JWST—JAMES WEBB SPACE TELESCOPE

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Outline

James E. Webb: a former NASA administrator*; believed that NASA had to strike a balance between human space flight and science.*

"faster, better, cheaper" era in the mid-1990s

↓

1996. NGST(The next Generation Space Telescope—Hubble successor): 8-meter aperture; located at L_2; cost $500 million; Launch planned for 2007.

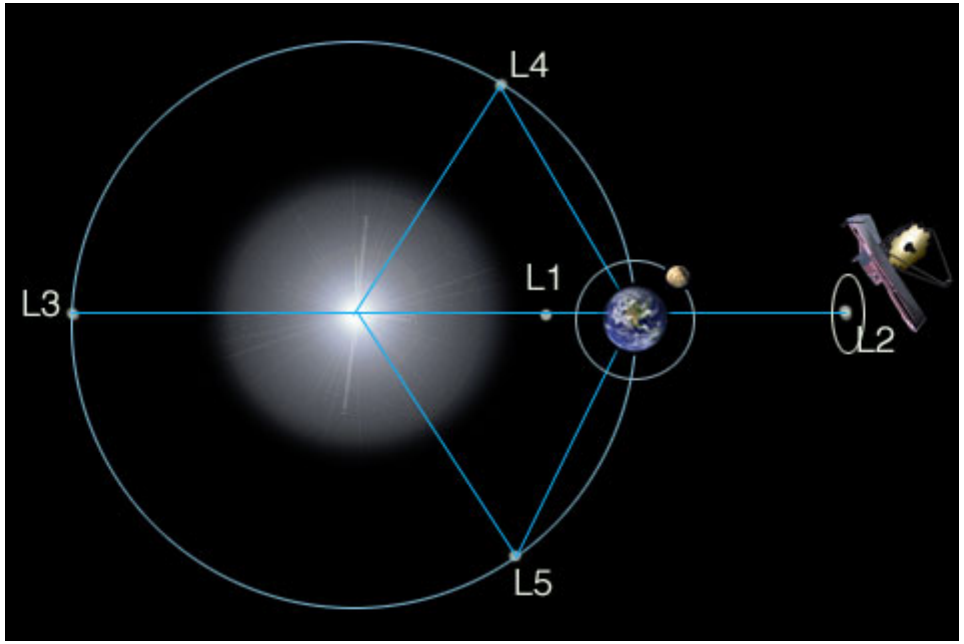
Pushed back…

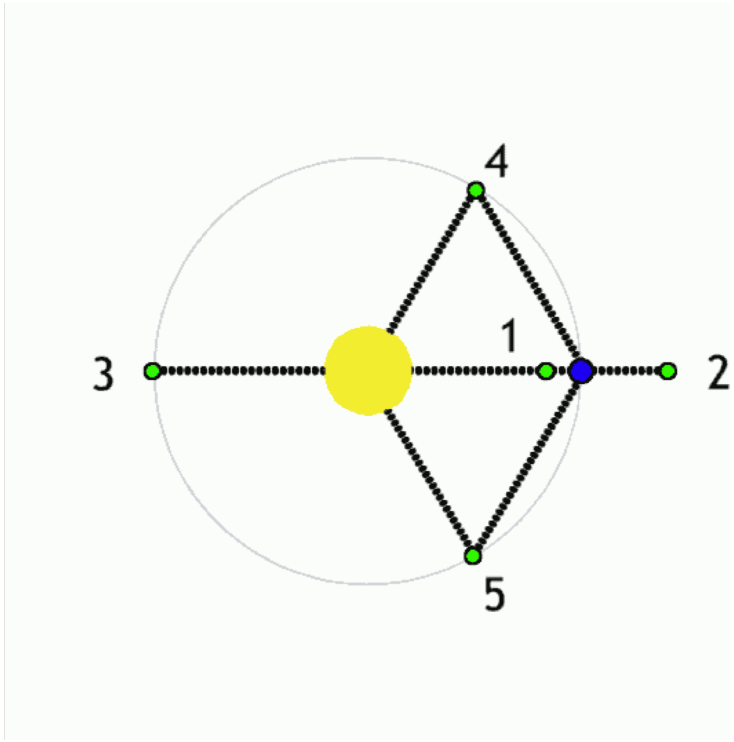
2002. Named JWST, 8 to 6.5-meter primary mirror.

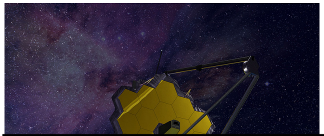
Pushed back…

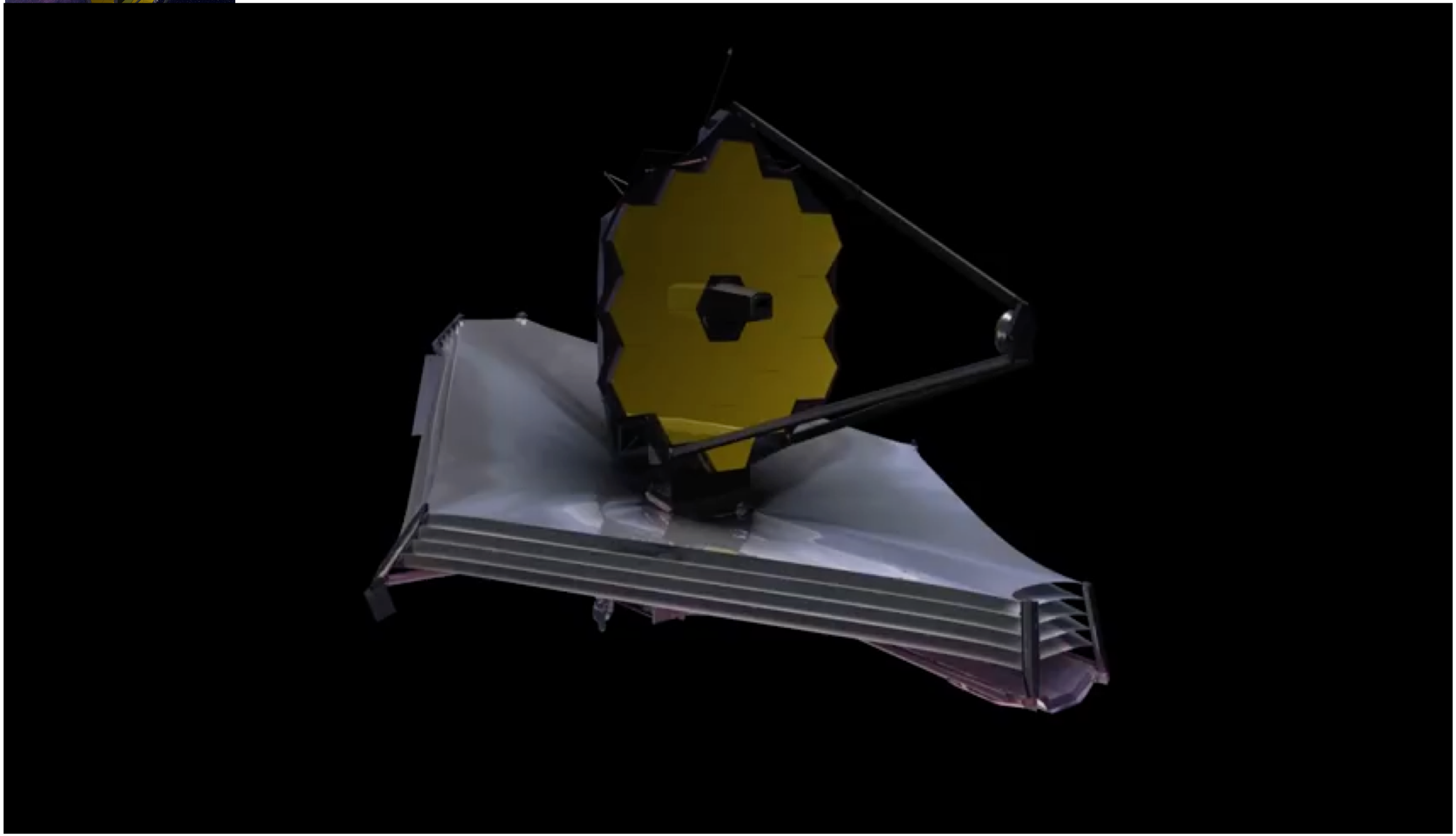
2021. New launch time; European Space Agency (ESA).

30-day, million-mile journey out to the second Lagrange point (L2).



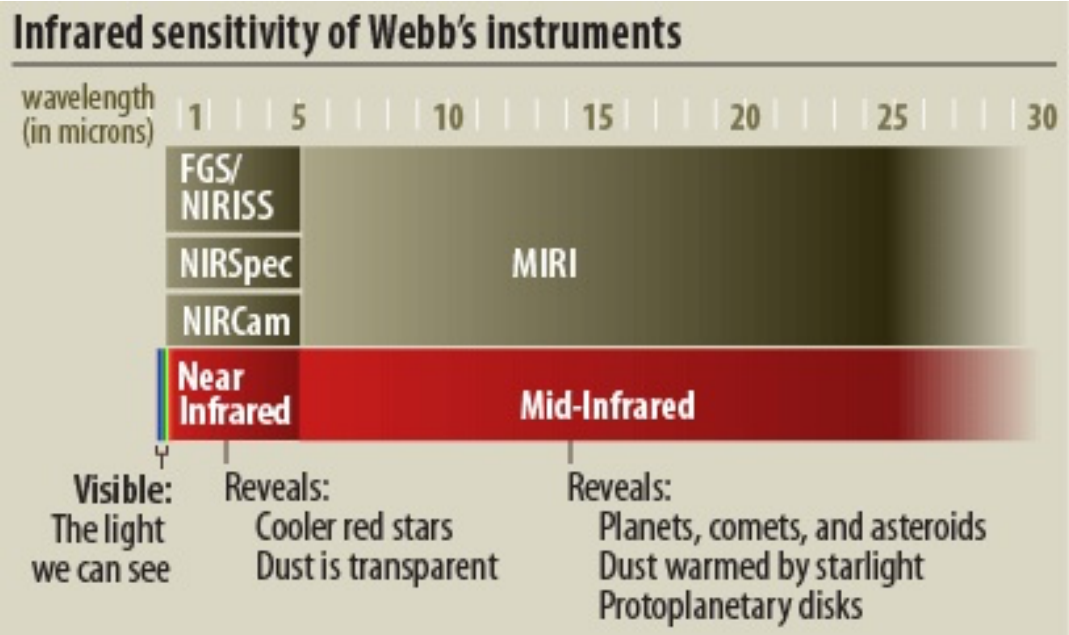




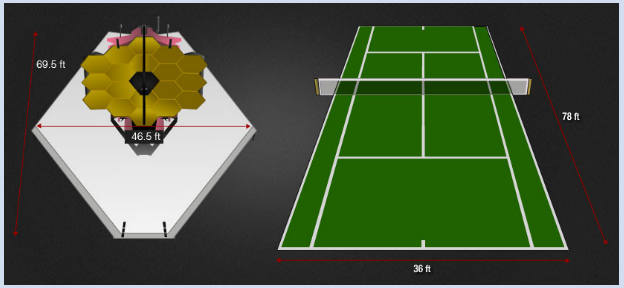
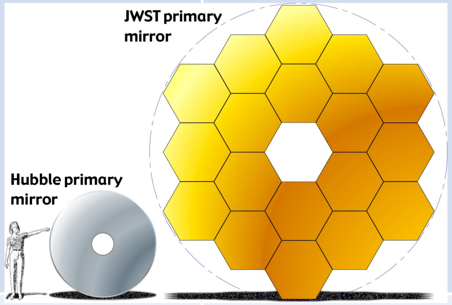
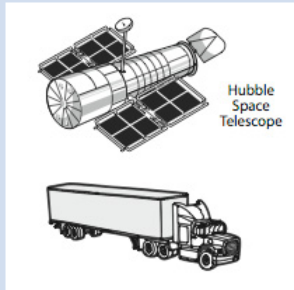
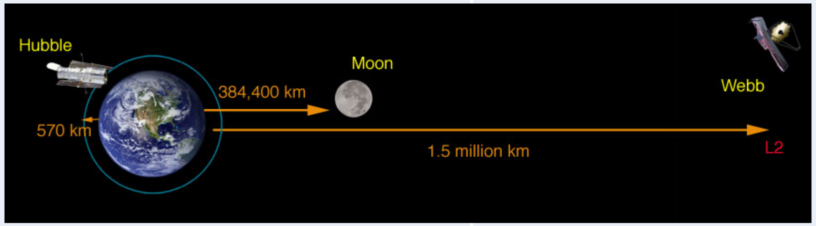


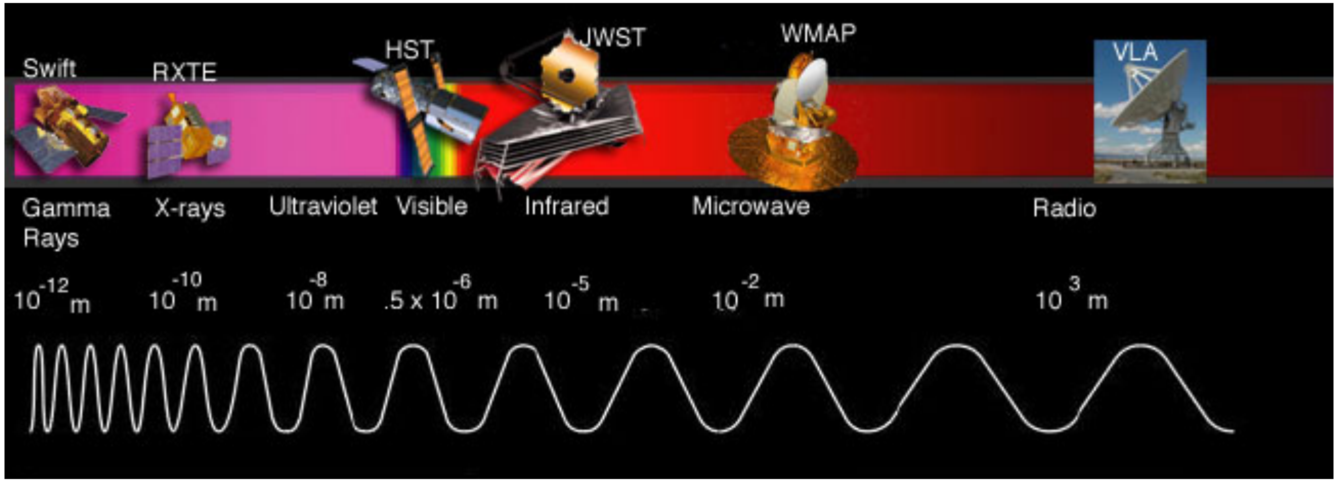
Integrated Science Instrument Module (ISIM)

- Near-Infrared Camera, or NIRCam
- Near-Infrared Spectrograph, or NIRSpec
- Mid-Infrared Instrument, or MIRI
- Fine Guidance Sensor/ Near Infrared Imager and Slitless Spectrograph , or FGS/NIRISS



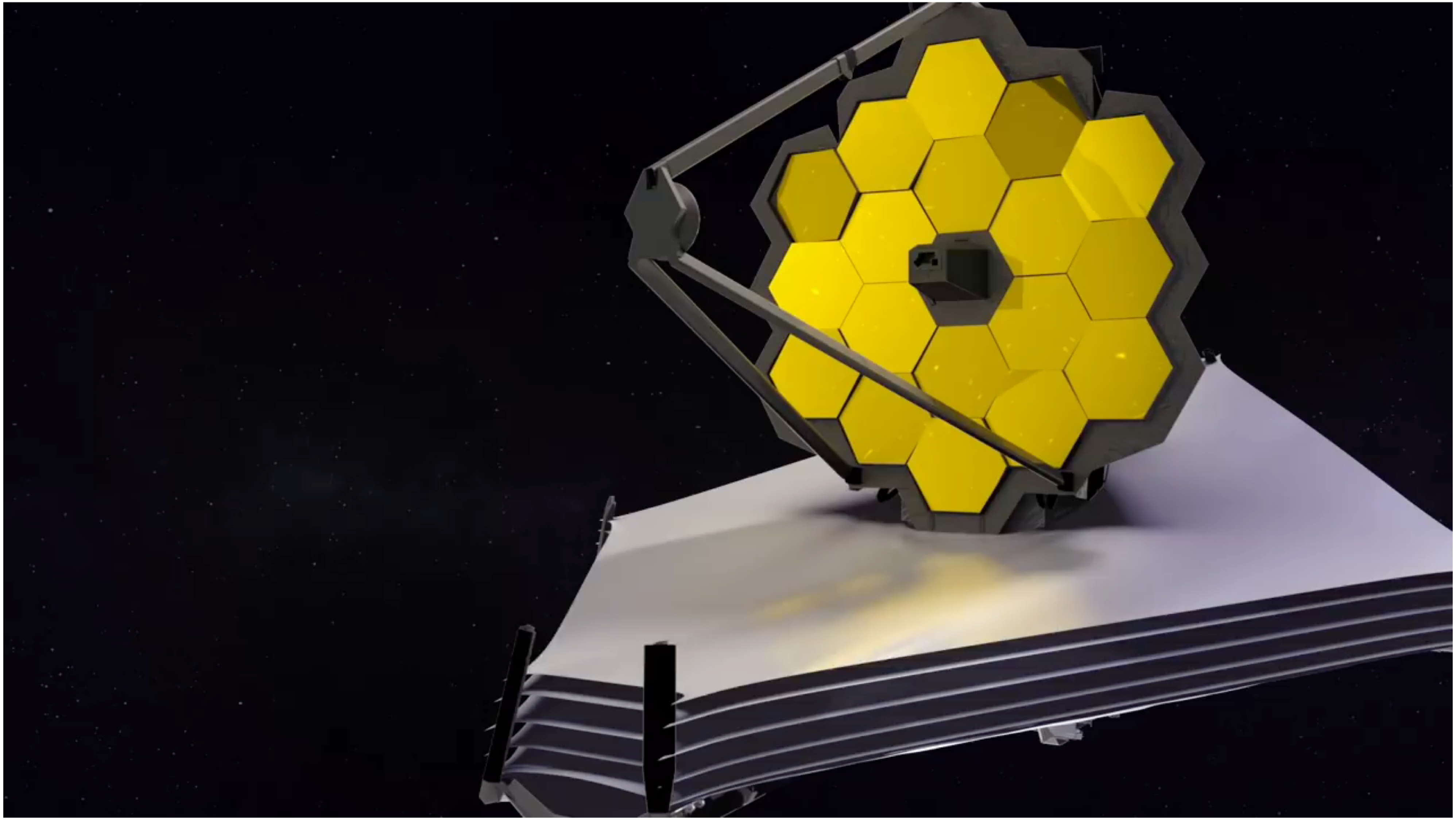
Primary Mirror Stats		Observatory Stats	
Mirror Type	Segmented parabolic reflector	**Operating Temperature**	40 kelvin; -233.2 degrees Celsius
Width	21.6 feet (6.5 meters) at its widest point	**Orbit Shape**	loop twice a year
Area	269 square feet (25 m^2)	**Science Mission Lifetime**	5 years, with a goal of 10 years
Optical Resolution	0.07 arcseconds, diffraction-limited at 2-micrometer wavelengths	**Solar Array Power**	2,000 watts
Number of Segments	18 segments	**Maximum Data Rate**	28 megabits per second (Mbps)
Material	Beryllium, with a thin coating of **gold**	**Cost at Launch**	$8 billion, plus ESA CSA contributions

	JWST	Hubble
Wavelength	0.6 to 28 microns(infrared, some capability in the visible range)	0.8 to 2.5 microns(infrared); 0.1 to 0.8 microns(ultra-violet and visible parts)
Size	*22 meters by 12 meters;* *a 6.5 meter diameter primary mirror*	*13.2 meters by 4.2 meters;* *a 2.4 meter diameter mirror*
Size direct comparison	 	
Orbit		
How Far to See	“baby galaxies”(General Relatively, visible light reaches us as infrared light.)	"toddler galaxies"

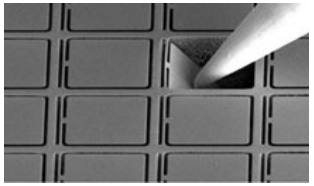


	JWST	Herschel
location	the L2 point	the L2 point
wavelength ranges	0.6 to 28.5 microns	60 to 500 microns(most actively star-forming galaxies)
Mirror size	6.5 meters	3.5 meters

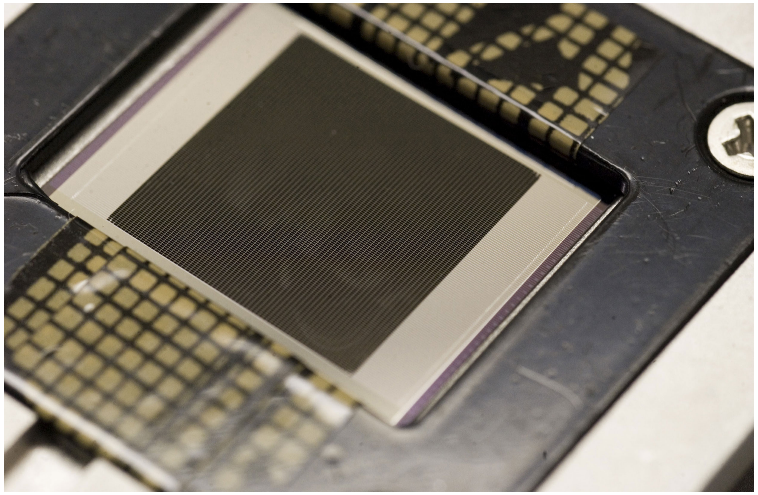
Aligning The Mirror



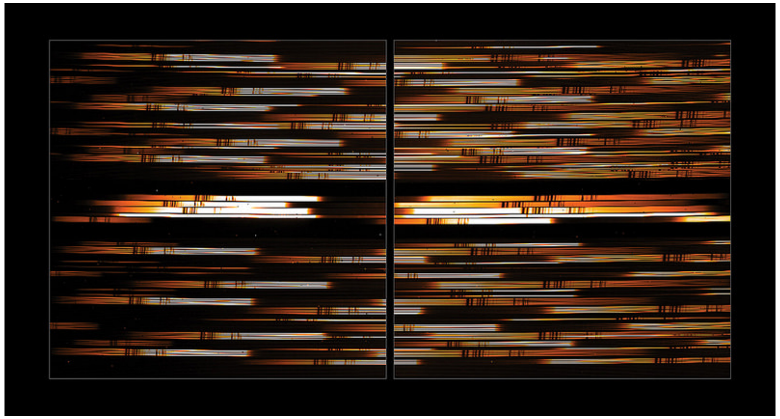
Take the First spectrograph(in *NIRSpec*) in space that has multi-object capability.



minuscule windows with shutters



microshutter device



Testing spectra from 100 microshutters of 2 devices

Microshutter device:

- *more than 62,000 individual windows with shutters(each 100 by 200 microns, a bundle of only a few human hairs).*
- *¼ of the microshutter device (shown at left) is about the size of a postage stamp.*

Passive cooling:

- Three of Webb's four scientific instruments(see reddest of visible light as well as near-infrared light) work at 37K.
- Sunshield prevent light and heat from the moon, earth and sun.

Active Cooling:

- MIRI(see mid-infrared (MIR) light), work well at less than 7K.
- Cryocooler, basically a sophisticated refrigerator with its pieces distributed throughout the observatory.

Exactly when the first stars formed and when this reionization process started to occur?

Detection: near- and mid-infrared light

gets shifted by inflation

first stars and galaxies: visible or ultraviolet light

1 billion years

How clumpy galaxies evolve and develop structure over time?

How did the first galaxies form? And how did we end up with the large variety of galaxies we see today?

What is the nature of the relationship between the black holes and the galaxy that hosts them?

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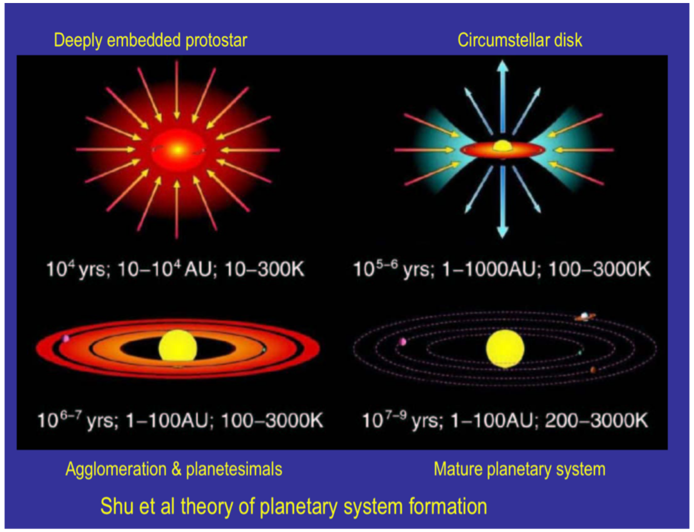
The JWST will observe galaxies far back in time.

Science—*Birth of Stars & Protoplanetary Systems*



Theory

Carina Nebula in visible light (left) and infrared (right), both images taken by Hubble.

Hubble: optimized for visible light.

Webb: optimized for near-infrared and 100x more powerful than Hubble.

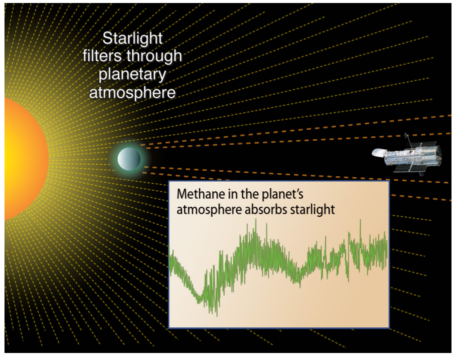
Infrared Cameras: sees the heat or infrared light being emitted by the stars within the cooler dust clouds.

We can—

- Image disks of heated material around these young stars: beginnings of planetary systems
- Study organic molecules

- …

Exoplanets



methane in the atmosphere of extrasolar planet 189733b

Infrared telescope: measuring the intensity of light at infrared wavelengths

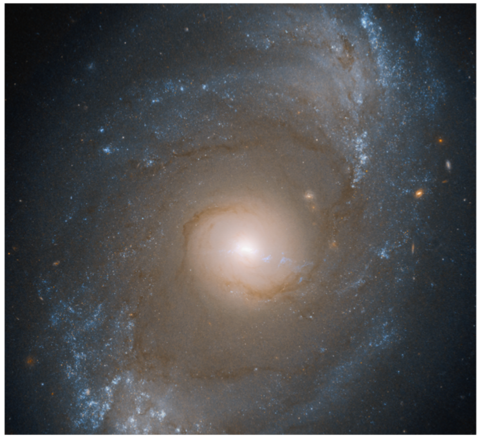
Coronagraphs: direct imaging of exoplanets near bright stars—its color, differences between winter and summer, vegetation, rotation, weather…

The Solar System

Near- and mid-infrared spectral instruments:
Inner solar system: trace organics in Mars' atmosphere.
Outer solar system: a better picture of the seasonal weather on our giant gas planets.
Small bodies: features in the spectra that Earth-based observatories are blind to.

~~Aliens?~~…

Ultimate goal: find planets orbiting in the habitable zone of their star, where it is possible for liquid water and perhaps even life(germ…) to exist.

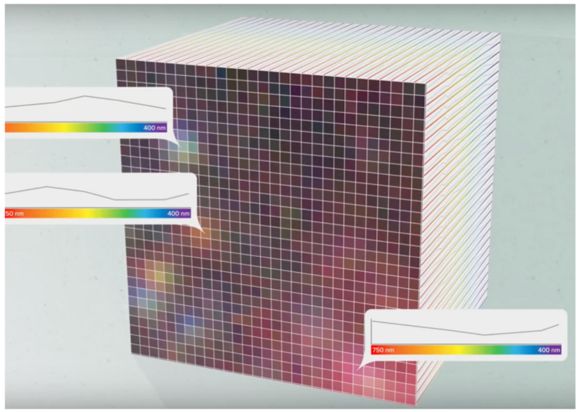


The spiral galaxy NGC 4151

Measuring the motions of stars in the galaxy's core

NGC 4151, Particularly active black hole with bright accretion disk

Probe closer to the galaxy's center and take a thousand spectra at once



(NIRSpec) integral field unit(IFU)

The elements that make up the stars, gas, relative motion of stars.

JWST is designed as a successor to Hubble telescope. It is a space-based telescope which focus on the infrared part of wavelength.

JWST has many innovations that can be applied to both space- and ground-based telescope.

JWST will provide greatly improved resolution and sensitivity(much larger mirror), and aim at major four scientific objectives: *First Light & Reionization, Assembly of Galaxies, Birth of Stars & Protoplanetary Systems, Origins of Life.*

Pushed back when 2021?...

Reference

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