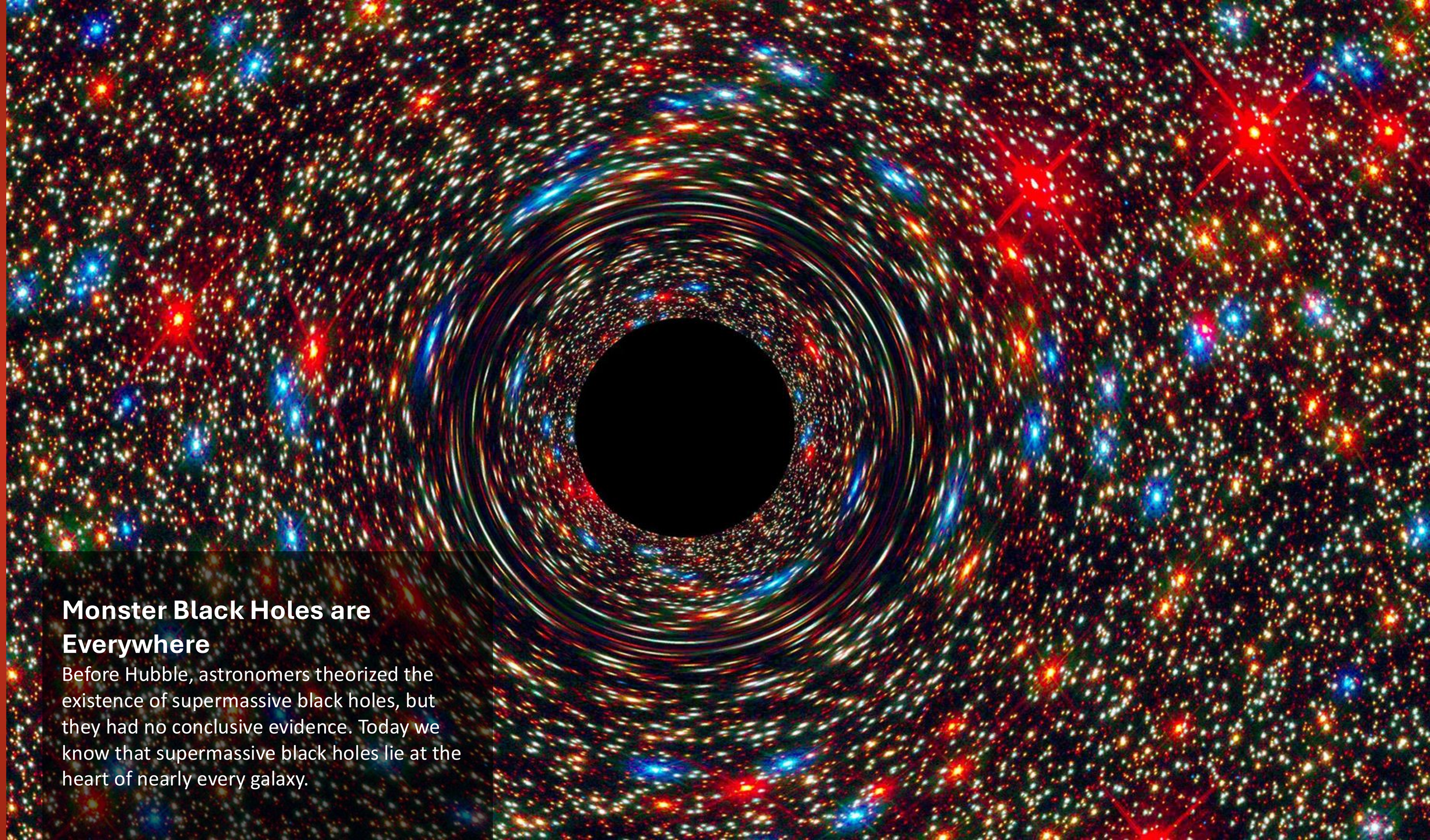
Hubble Ultra Deep Field

Galaxy Details and Mergers

Hubble observations showed that many galaxies interact with one another, that mergers are common, and that galaxies grow and evolve by merging.

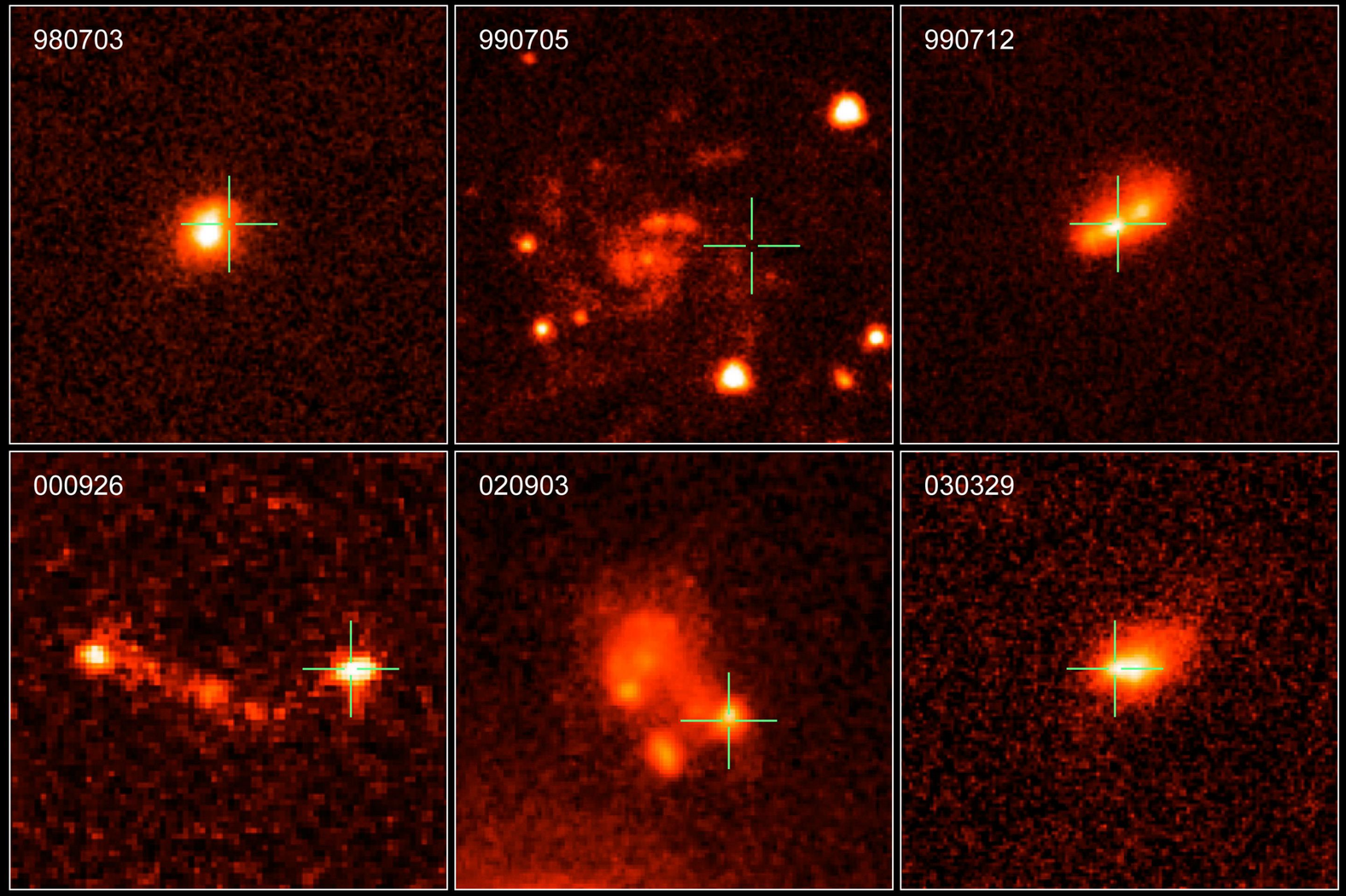


The Antennae (NGC 4038, NGC 4039)



Monster Black Holes are Everywhere

Before Hubble, astronomers theorized the existence of supermassive black holes, but they had no conclusive evidence. Today we know that supermassive black holes lie at the heart of nearly every galaxy.



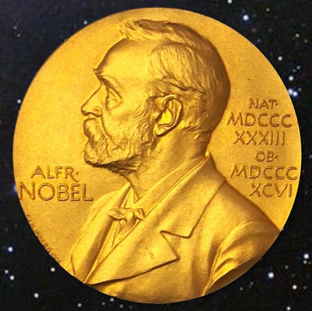
Homing in on Cosmic Explosions

For decades, astronomers pondered the source of one of the most energetic and mysterious events in the universe, gamma-ray bursts (GRB). In a few seconds, GRBs can emit more energy than the Sun over its entire 10-billion-year life.

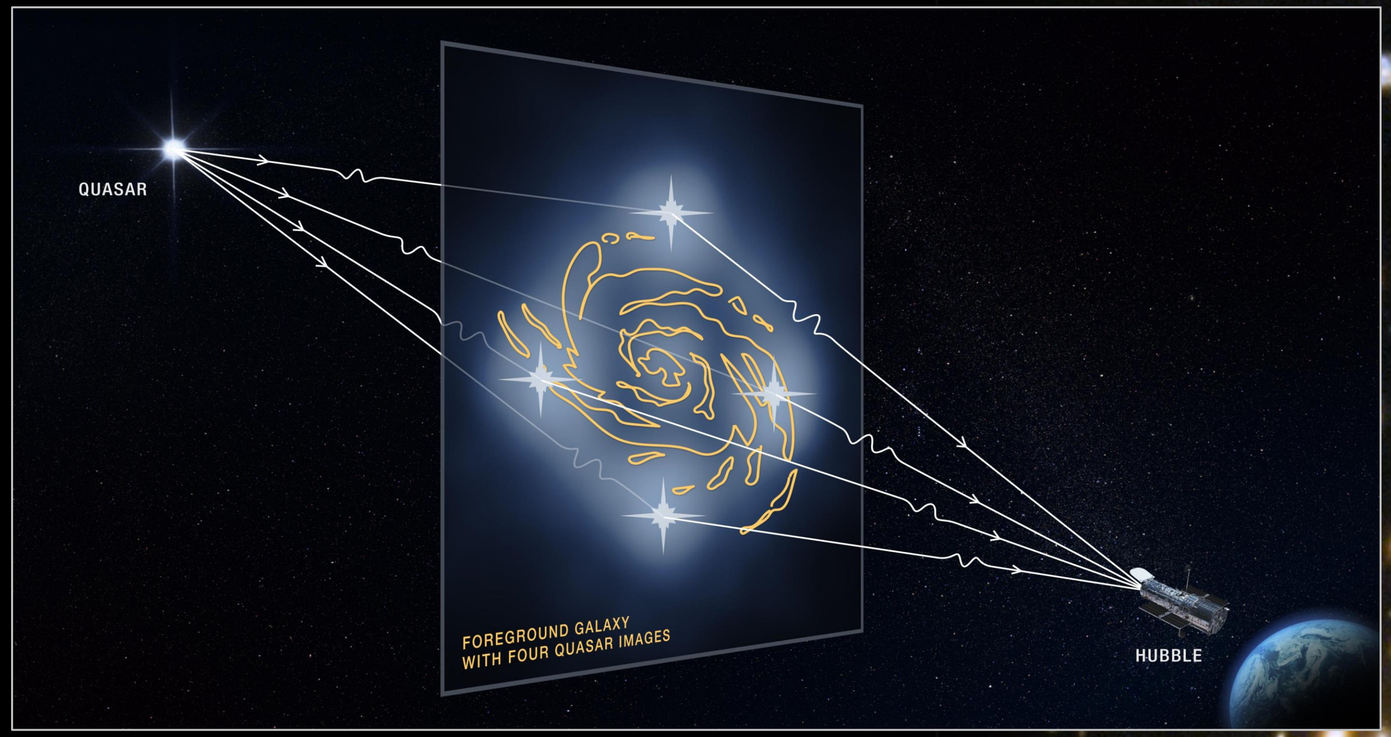
GRB Host Galaxies

Discovering the Runaway Universe

Astronomers use the Hubble telescope to measure distances by comparing the brightness of a known object in our galaxy (like a star or a supernova) to that of similar objects in a distant galaxy.



Andromeda Galaxy Cepheid Variable



Focusing in on Gravitational Lenses

Gravity acts as a lens, magnifying and distorting space and time in a way that is similar to an optical lens like those in eyeglasses or contact lenses.

Supernova Refsdal

Shining a Light on Dark Matter

More than 80% of the universe is stuff we have never seen. Its gravity drives normal matter (gas and dust) to collect and build up into stars, galaxies, and massive galaxy clusters.

Abell 1689

Mapping the Cosmic Web

Hubble’s high resolution can spot minute distortions in how light behaves in areas of great mass, allowing astronomers to map large-scale structures of the universe.

MACS J0717.5+3745

"…the chief contribution of such a radical new and more powerful instrument, not to supplement the present ideas of the universe we live in, but rather to uncover new phenomena not yet imagined…"

Dr. Lyman Spitzer (1946)

Astronomer who first proposed a space-based observatory

Hubble's Future is Bright

- In good health
- Partner with the James Webb Space Telescope, the Nancy Grace Roman Space Telescope, and others
- Continue advancing known science while looking for the unknown

For more information, go to:

nasa.gov/hubble

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