Discoveries with the James Webb Space Telescope

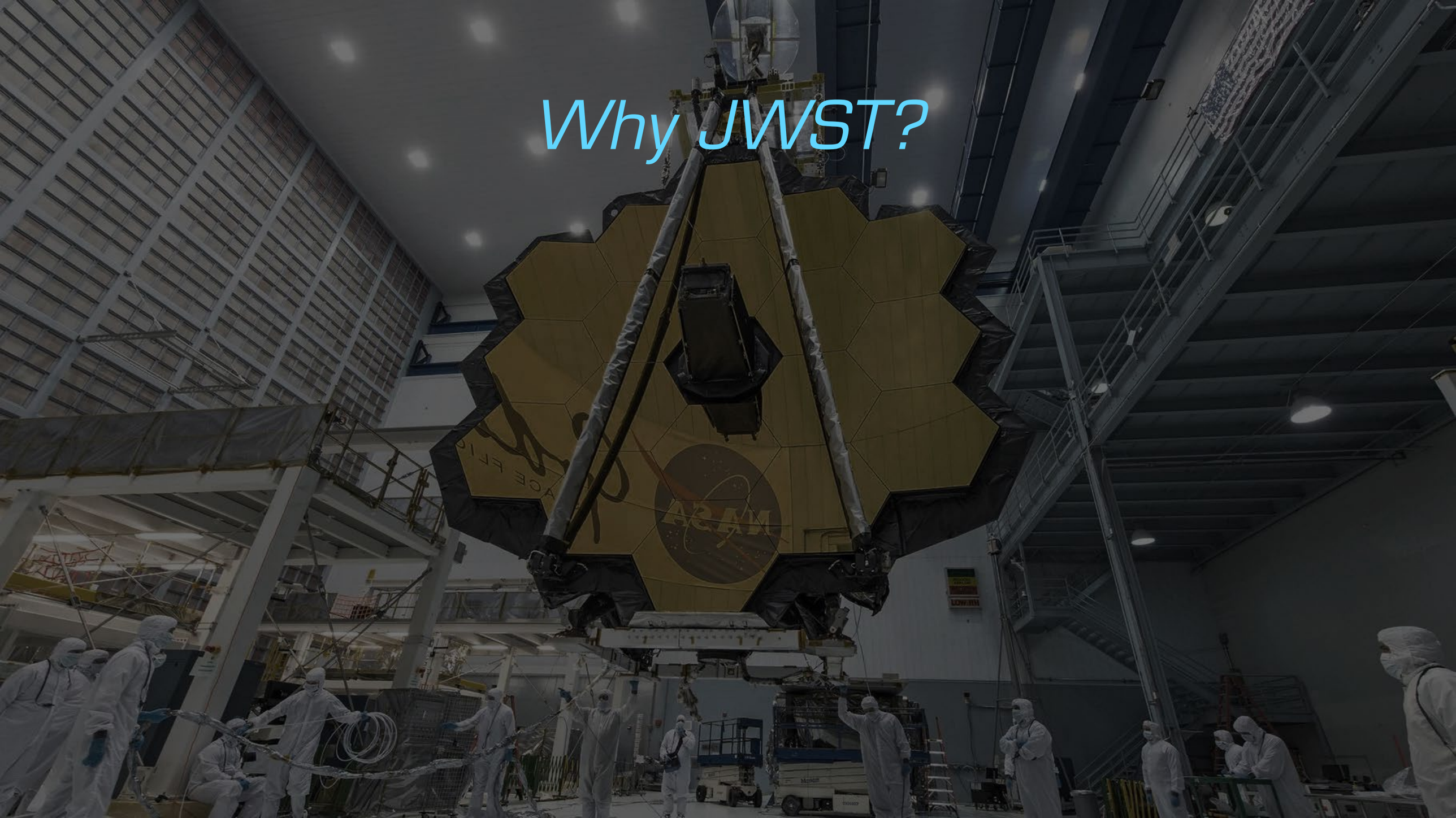
Dr. Ka Chun Yu

DENVER MUSEUM OF NATURE & SCIENCE

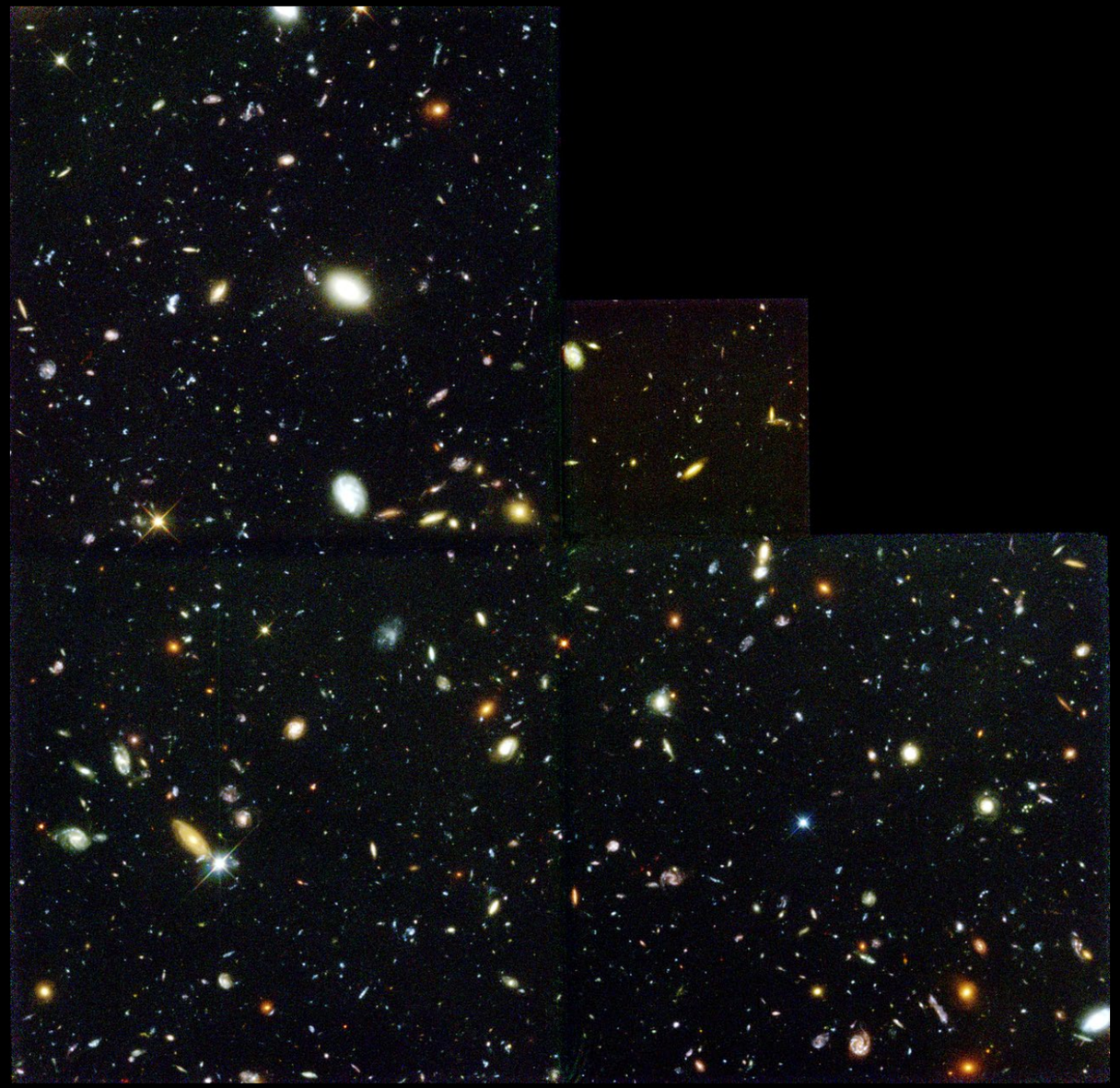
3 February 2023

Credit: JWST / NASA

Why JWST?



Hubble Deep Fields



Hubble Deep Fields

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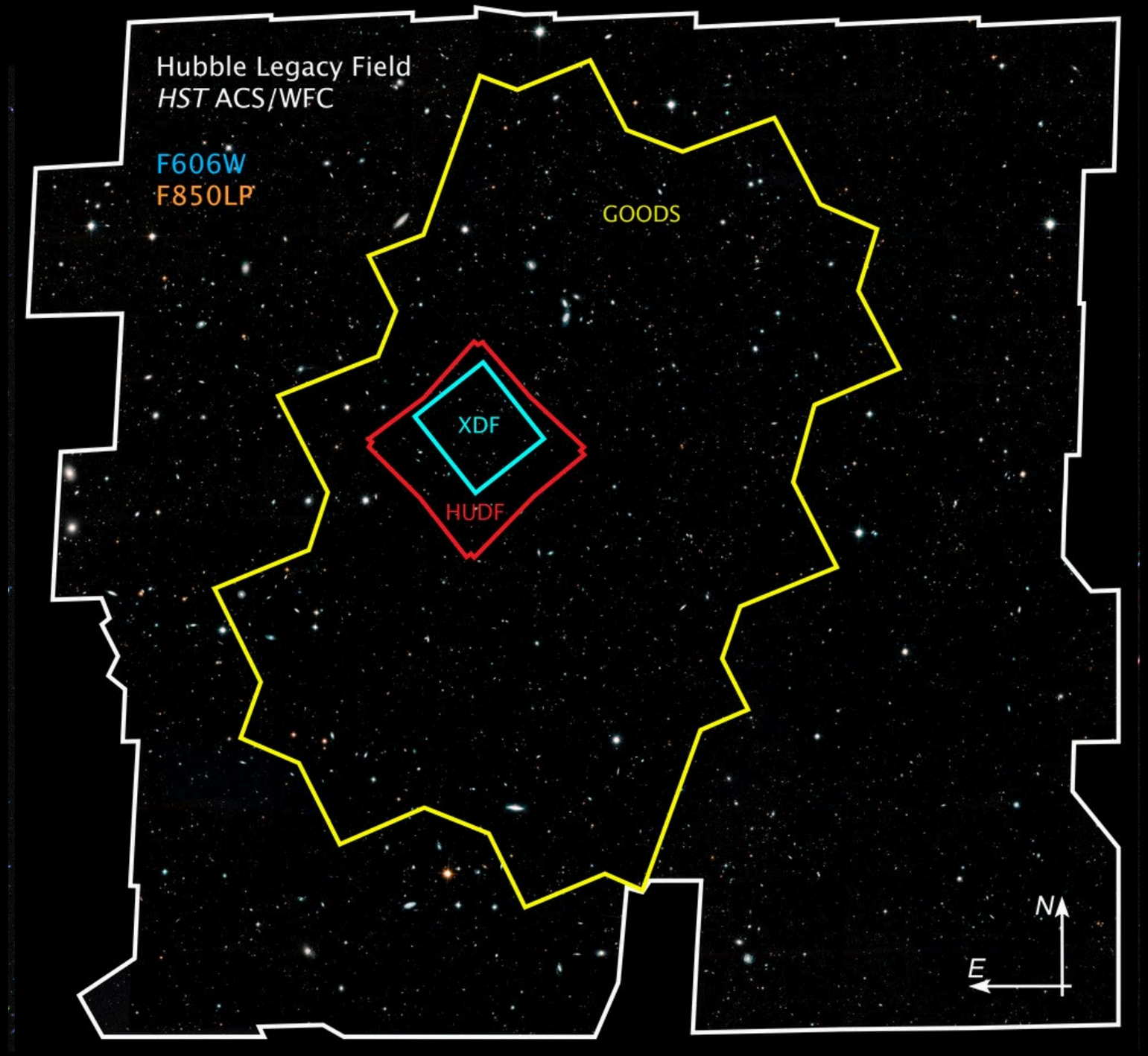
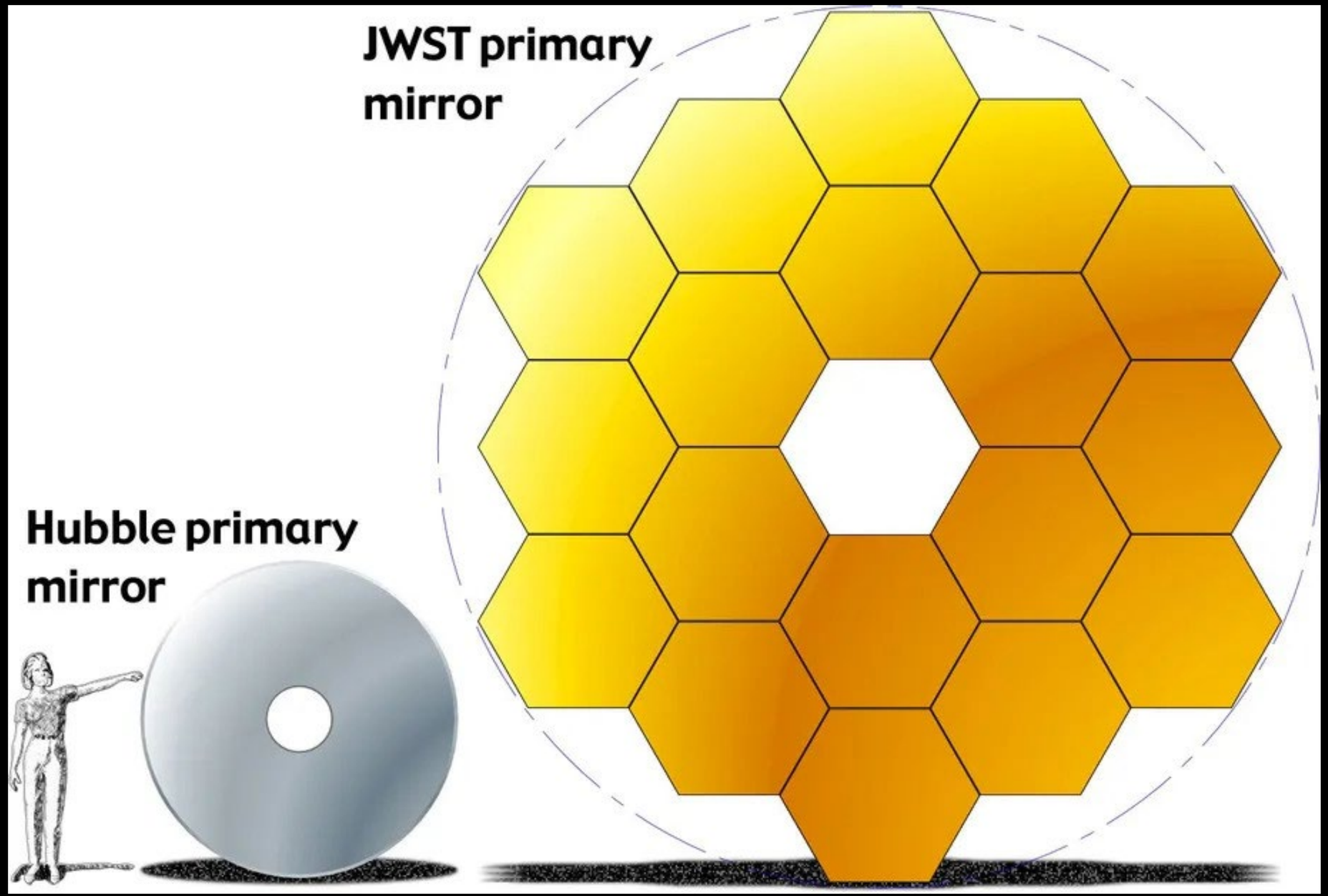
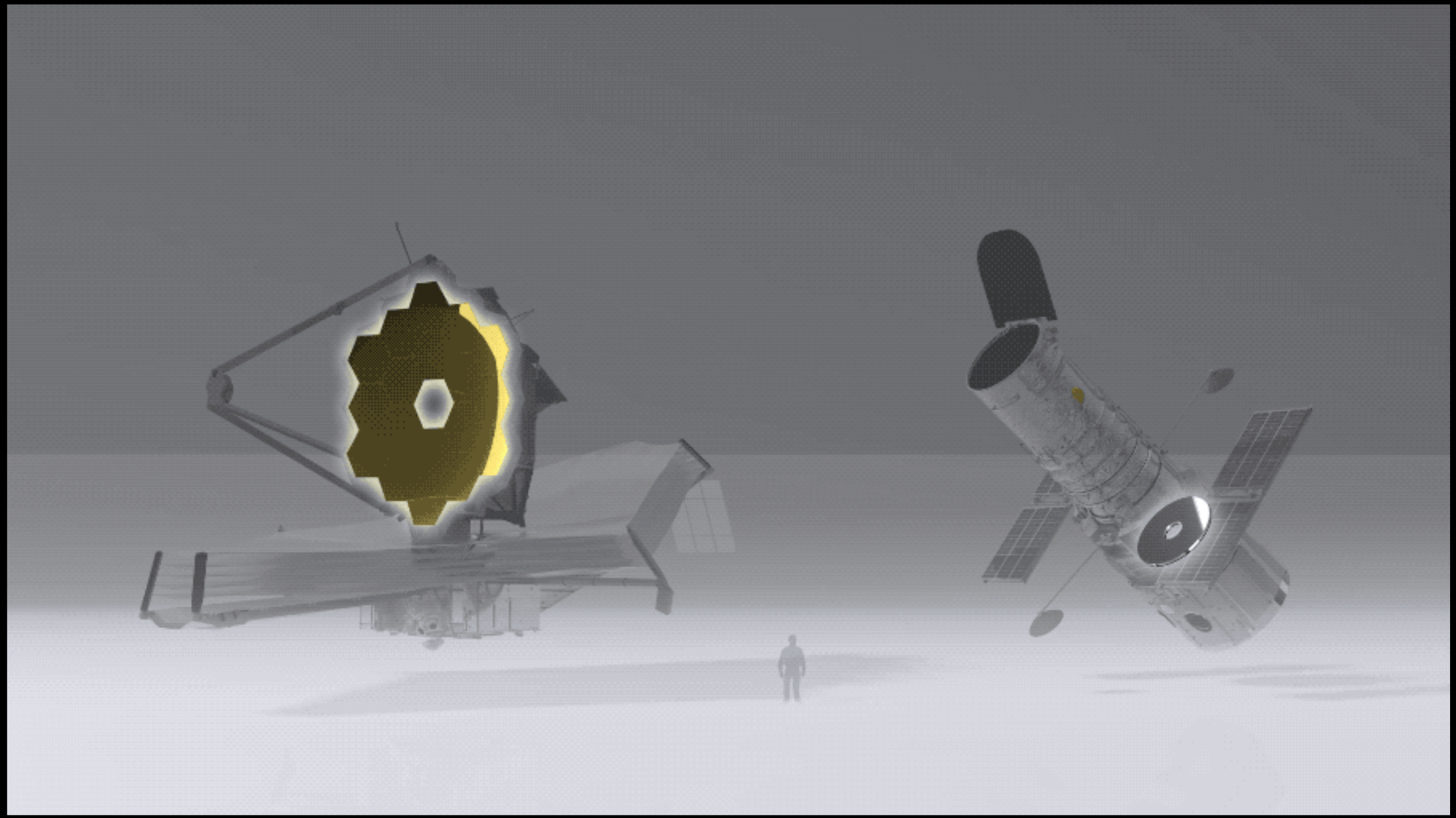
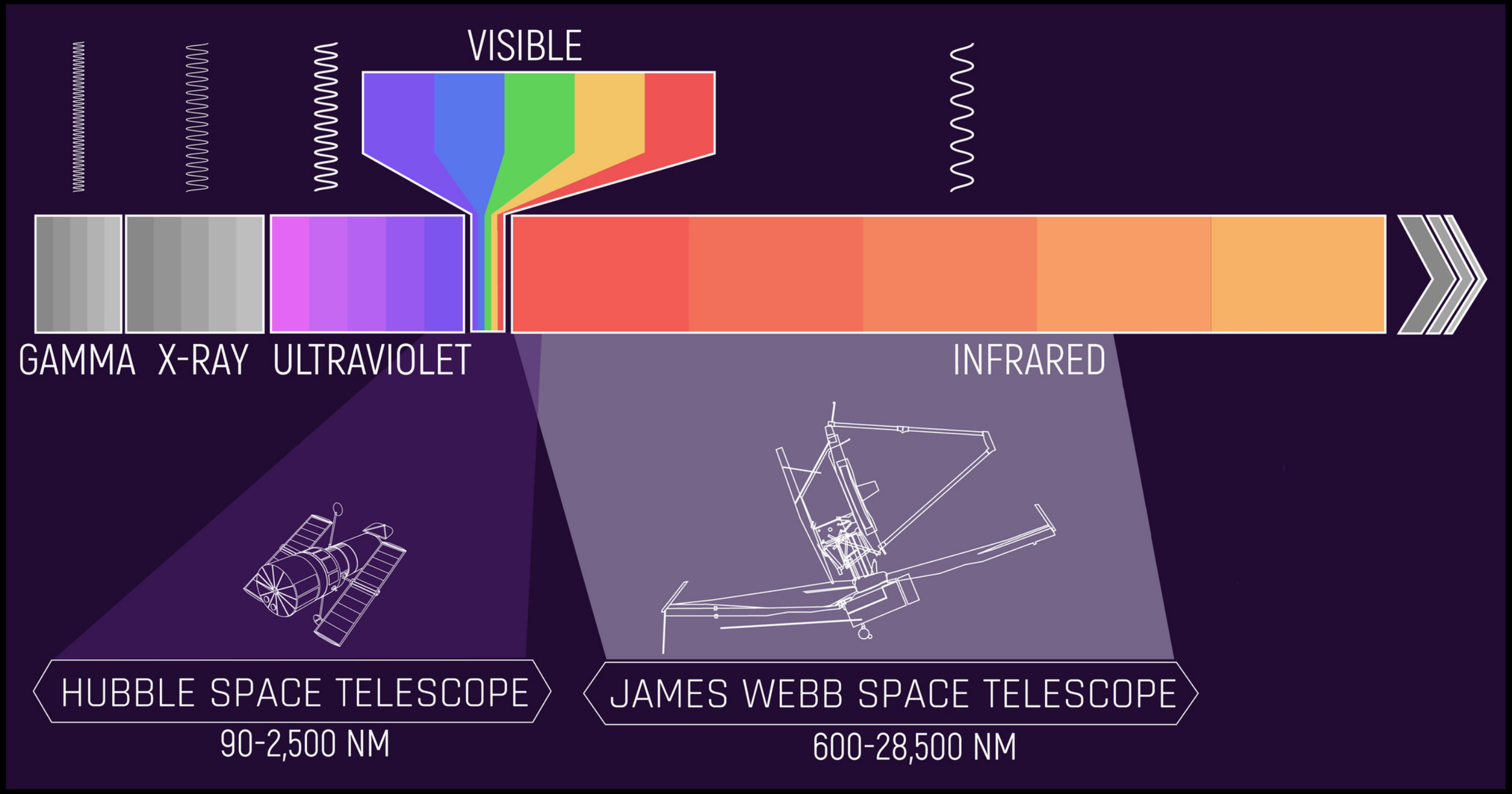




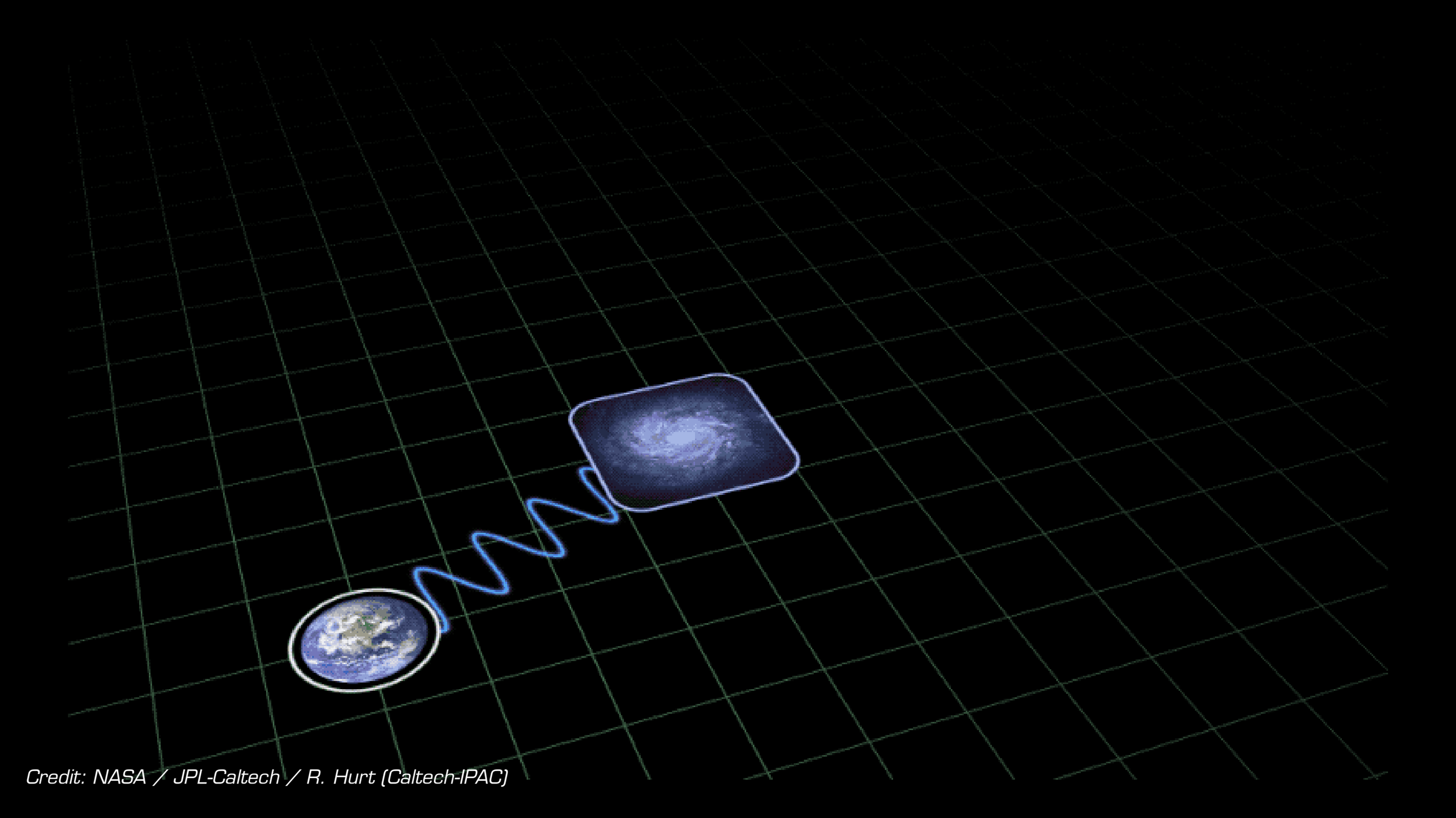
Credit: JWST / NASA



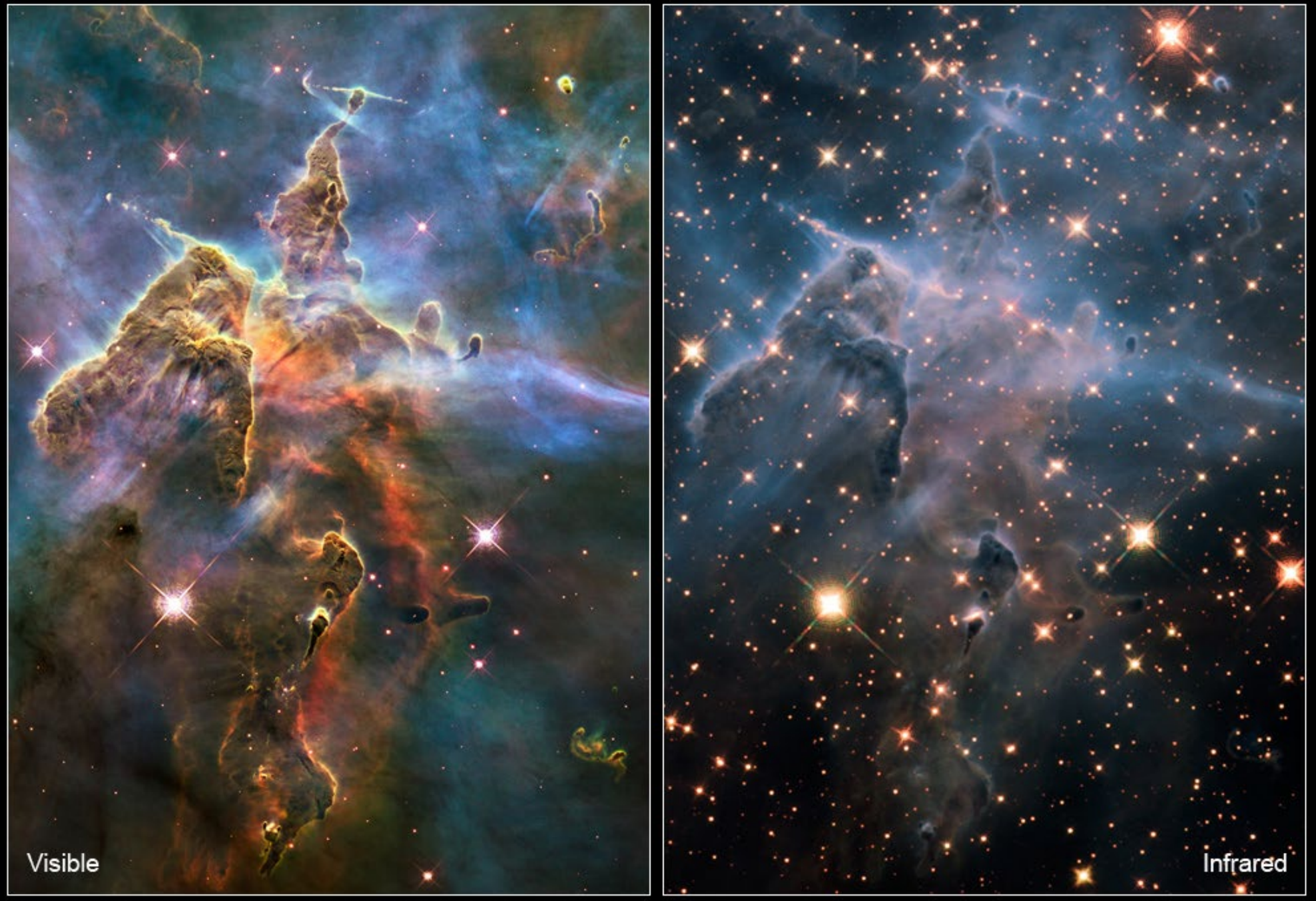
Credit: JWST / NASA


VISIBLE
GAMMA
X-RAY
ULTRAVIOLET
INFRARED
HUBBLE SPACE TELESCOPE
90-2,500 NM
JAMES WEBB SPACE TELESCOPE
600-28,500 NM

Credit: NASA

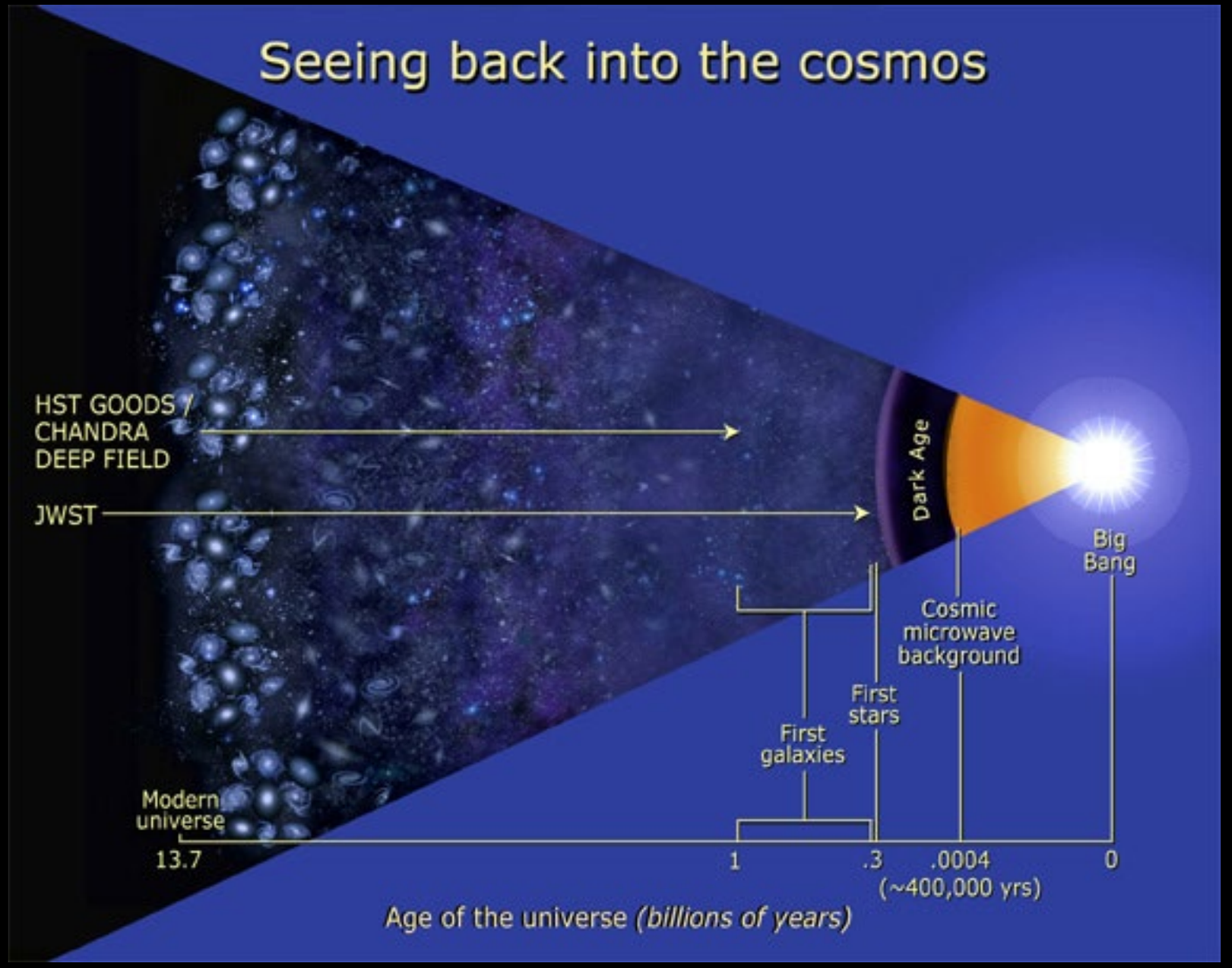


Credit: NASA / JPL-Caltech / R. Hurt (Caltech-IPAC)



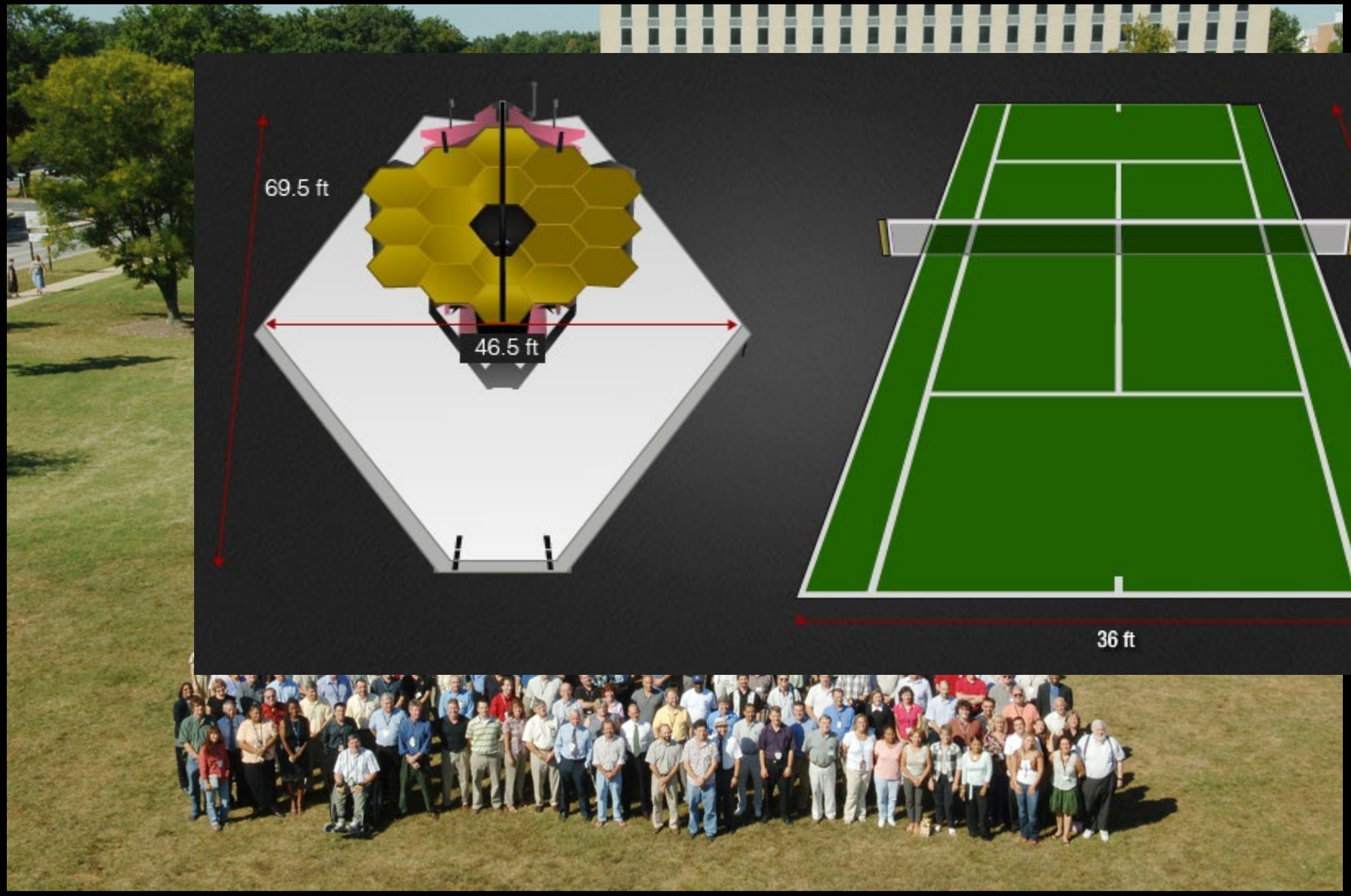
NASA, ESA, and M. Livio and the Hubble 20th Anniversary Team (STScI)

STScI-PRC10-13b



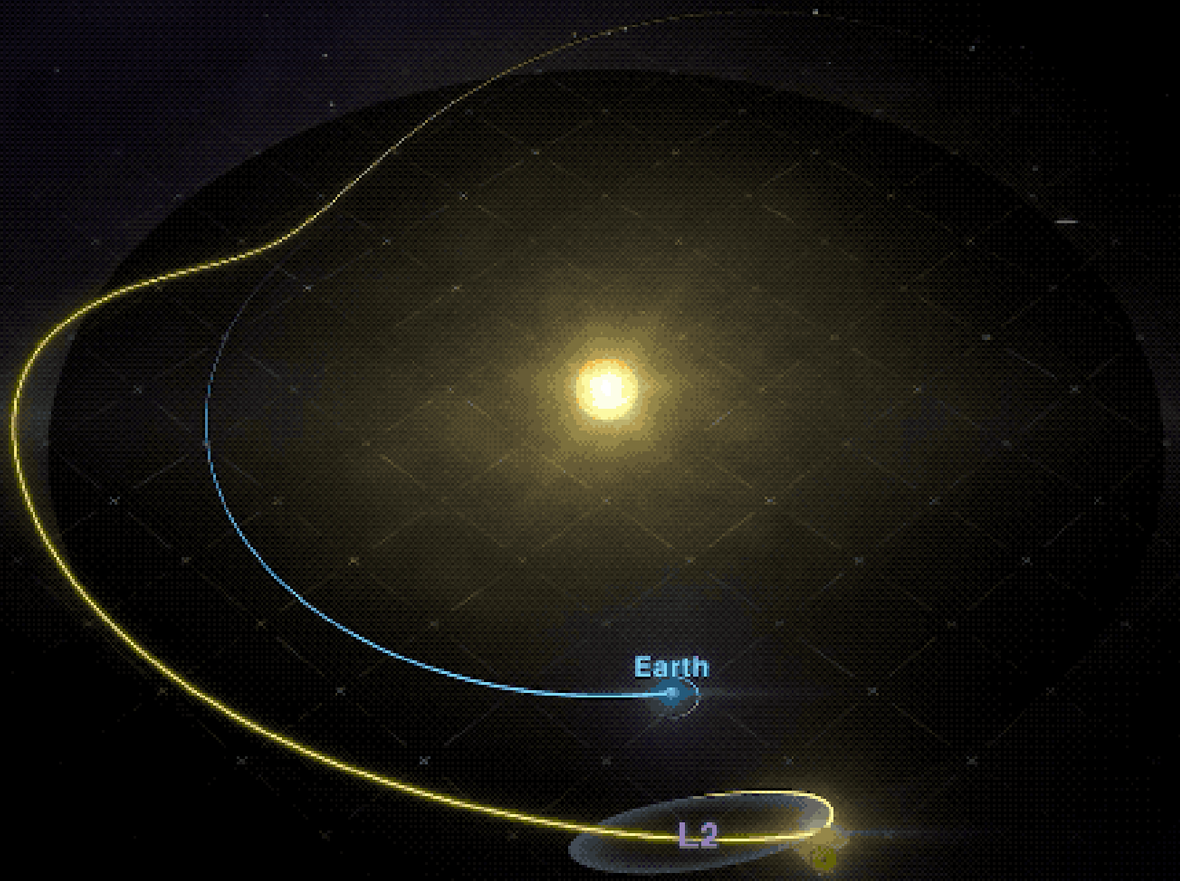
Credit: NASA / Ann Field (STScI)

Credit: Northrup Grumman



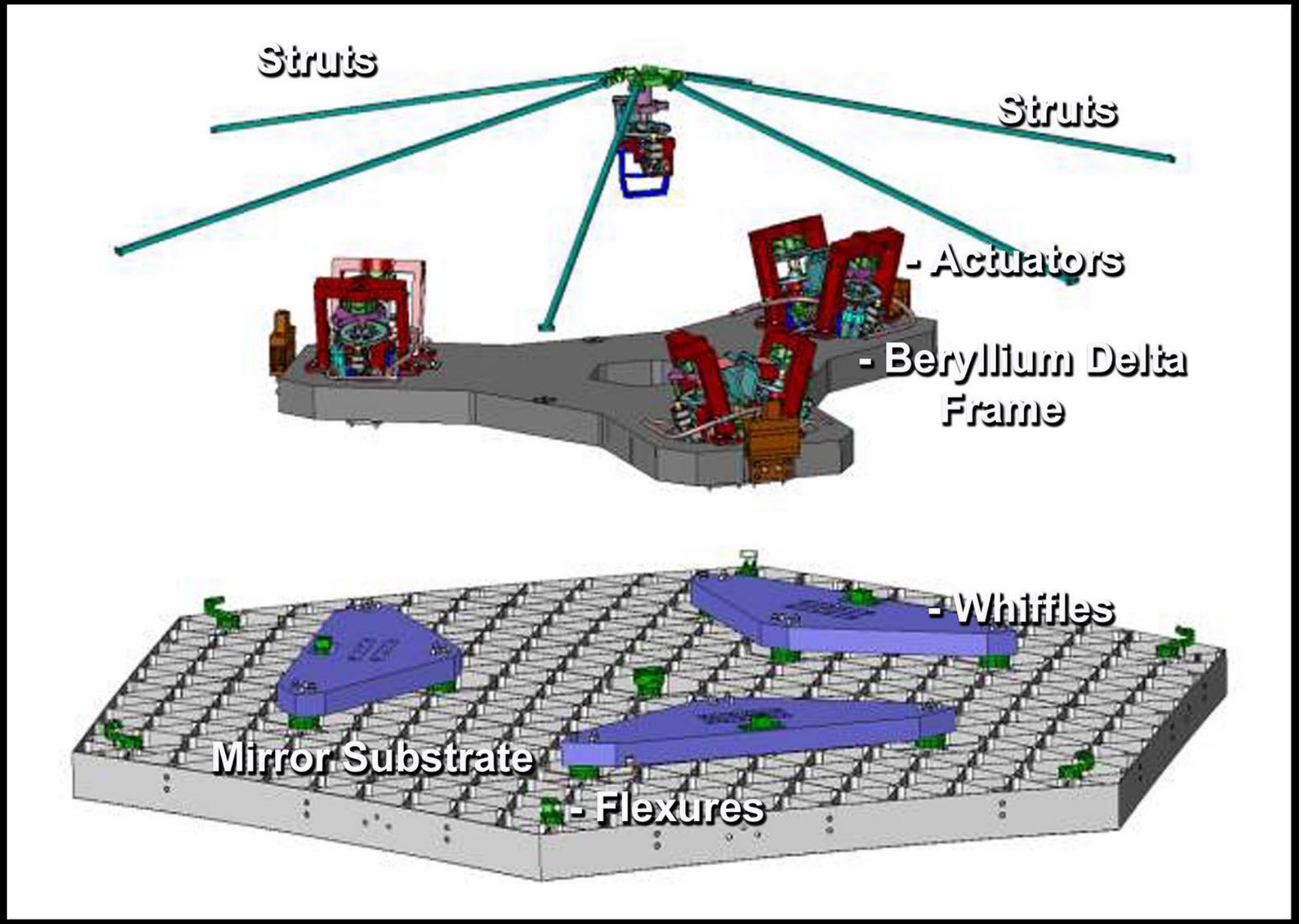
Credit: JWST / NASA

JWST Orbit



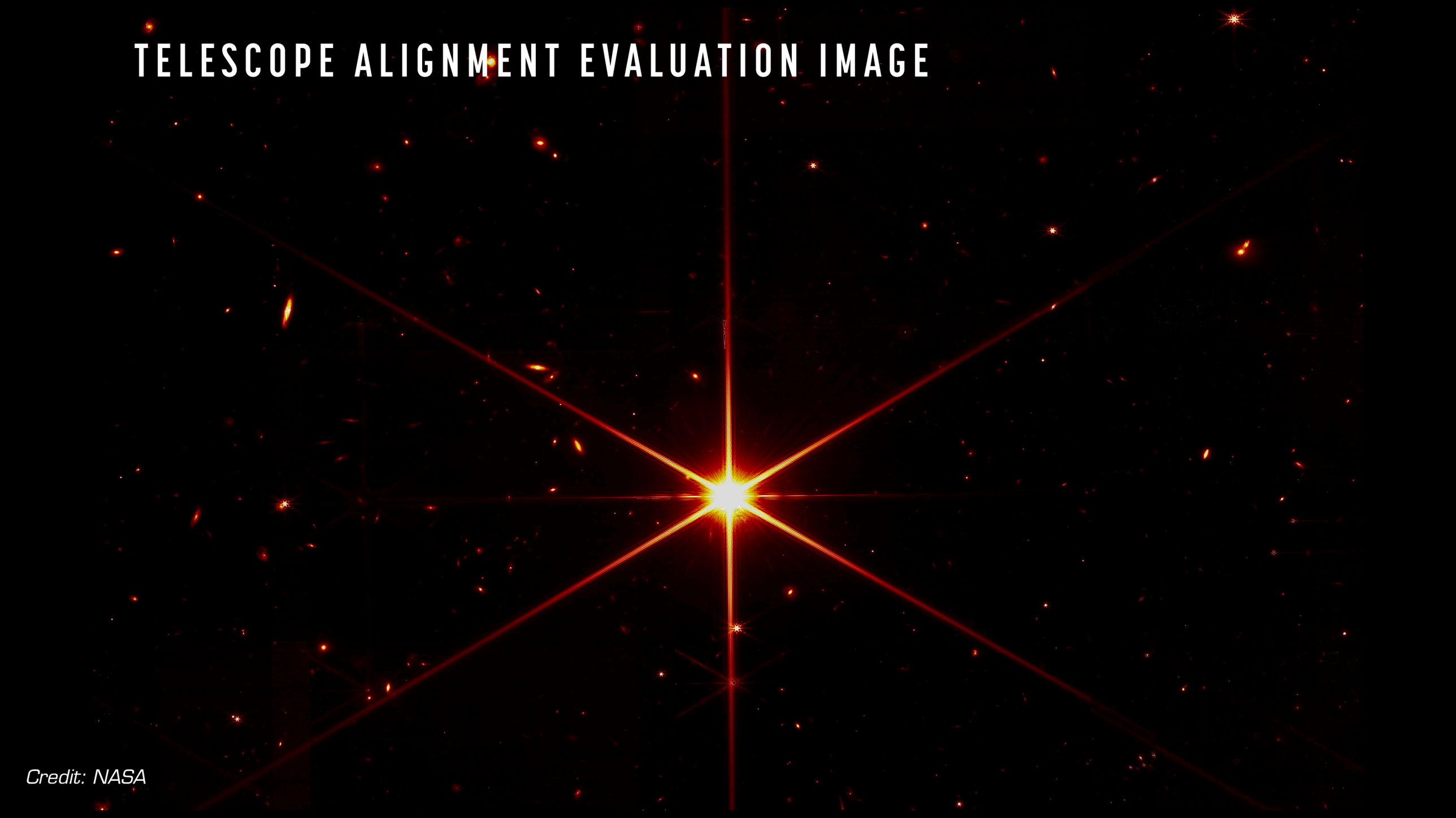
Credit: NASA

JWST Mirror Segments



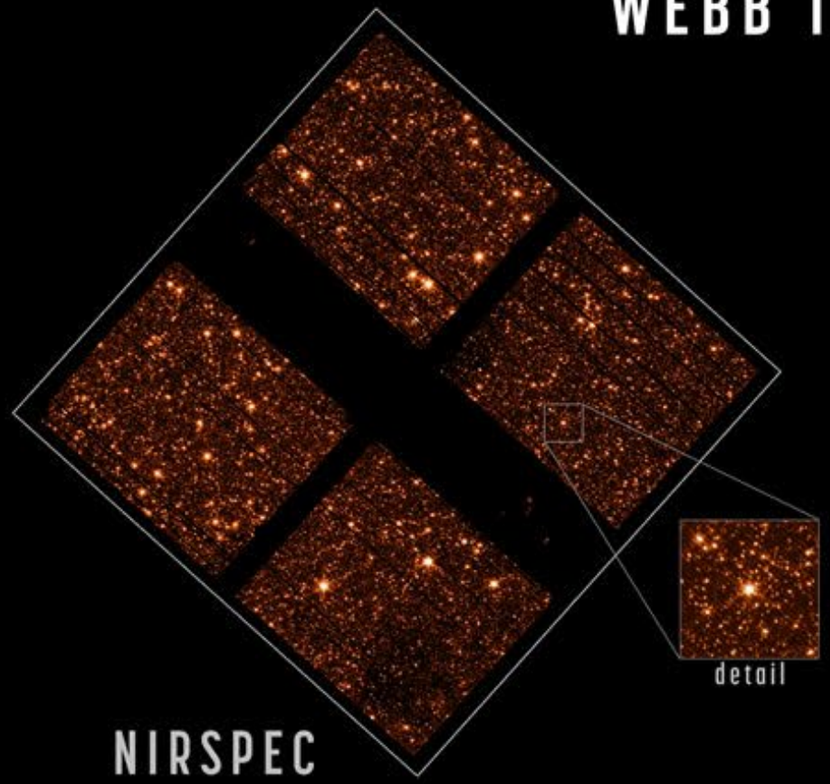
Credit: NASA

TELESCOPE ALIGNMENT EVALUATION IMAGE

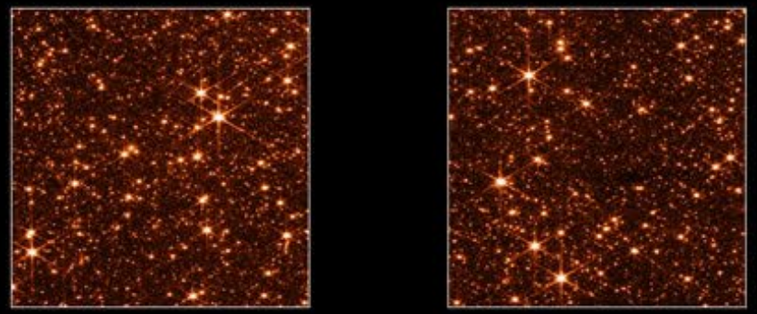


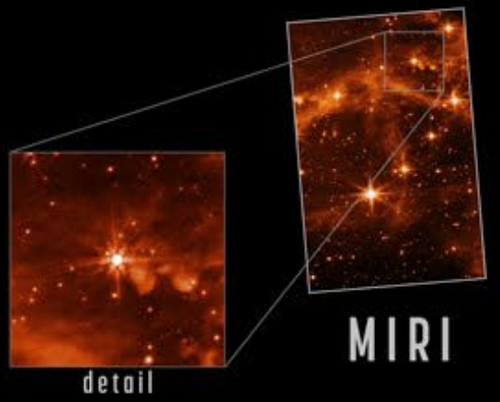
Credit: NASA

WEBB TELESCOPE IMAGE SHARPNESS CHECK

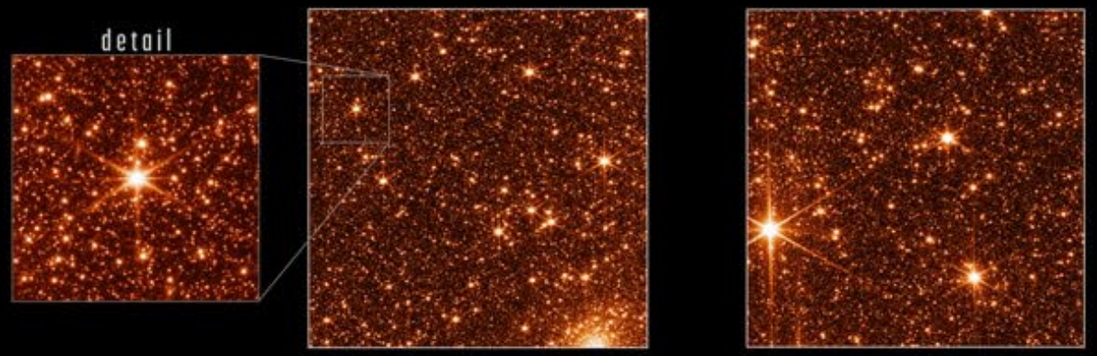


NIRCAM

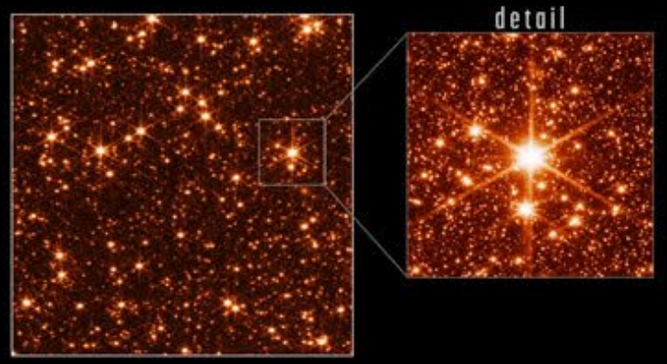




FINE GUIDANCE SENSOR

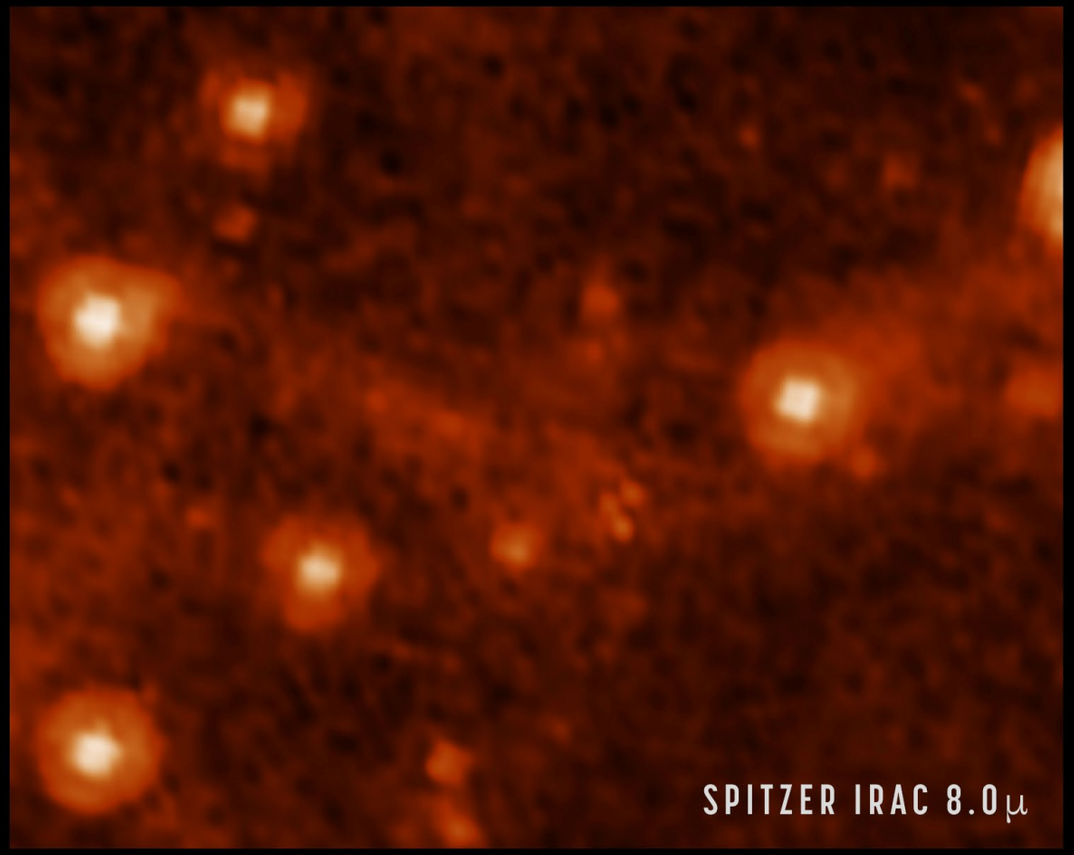


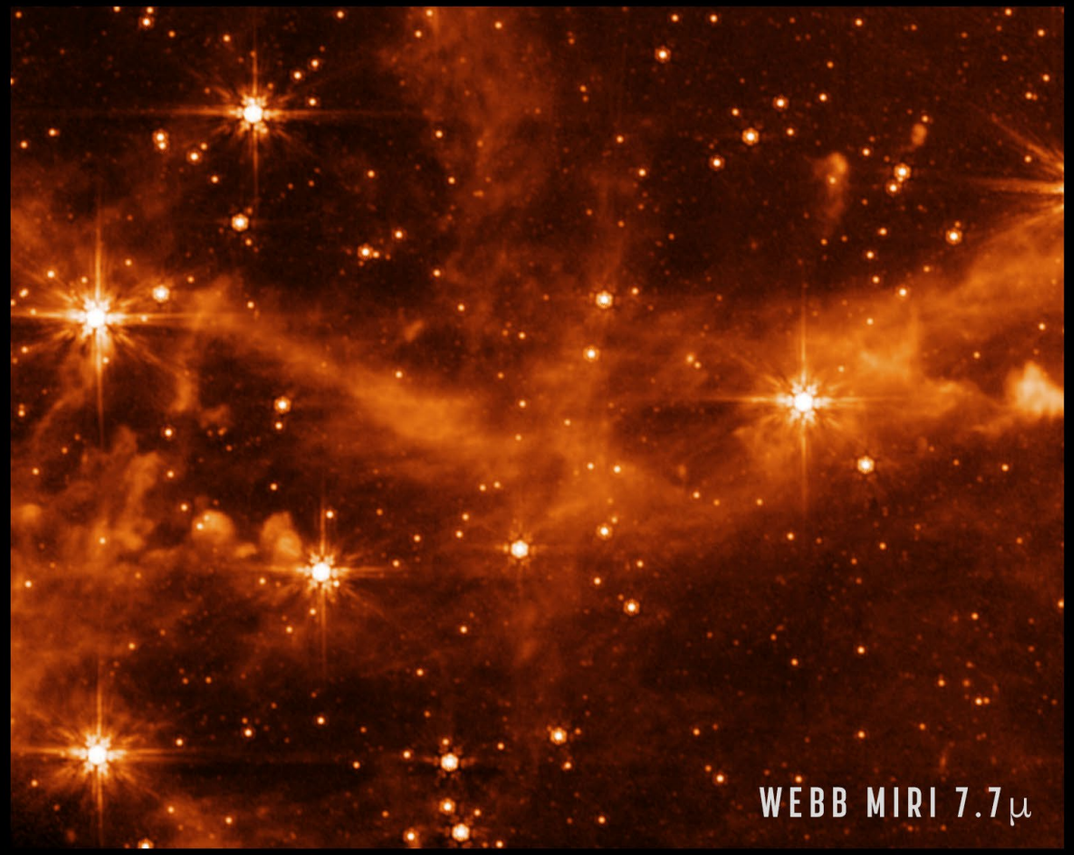
NIRISS



Credit: NASA

MIRI Commissioning

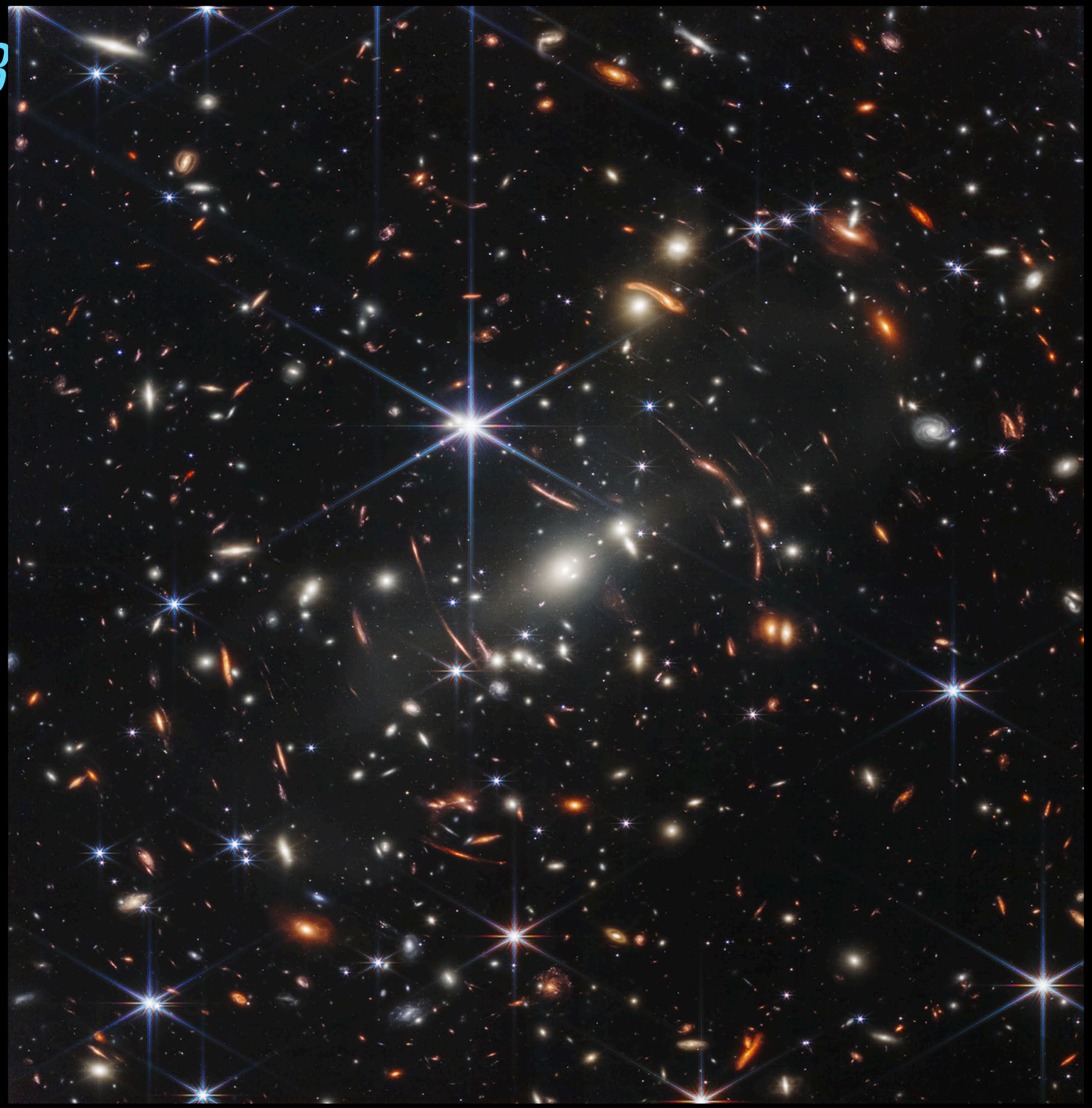




Mirror Diameter: *0.85 m* *6.5 m*

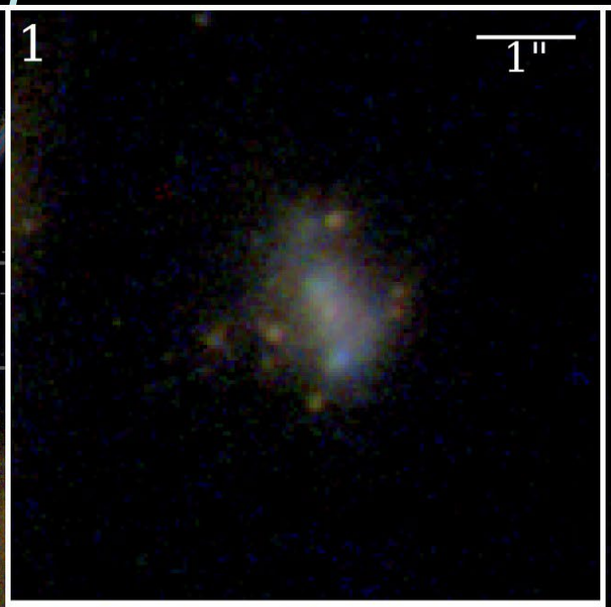
Credit: NASA

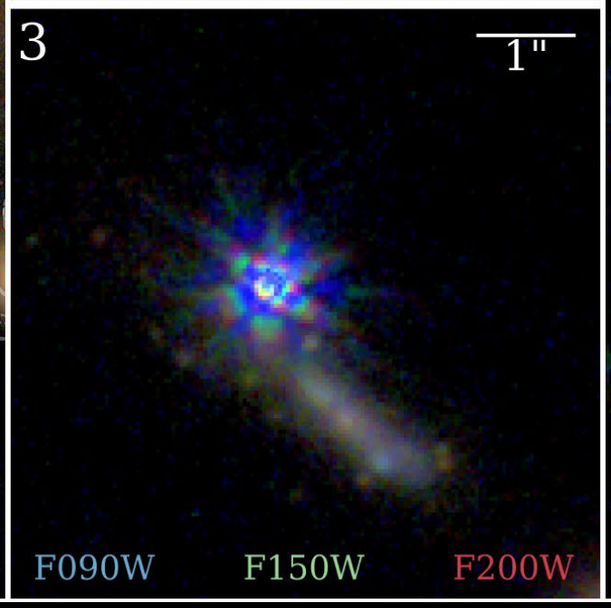
SMACS 0723

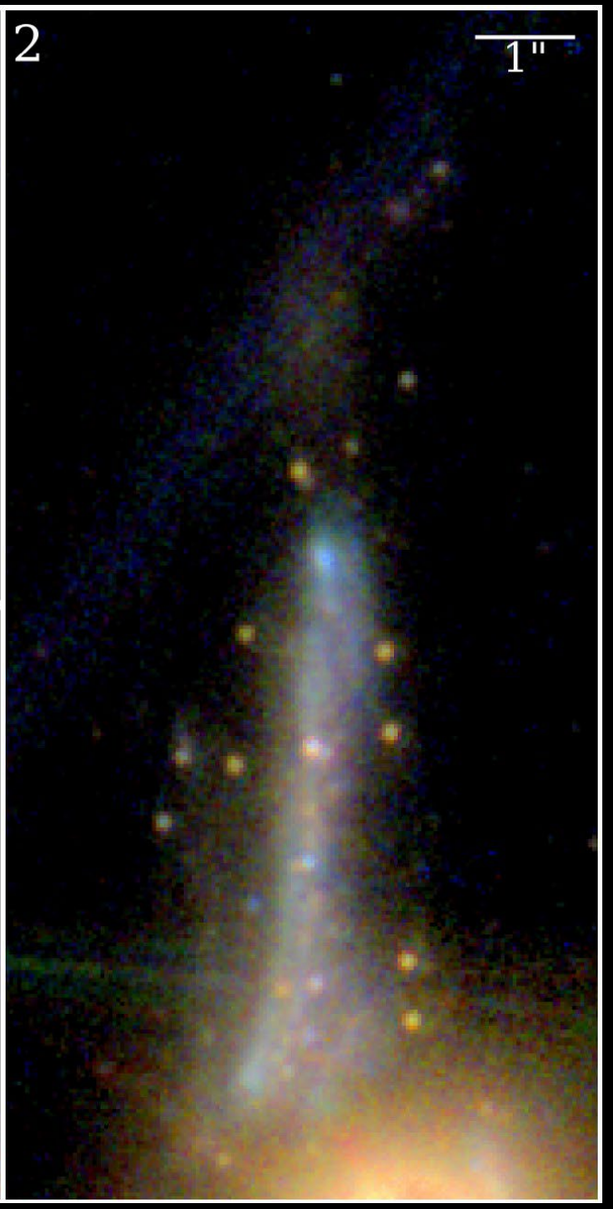


Credit: STScI

“Sparklers”



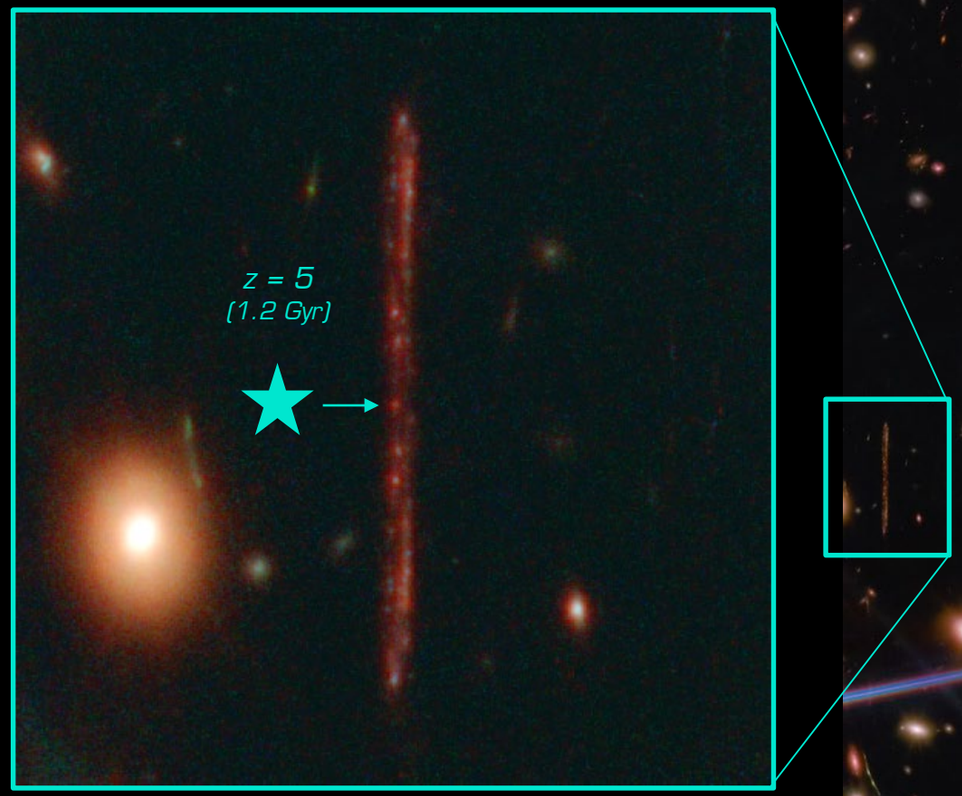




Credit: M. Bolcha/NOIRLab/NSF/AURA/Gemini/Subaru/Lemmon SkyCenter

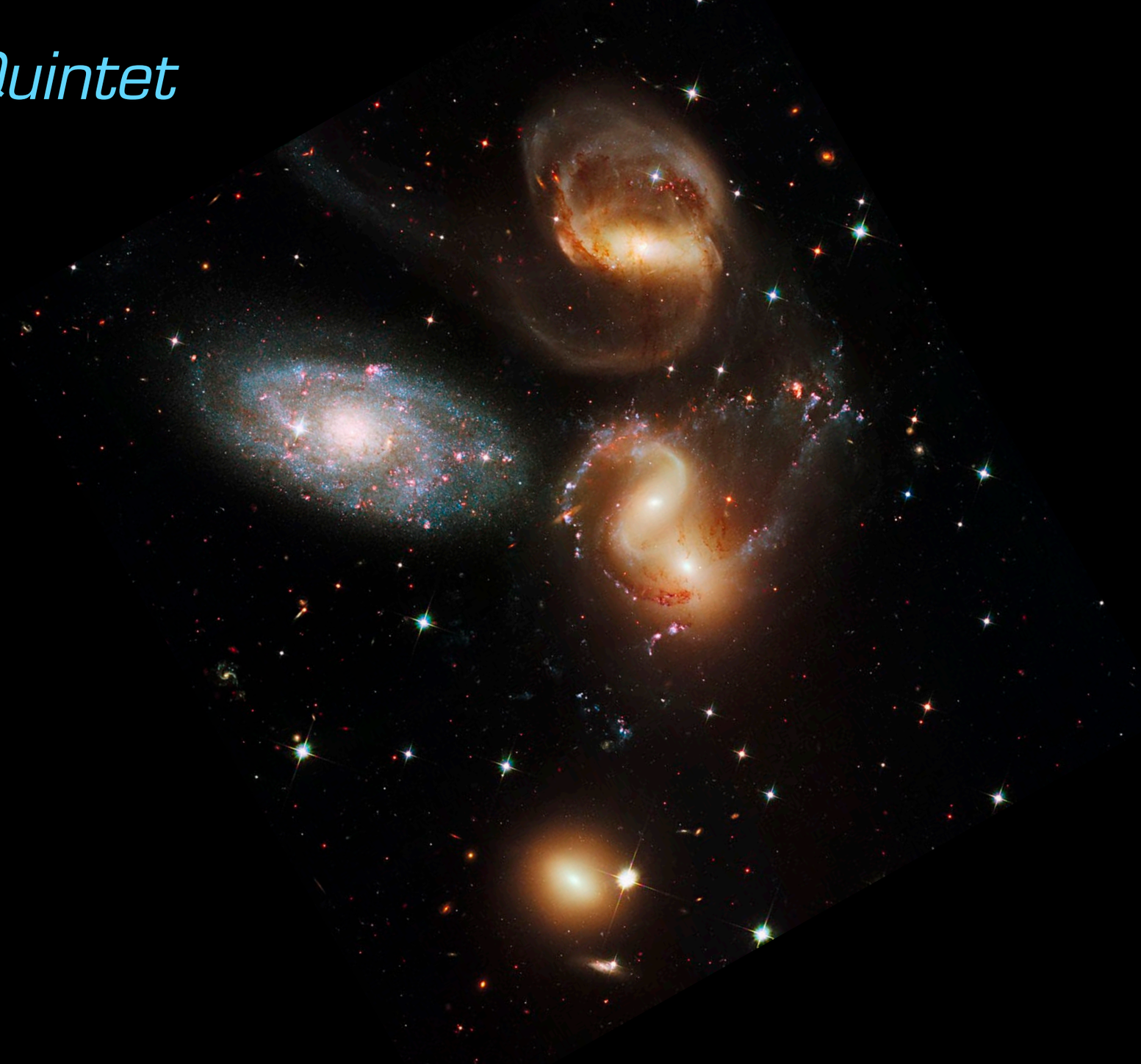
MACS J0647+7015

(star magnified by gravitational lens)



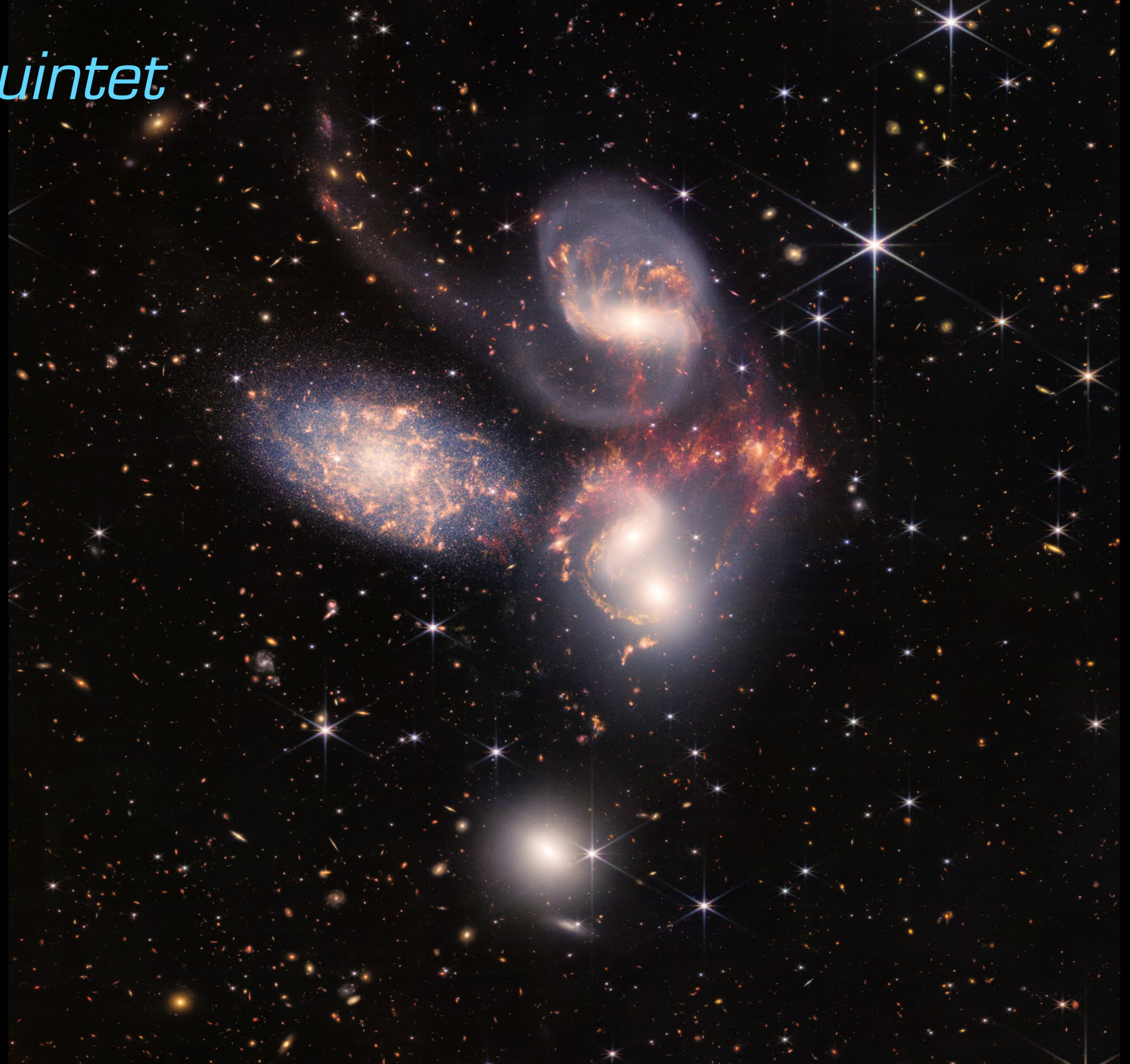
Meena et al. arXiv:2211.13334

Stephan's Quintet



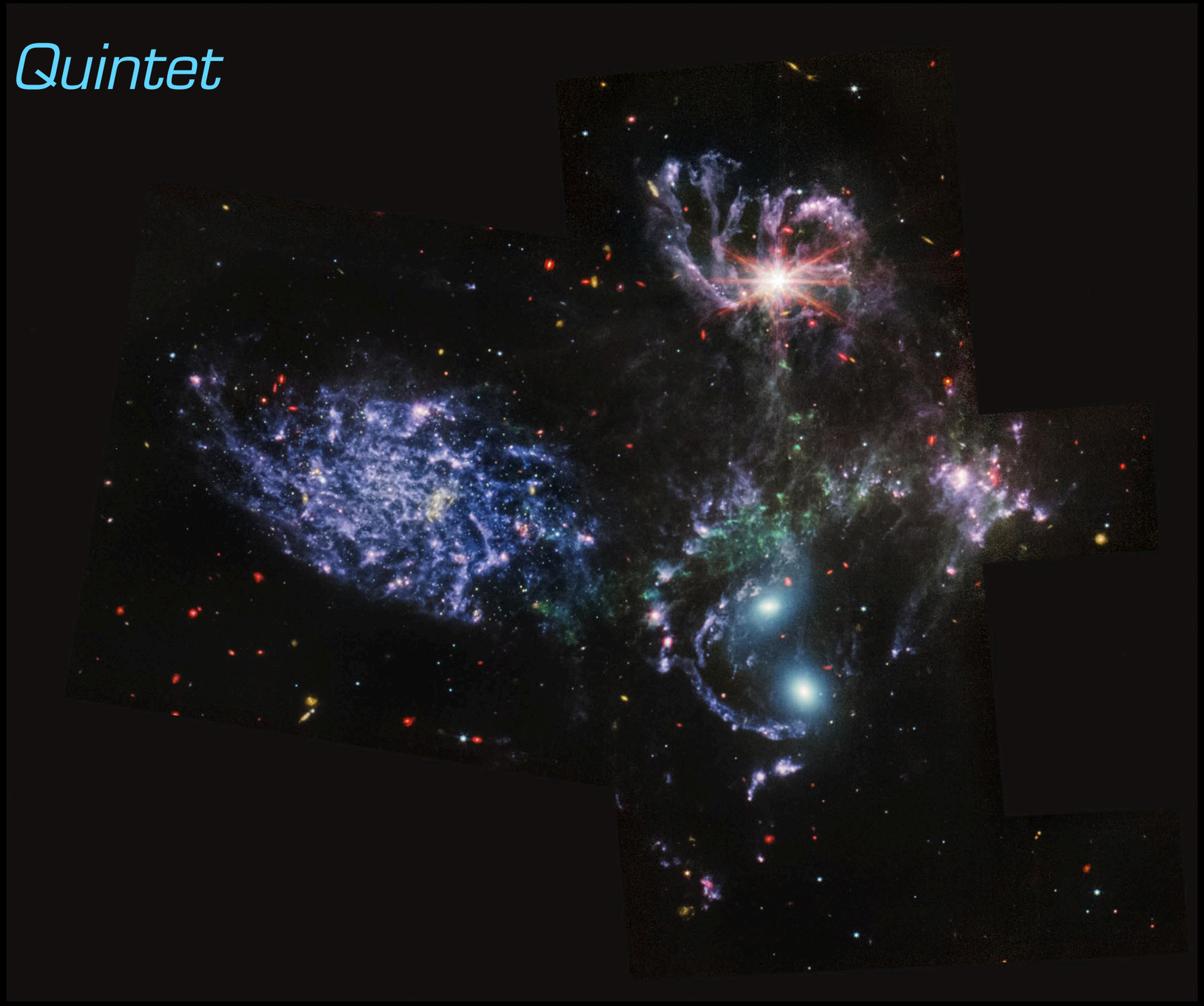
Credit: STScI

Stephan's Quintet



Credit: STScI

Stephan's Quintet



Credit: STScI

M74 / NGC 628 with Hubble Space Telescope

Credit: NASA/ESA/Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration

M74 / NGC 628 with Hubble Space Telescope

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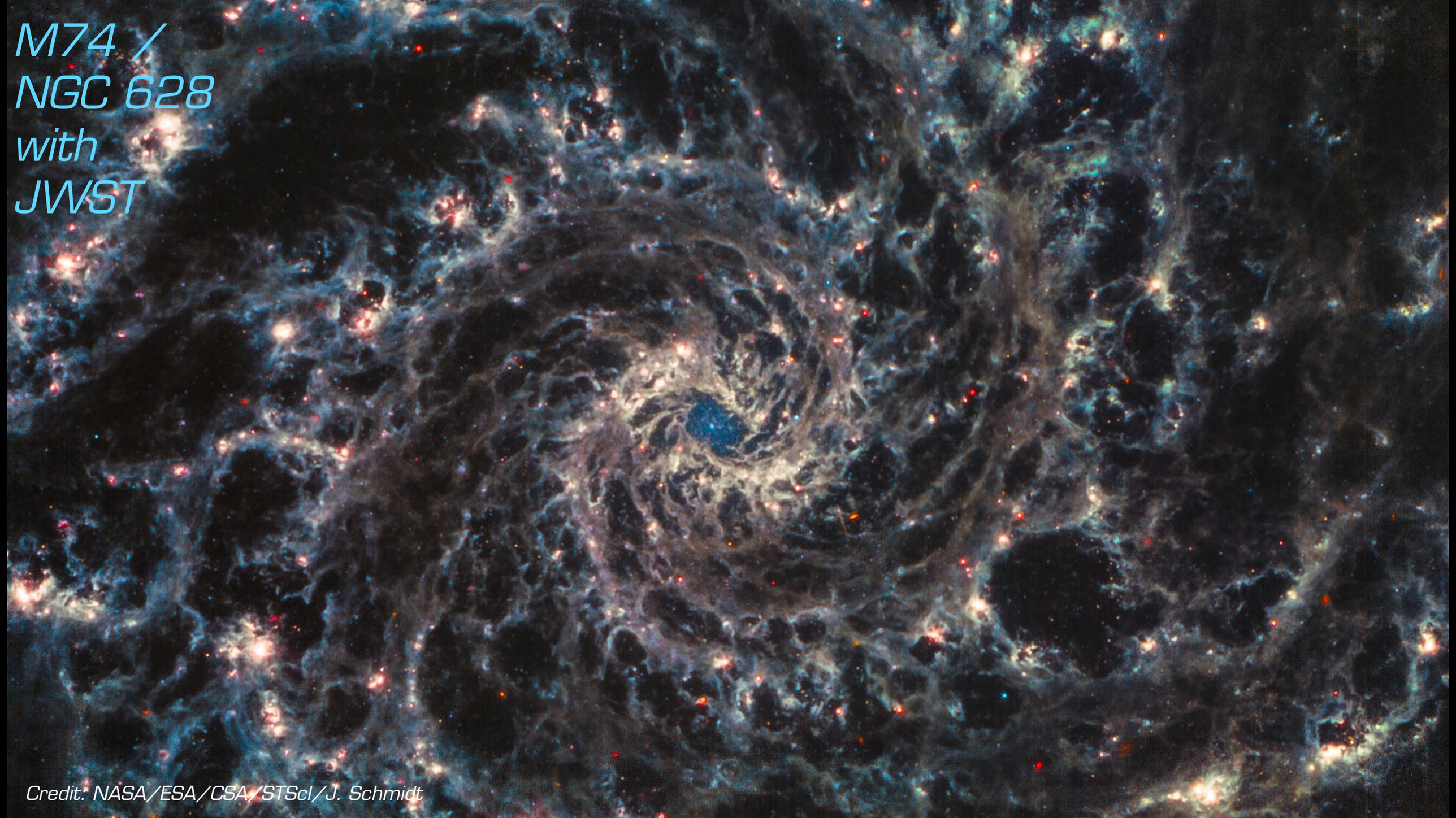
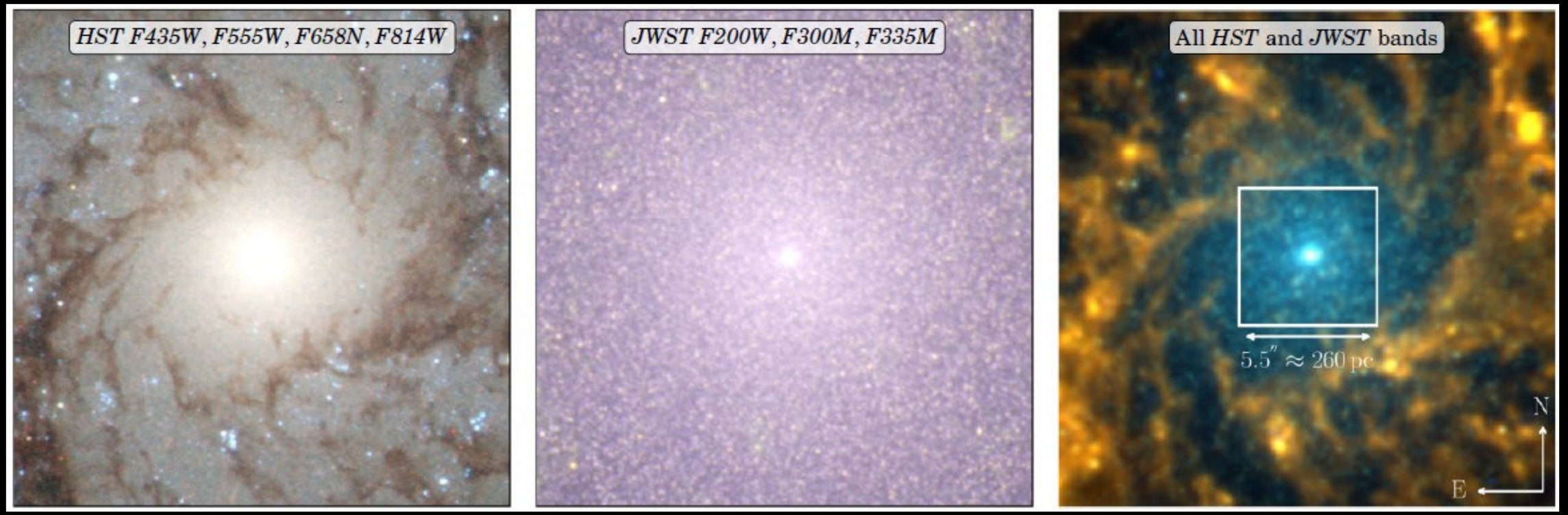
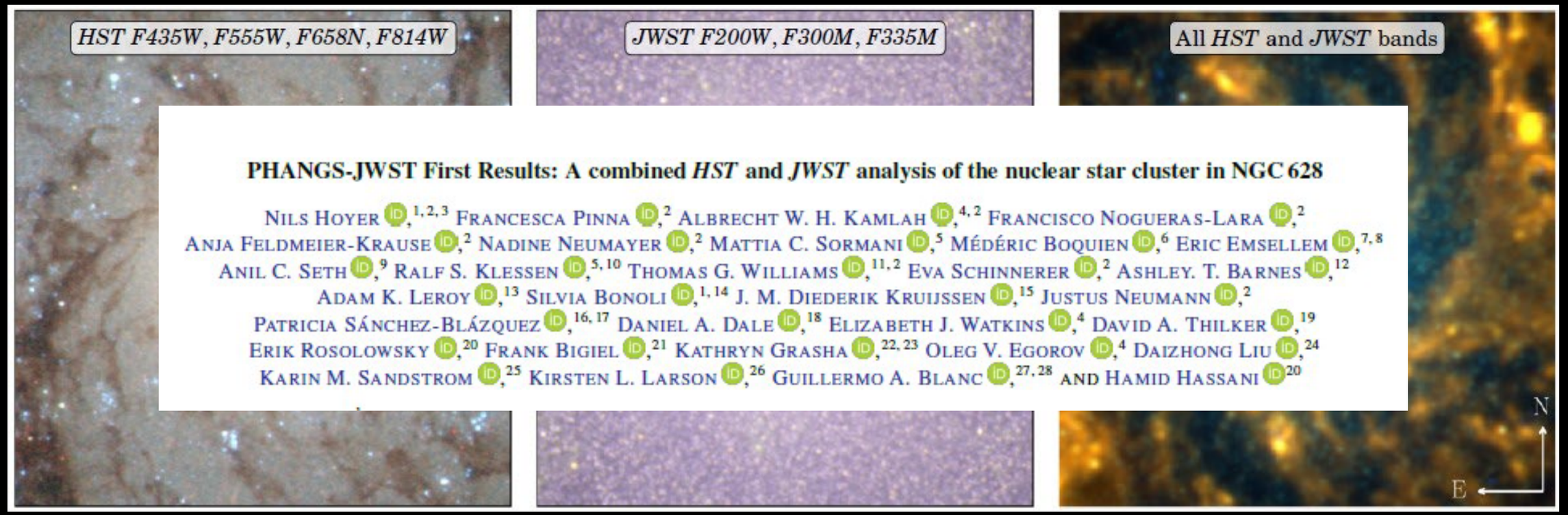
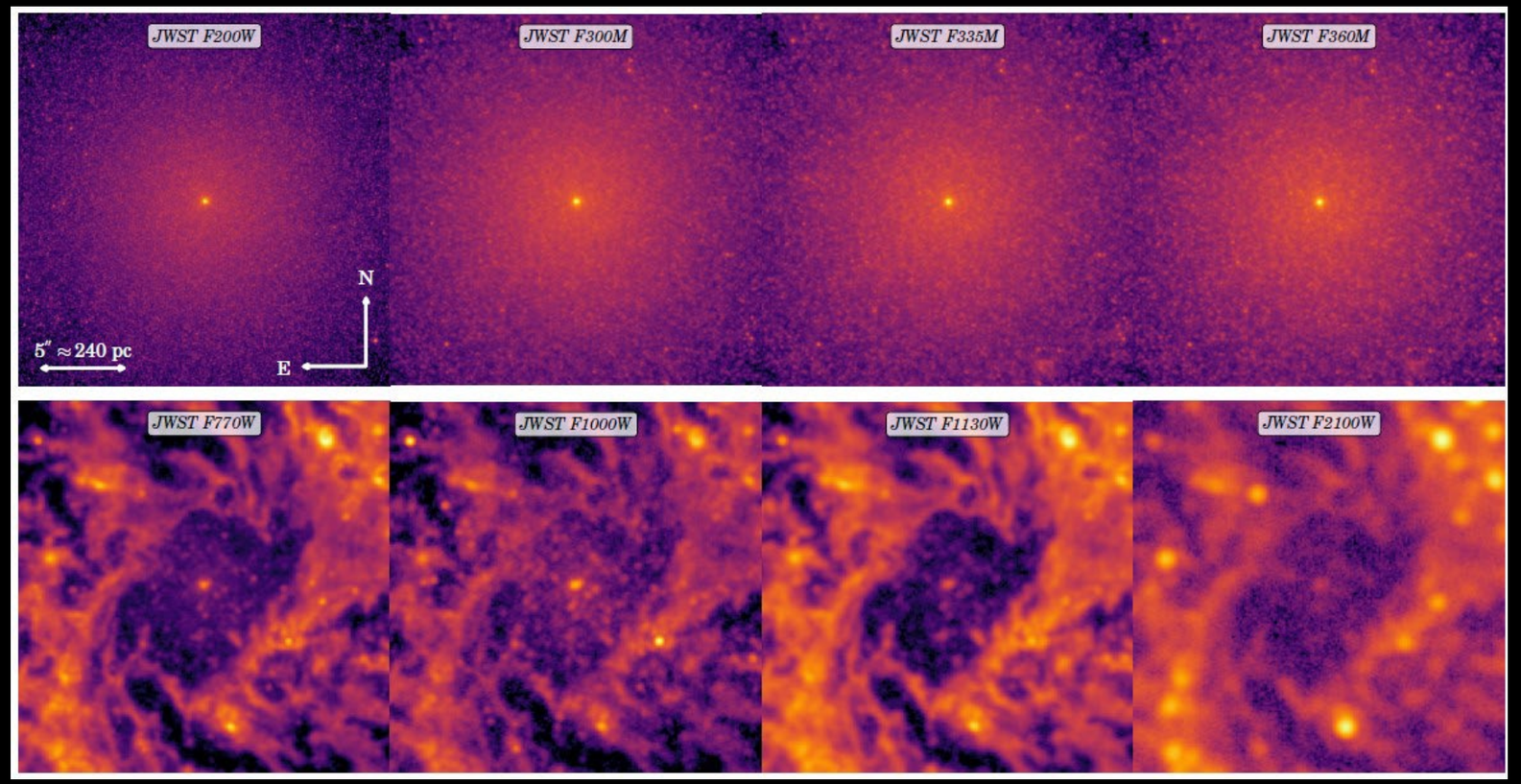

M74 /
NGC 628
with
JWST
Credit: NASA/ESA/CSA/STScI/J. Schmidt



Credit: Hoyer et al. 2023



Credit: Hoyer et al. 2023



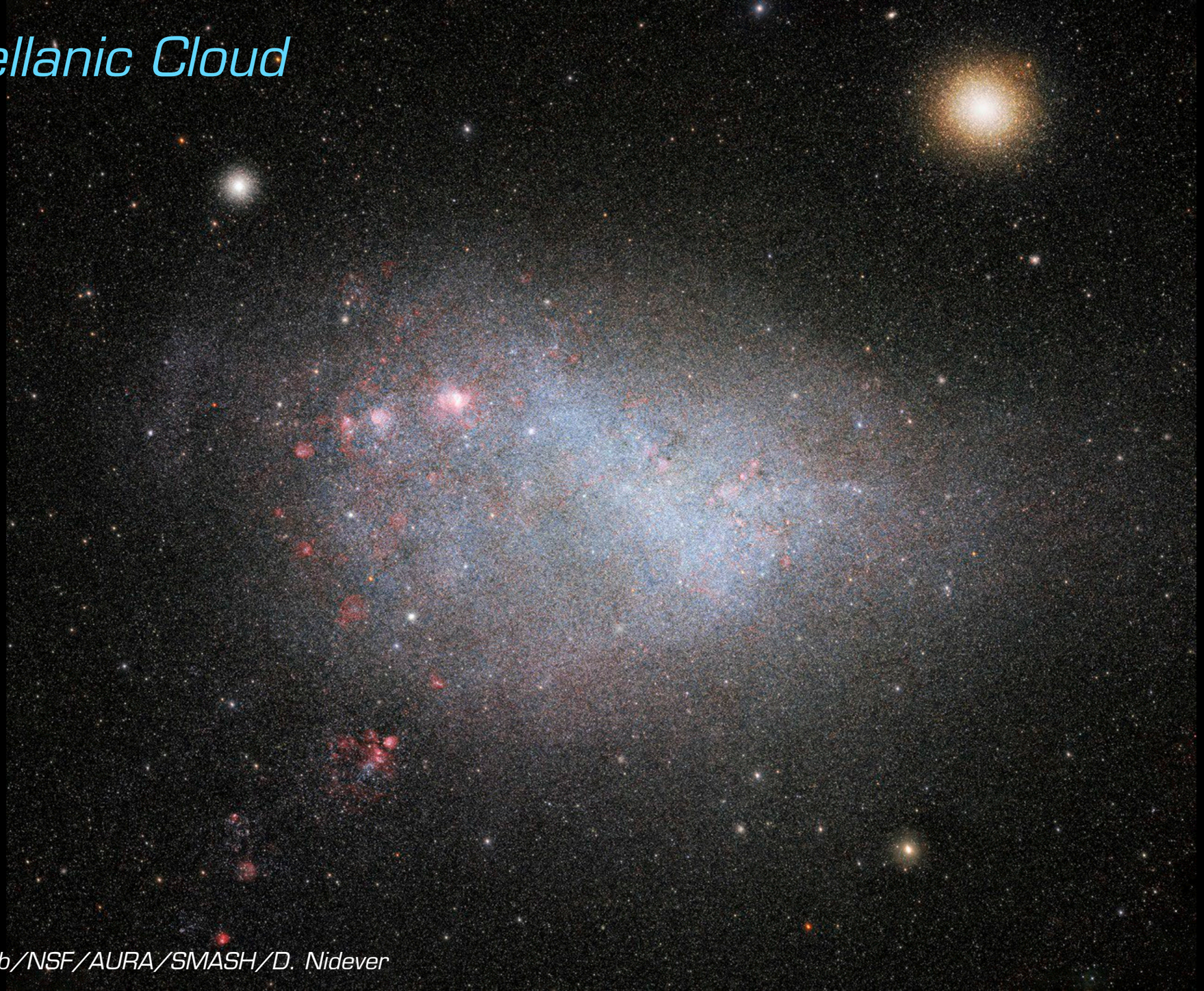
- *Stars 8 billion years old*
- *Few young stars*
  - *Gas & dust can't get to center?*
  - *Central black hole?*

Credit: Hoyer et al. 2023

Credit: ESO

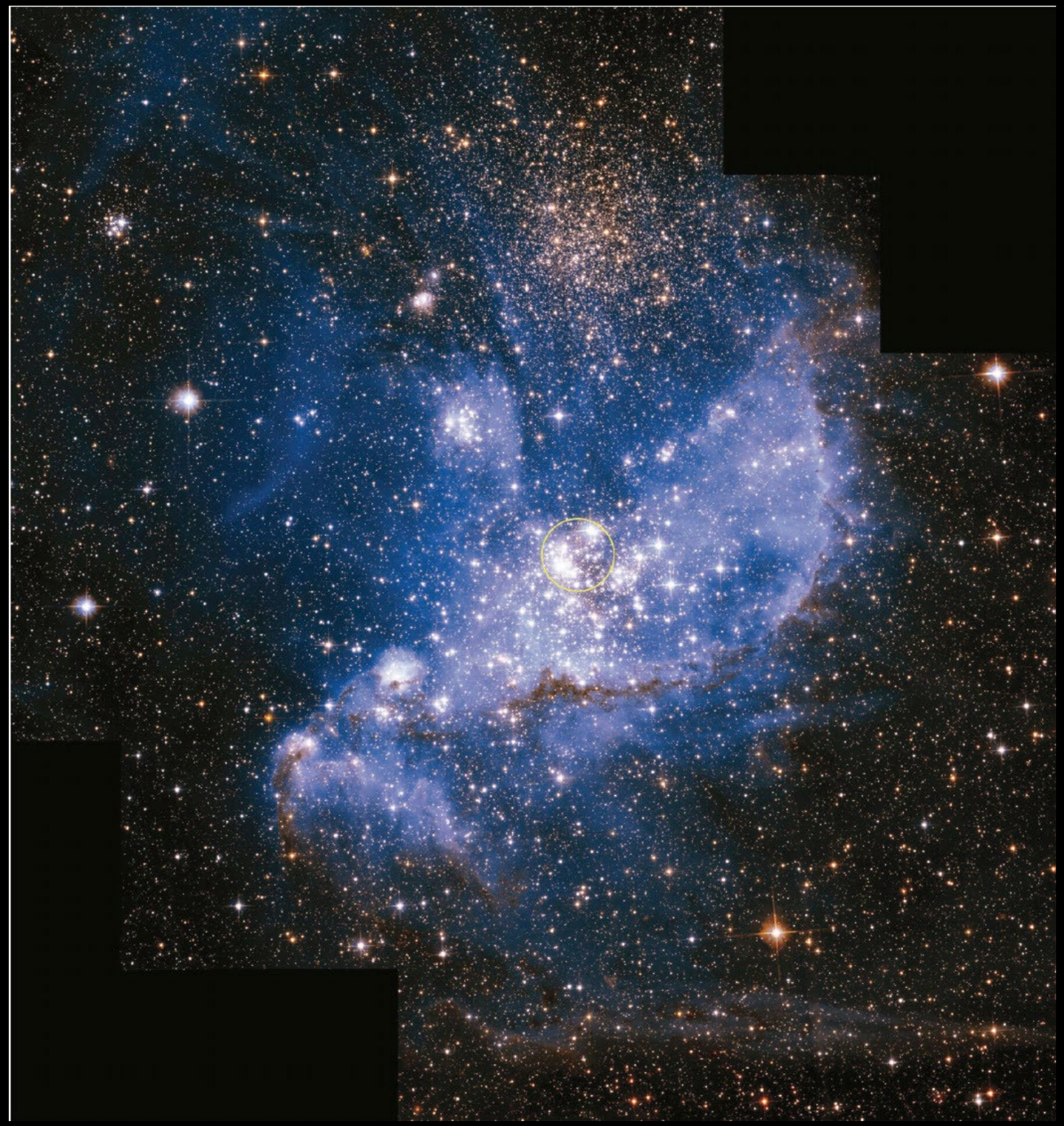
Small Magellanic Cloud

Less heavy elements than Milky Way



Credit: CTIO/NHNOIRLab/NSF/AURA/SMASH/D. Nidever

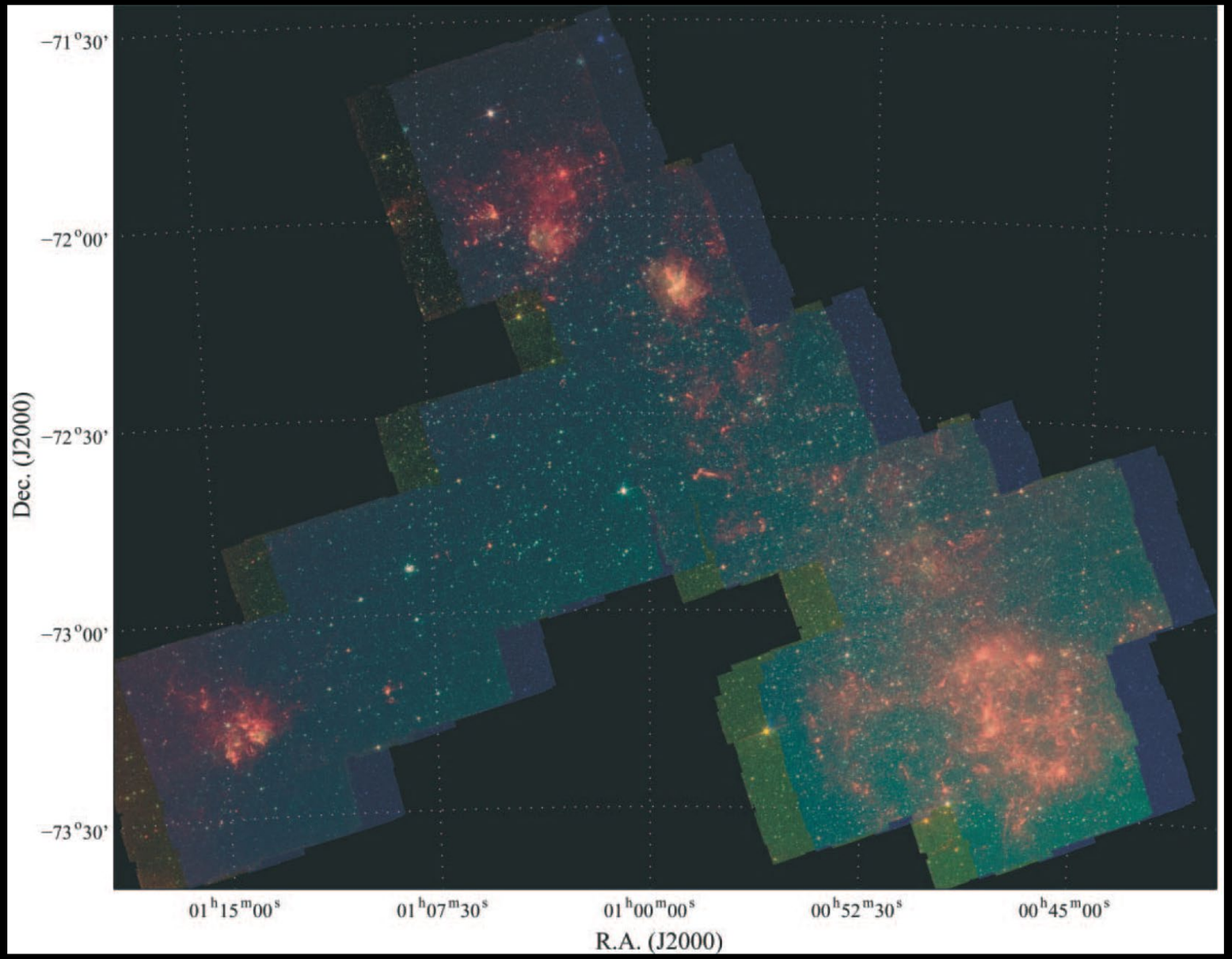
NGC 346 with Hubble Space Telescope



Credit: Nota et al. 2006

NGC 346 with Spitzer Space Telescope

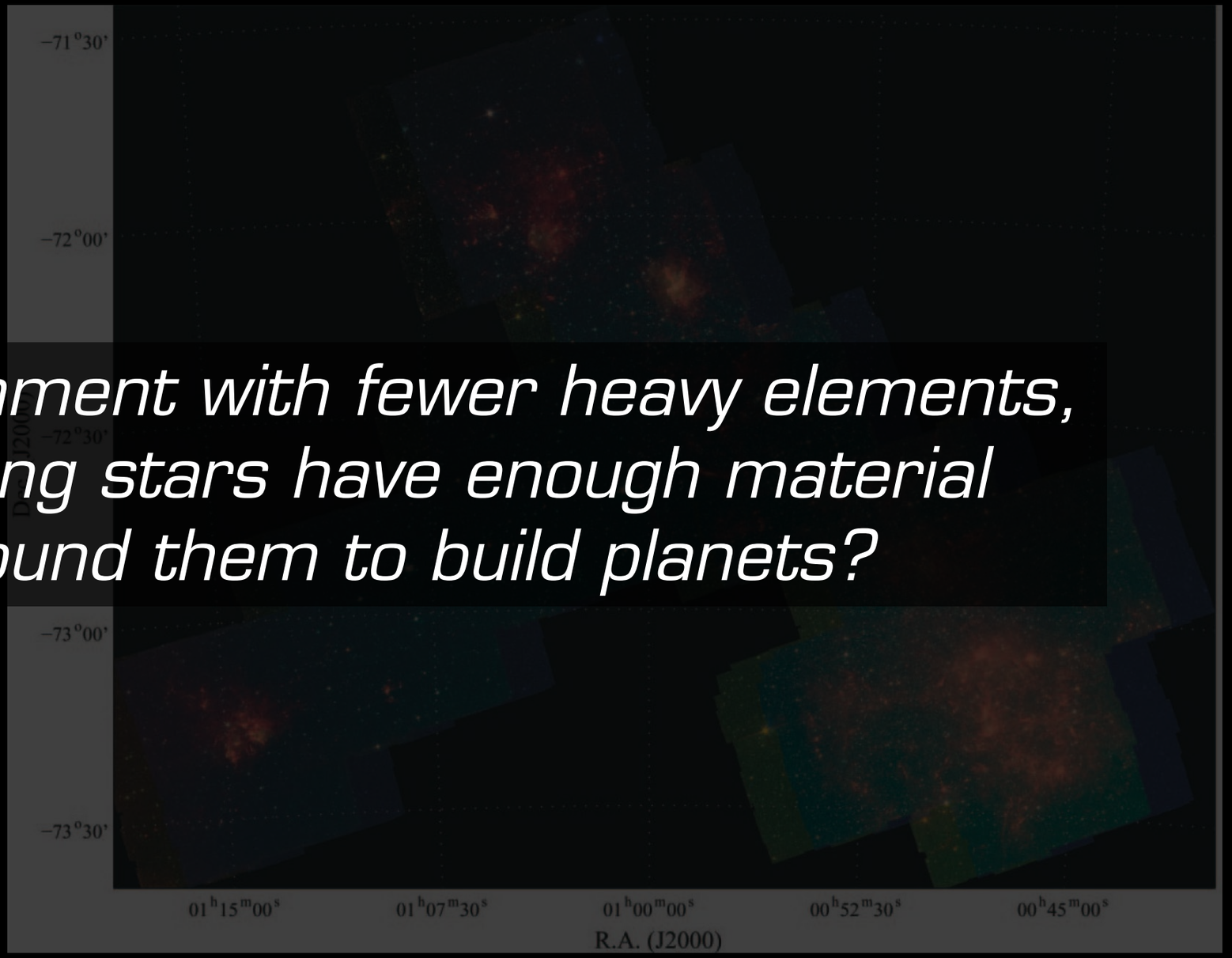
- ~100 high mass young stars



Credit: Bolatto et al. 2007

NGC 346 with Spitzer Space Telescope

- ~100 high mass young stars



In environment with fewer heavy elements, do young stars have enough material around them to build planets?

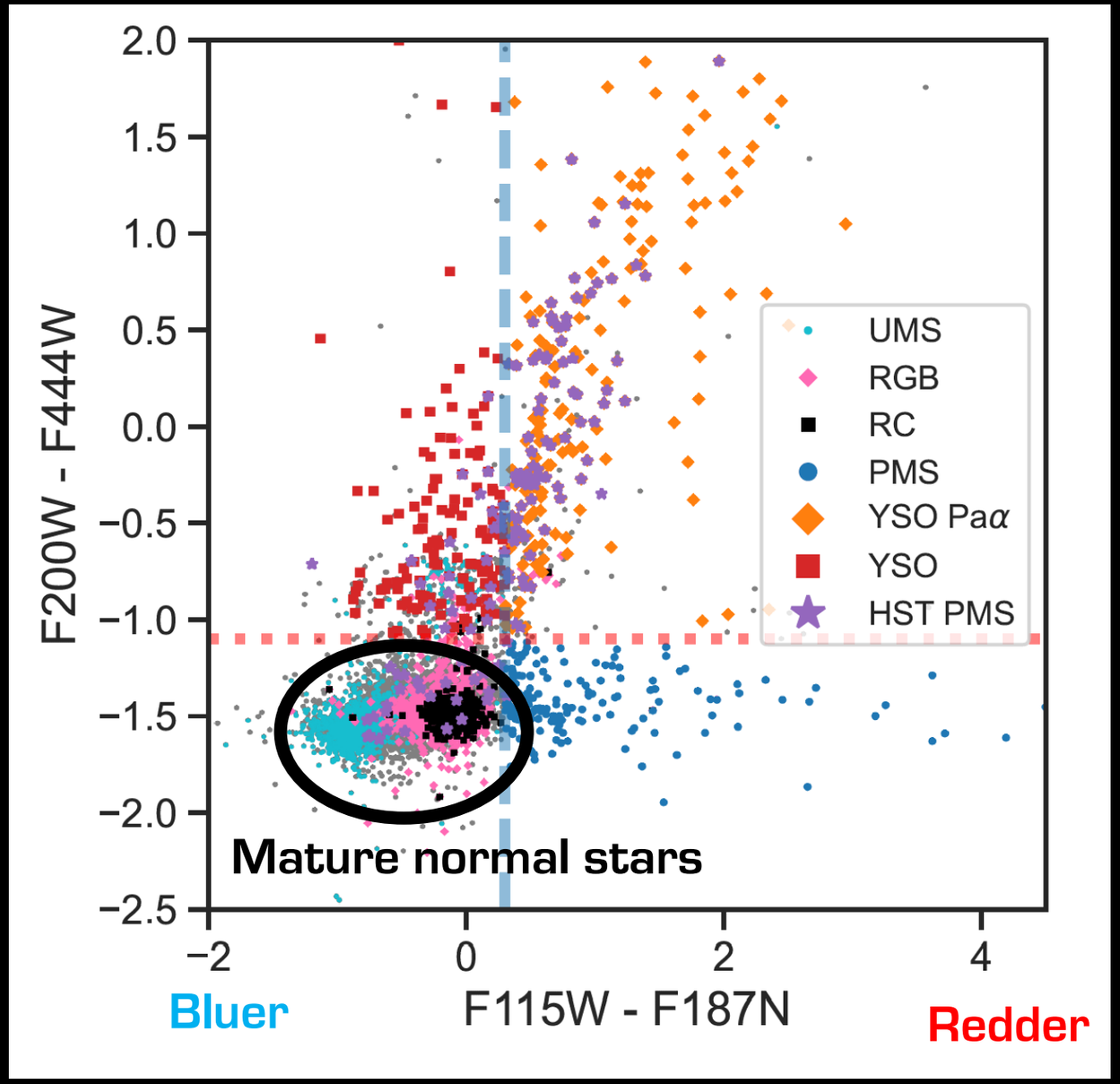
Credit: Bolatto et al. 2007

NGC 346

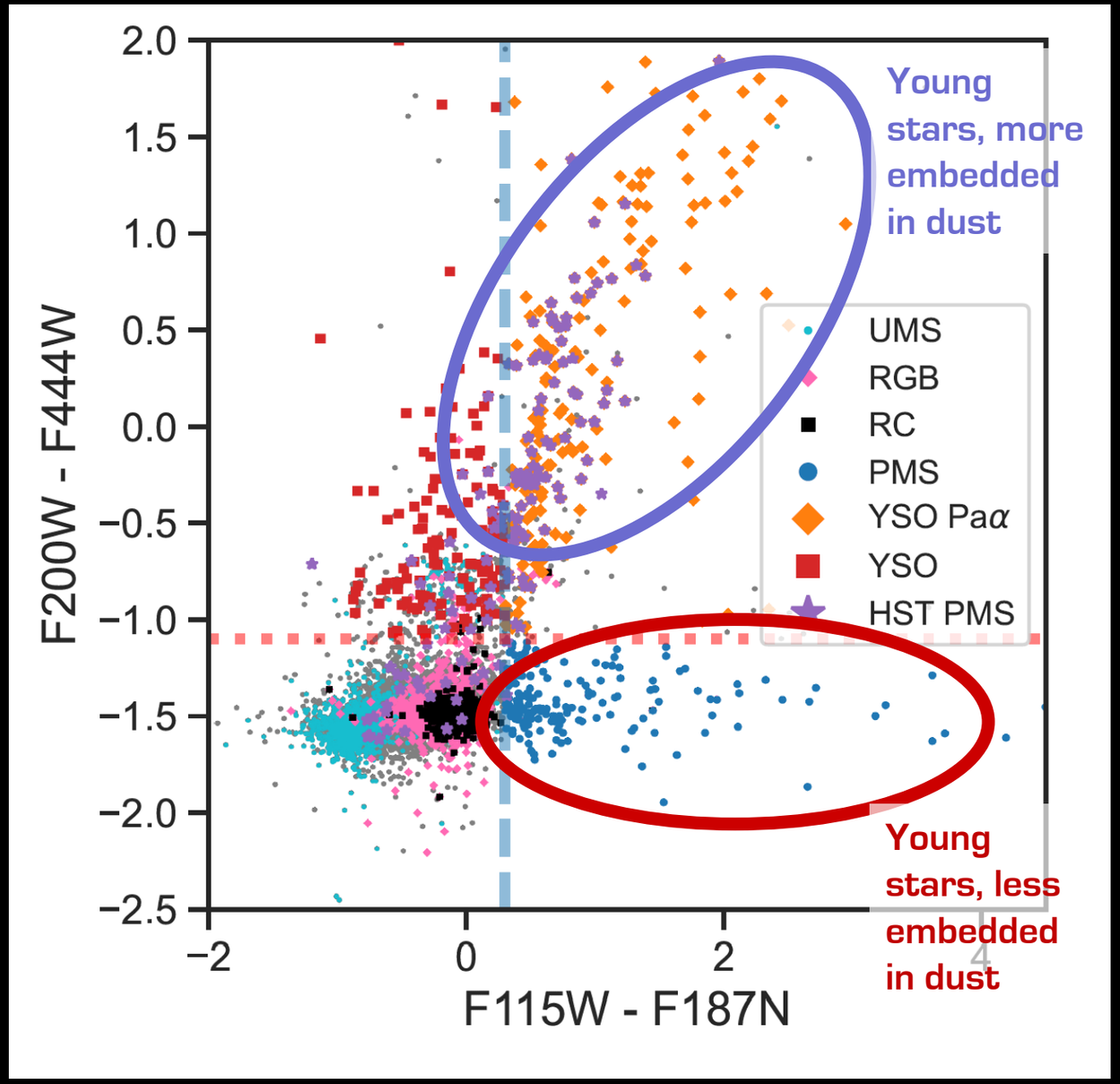
Credit: NASA/ESA/CSA/O Jones, G. De Marchi, & M. Meixner

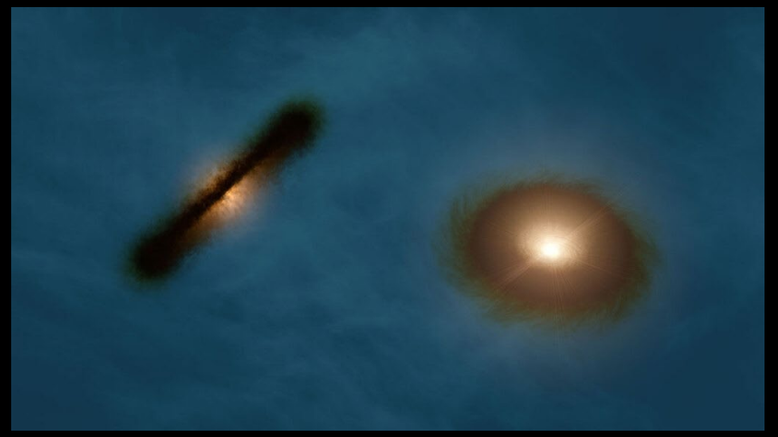
Redder

Bluer

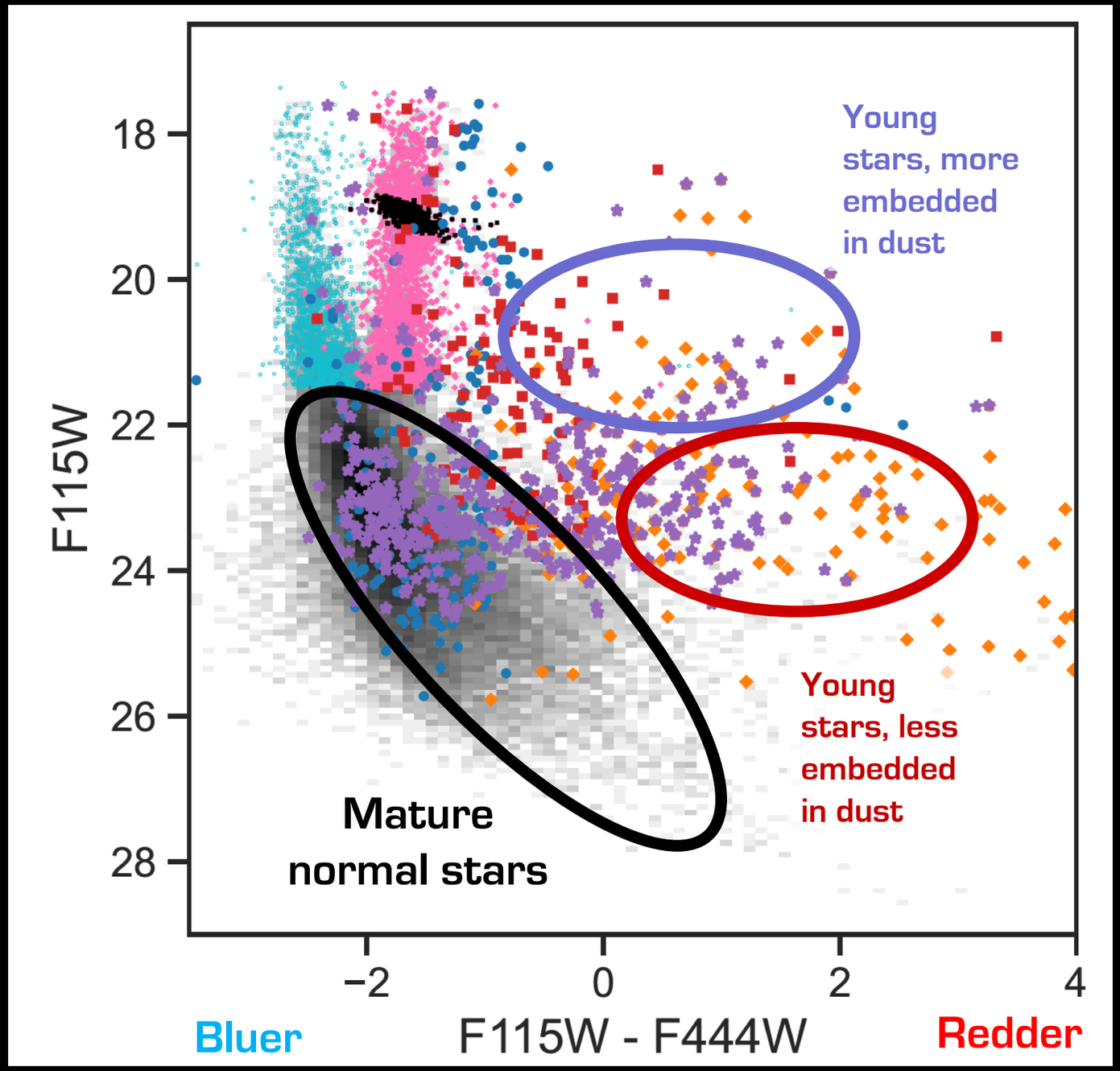


redit: Jones et al. 2023





Credit: Jones et al. 2023



Credit: Jones et al. 2023

NGC 346

Credit: STScI / NASA

NGC 346

- *“Excess” emission in near-infrared found for young stars*
- *Dusty disks around these stars!*
- *Possible for these stars to form planets even with fewer heavy elements*

Credit: STScI / NASA

Credit: STScI

Credit: STScI

Credit: STScI

Credit: STScI

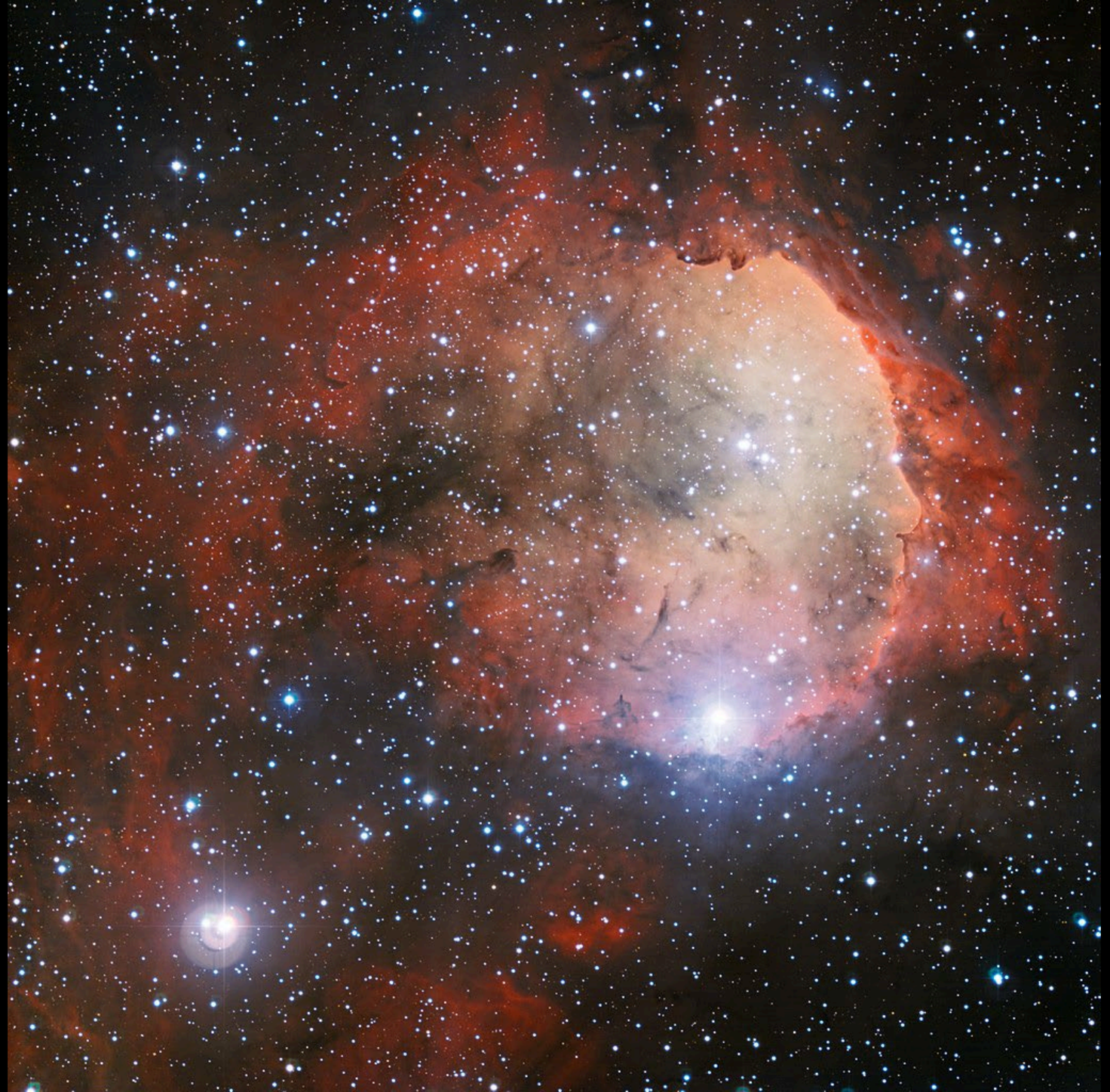
Credit: STScI

Credit: STScI

Carina Nebula

Credit: STScI

NGC 3324

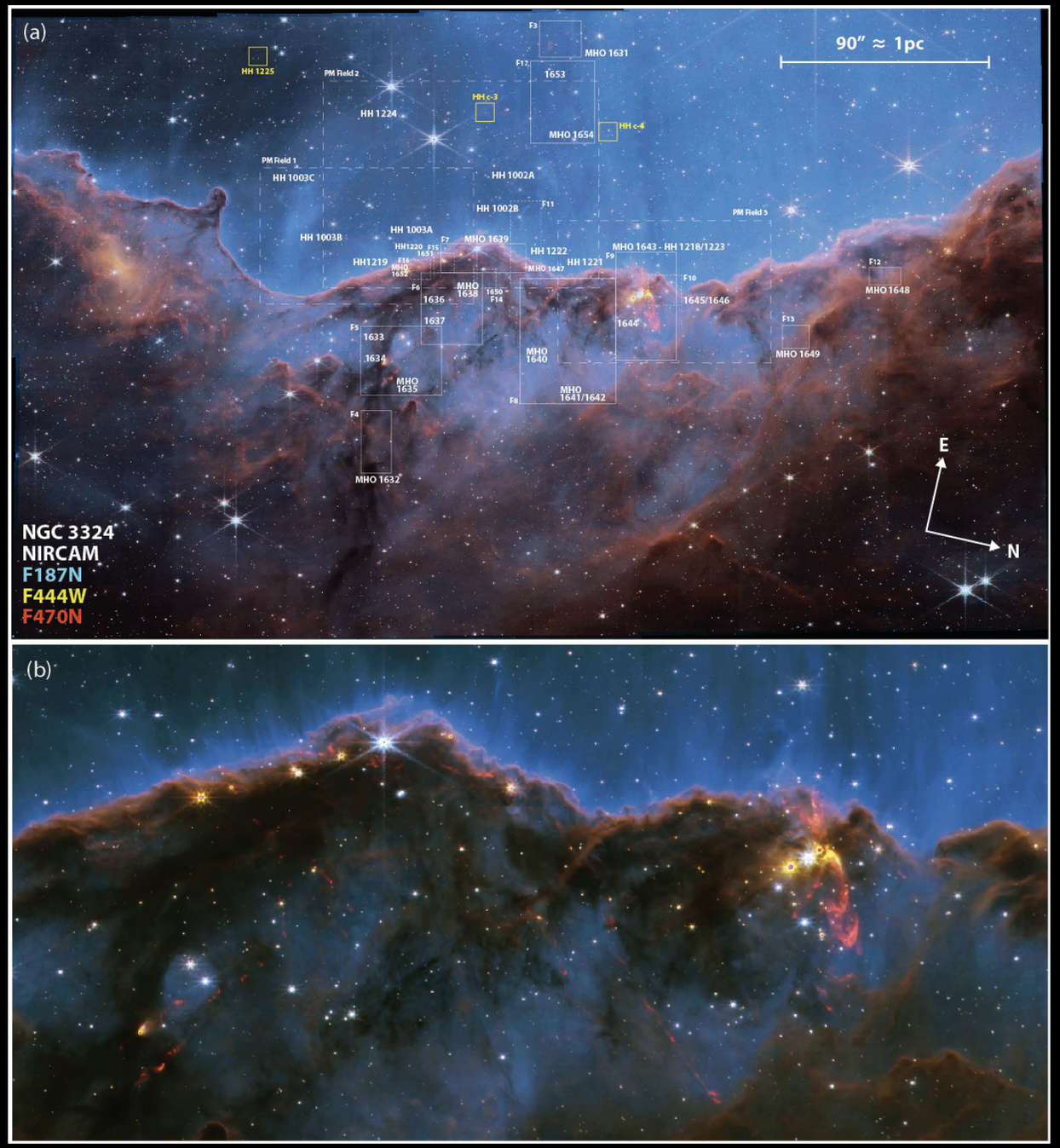


Credit: STScI

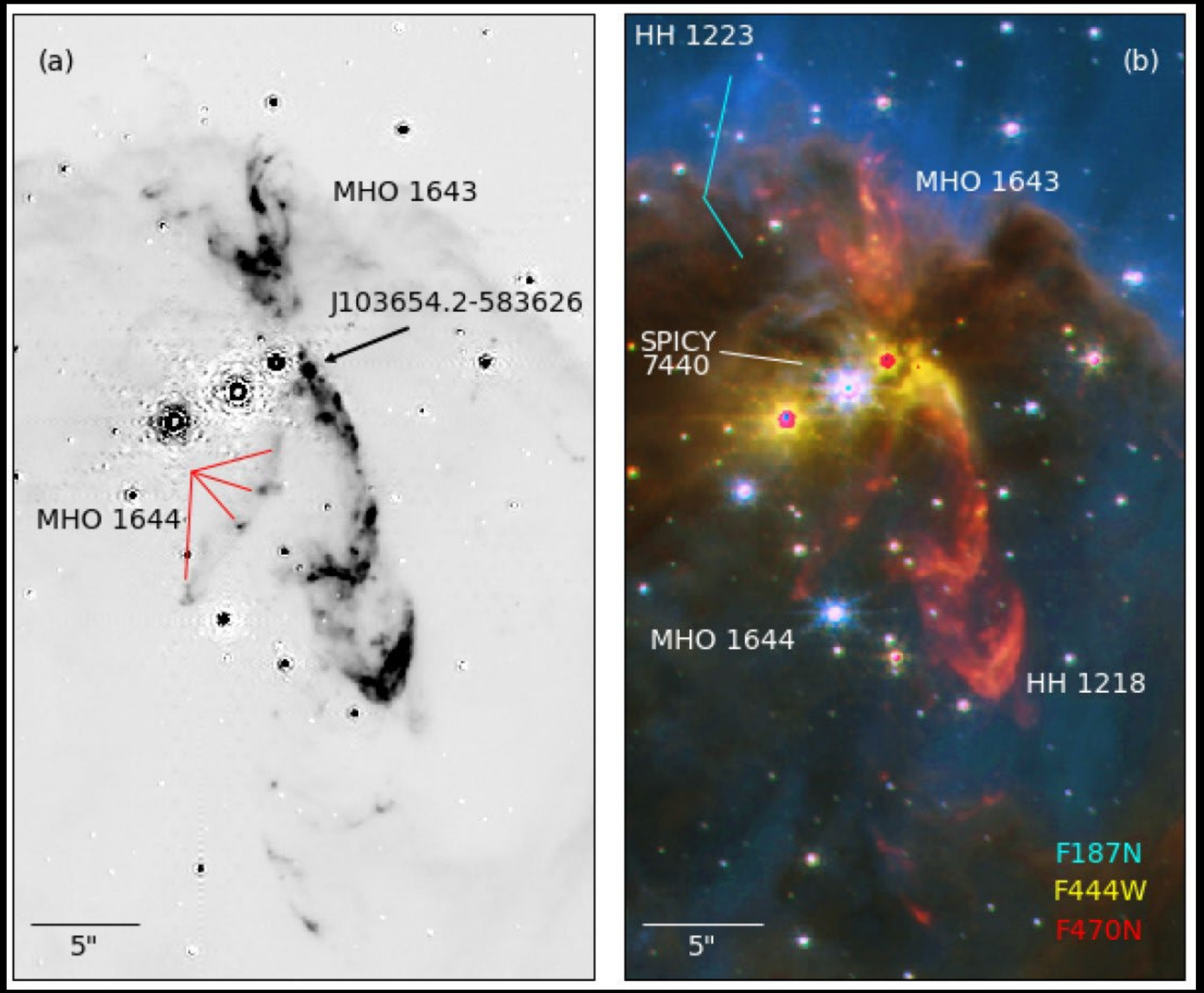
NGC 3324

Credit: STScI

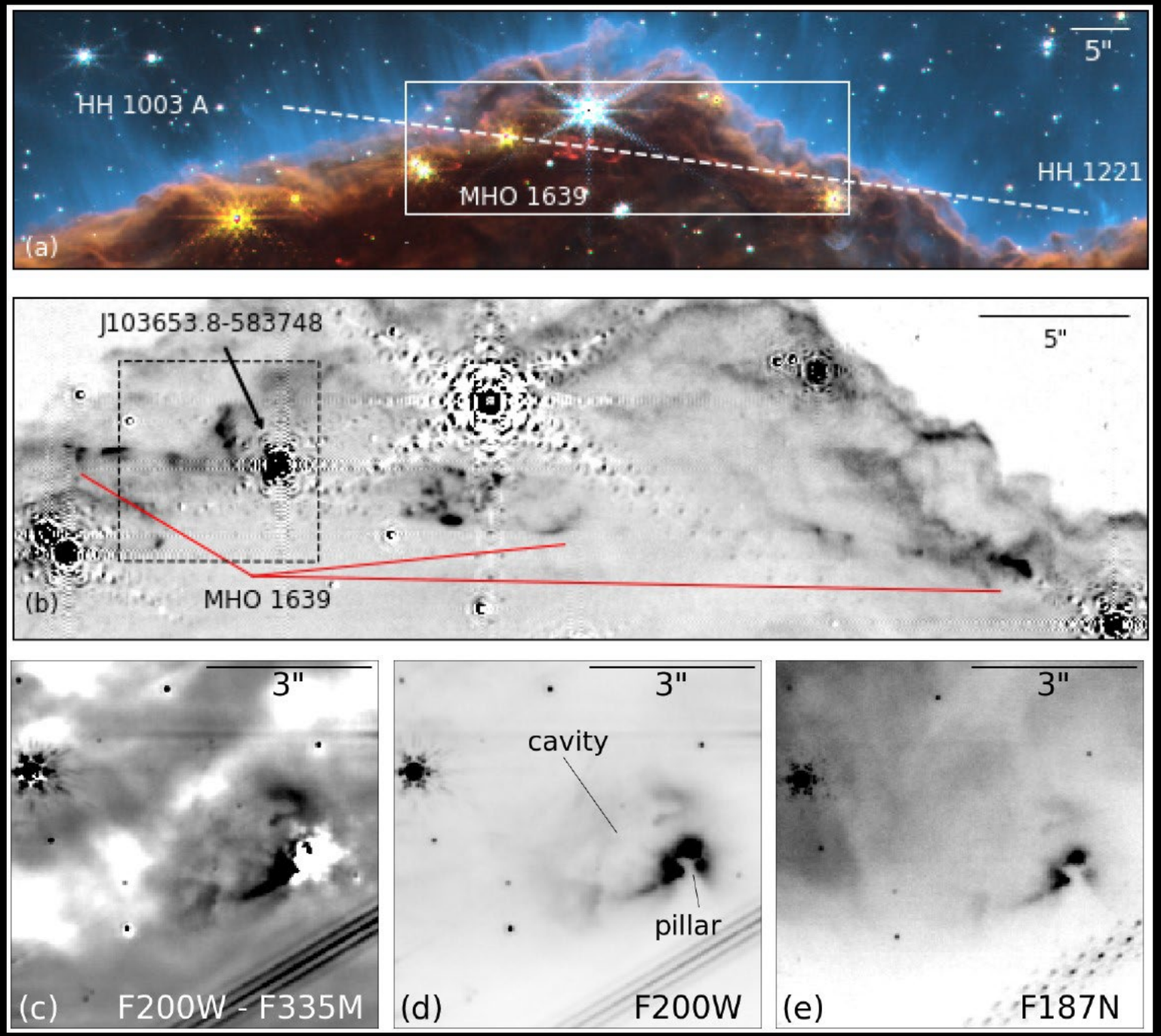
Credit: STScI



Credit: Reiter et al. 2022

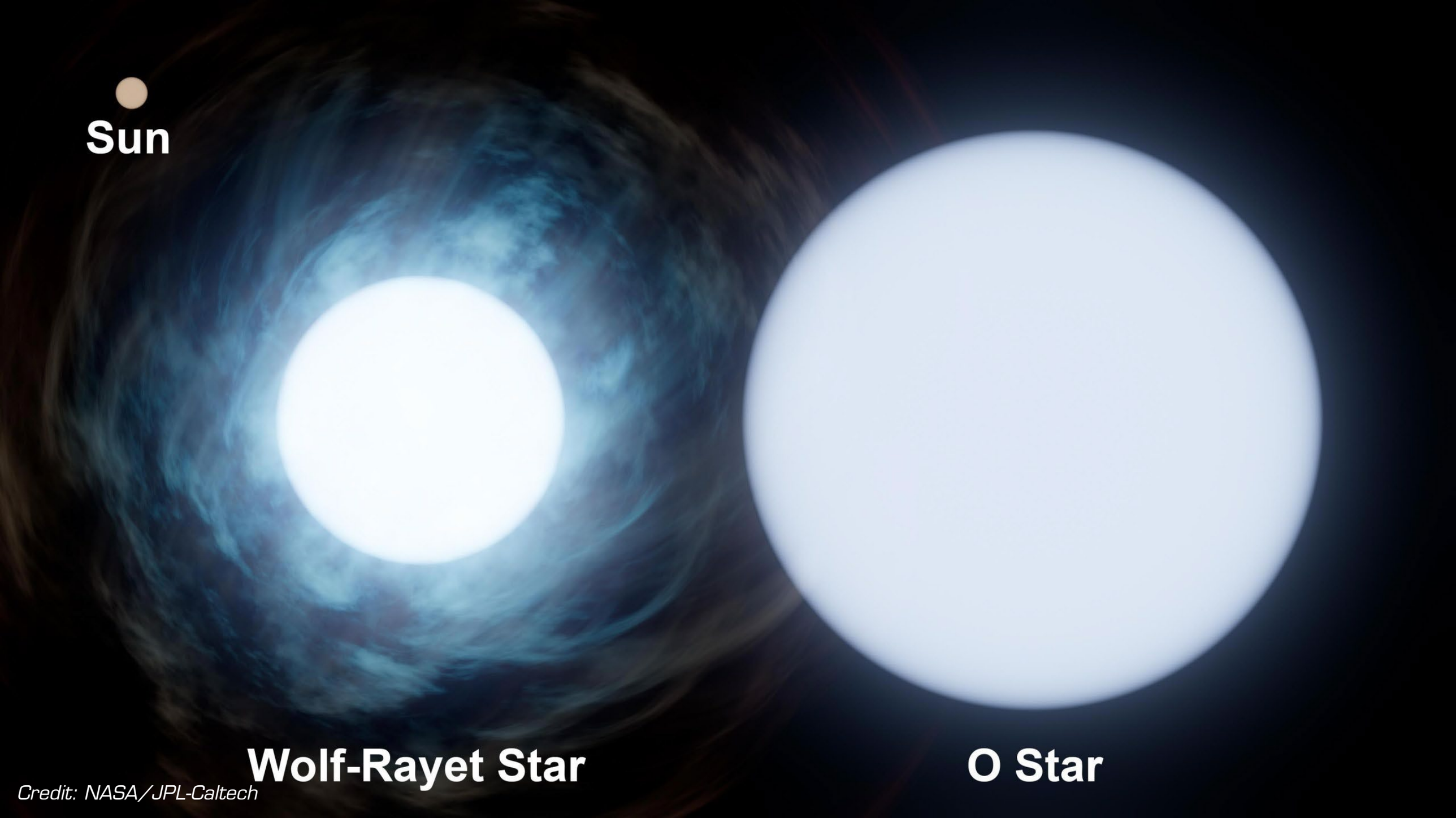


Credit: Reiter et al. 2022



Credit: Reiter et al. 2022


WR 140
Credit: NASA/ESA/CSA/STScI/JPL-Caltech



Credit: NASA/JPL-Caltech

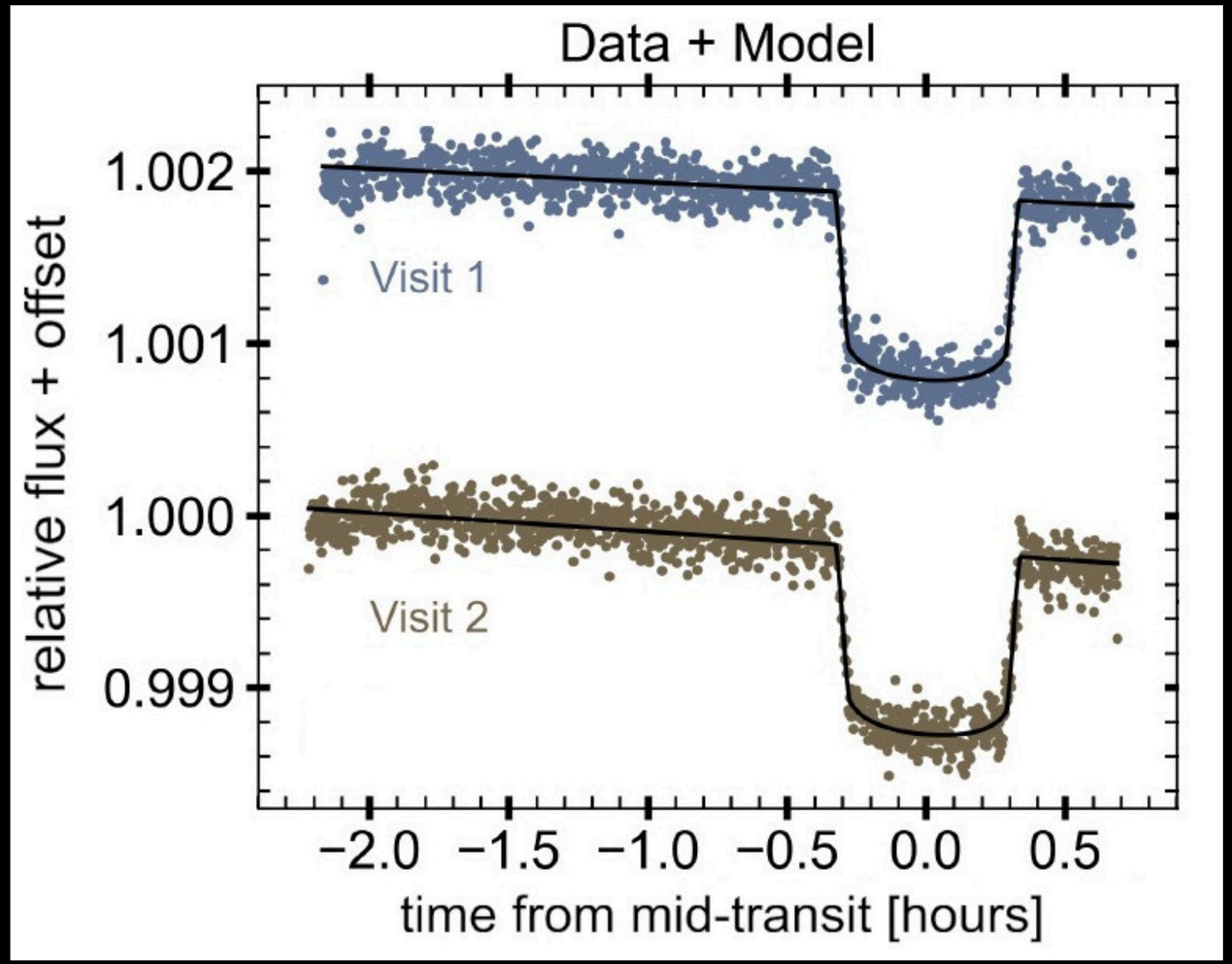
Transit Method for Discovering Exoplanets

Transiting planet LHS 475b (40 light years away)

A JWST transmission spectrum of a nearby Earth-sized exoplanet

Jacob Lustig-Yaeger[1*], Guangwei Fu[2*], E. M. May[1], Kevin N. Ortiz Ceballos[3], Sarah E. Moran[4], Sarah Peacock[5,6], Kevin B. Stevenson[1], Mercedes López-Morales[3], Ryan J. MacDonald[7,8], L. C. Mayorga[1], David K. Sing[2,9], Kristin S. Sotzen[1], Jeff A. Valenti[10], Jea Adams[3], Munazza K. Alam, Natasha E. Batalha[12], Katherine A. Bennett[9], Junellie Gonzalez-Quiles[9], James Kirk[13], Ethan Kruse[5,6], Joshua D. Lothringer[14], Zafar Rustamkulov[9] and Hannah R. Wakeford[15]

Credit: NASA/ESA/CSA

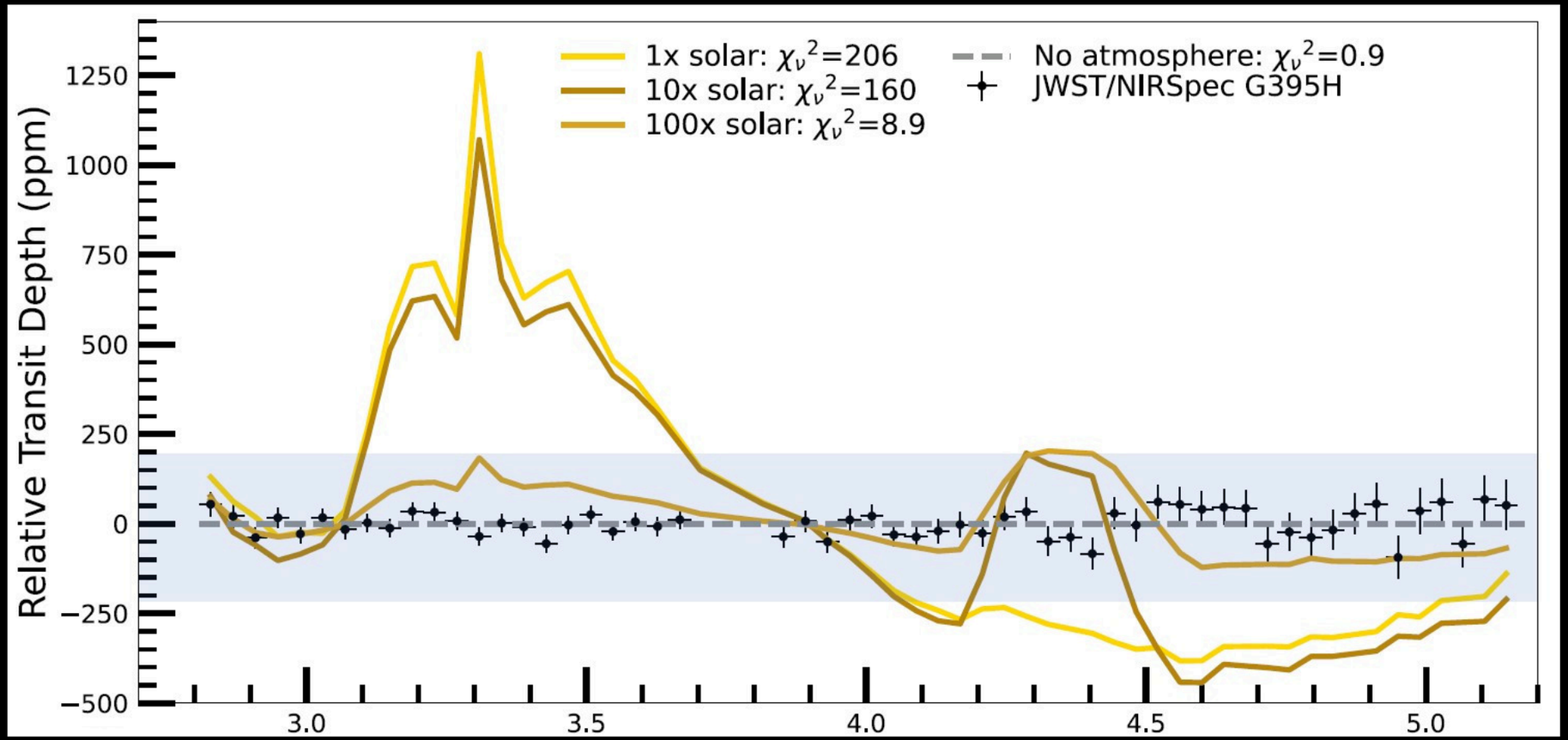


- *Orbital Period: 2.029 days*
- *Radius: 0.99 × Earth radius = 6319 km*
- *Mass = 0.914 × Earth mass*

Credit: Lustig-Yaeger et al. 2023

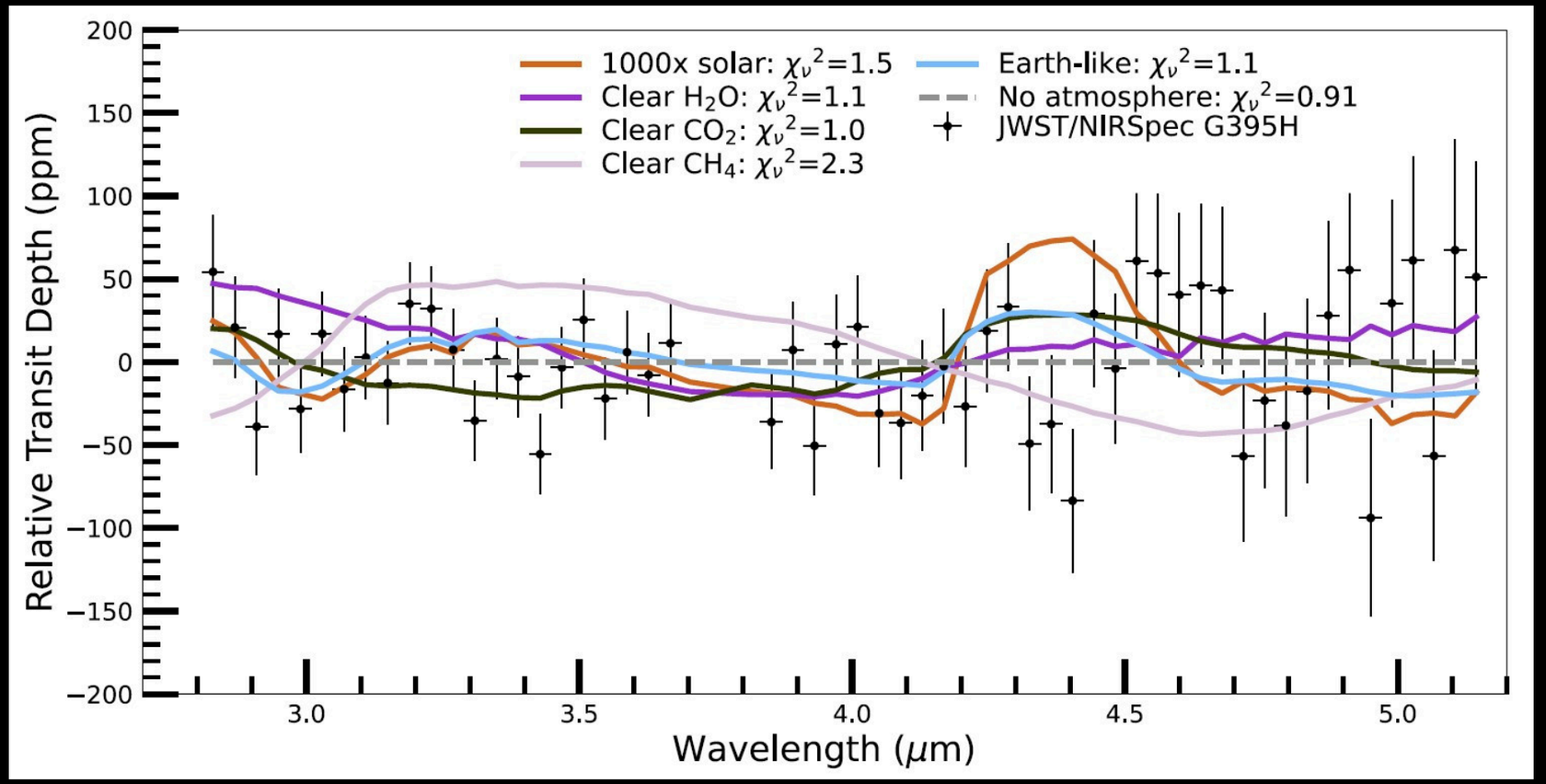
- *Orbital Period: 2.029 days*
- *Radius: 0.99 × Earth radius = 6319 km*
- *Mass = 0.914 × Earth mass*
- *Surface temp = 3000 C°*

Credit: NASA/DeepAI Fantasy World Generator



- **Not a hydrogen (Jupiter-like) atmosphere**

Credit: Lustig-Yaeger et al. 2023

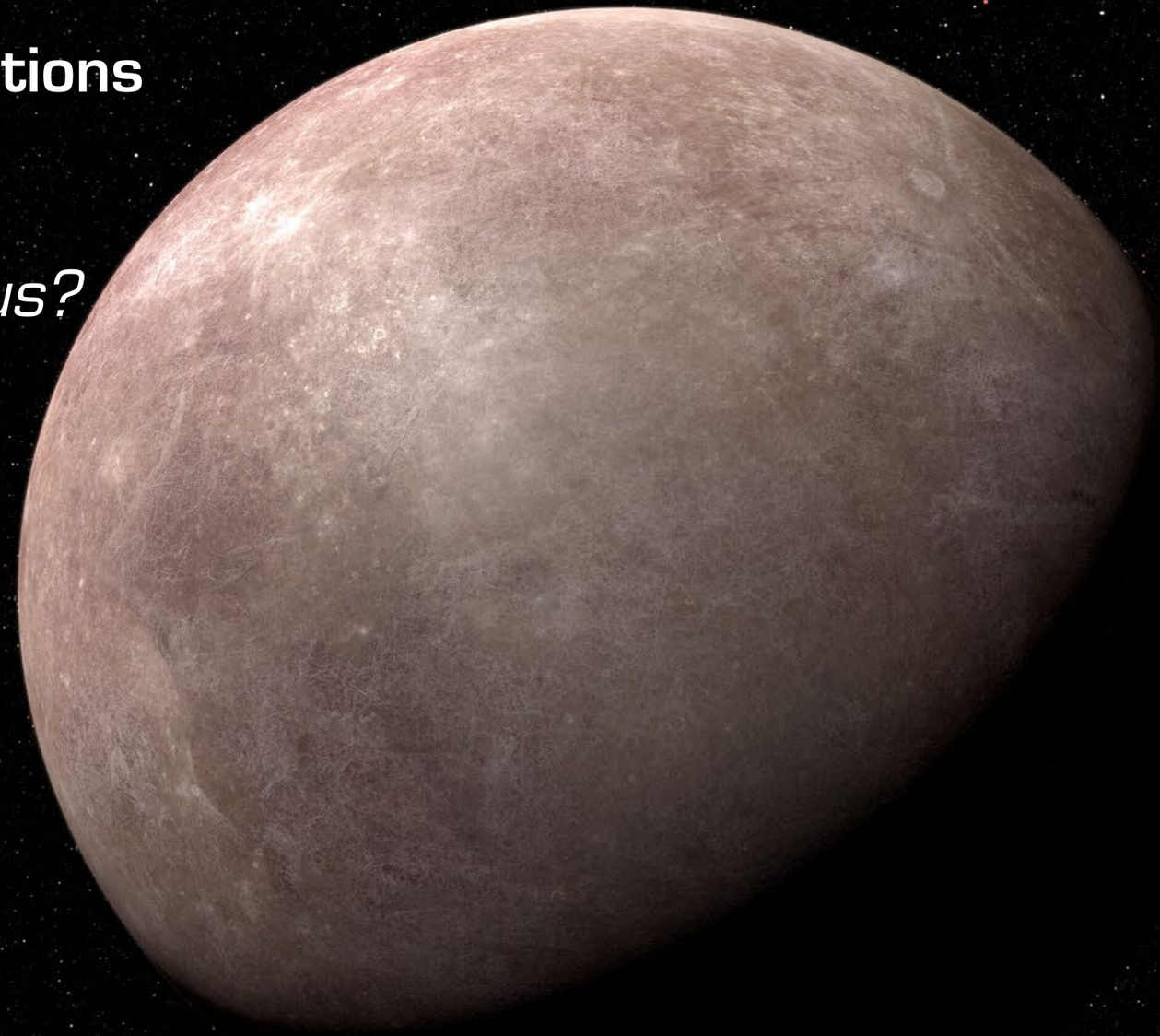


- Not a methane atmosphere
- Not Earth-like
- Not likely steam atmosphere
- Possibly carbon dioxide
- Possibly no atmosphere

Credit: Lustig-Yaeger et al. 2023

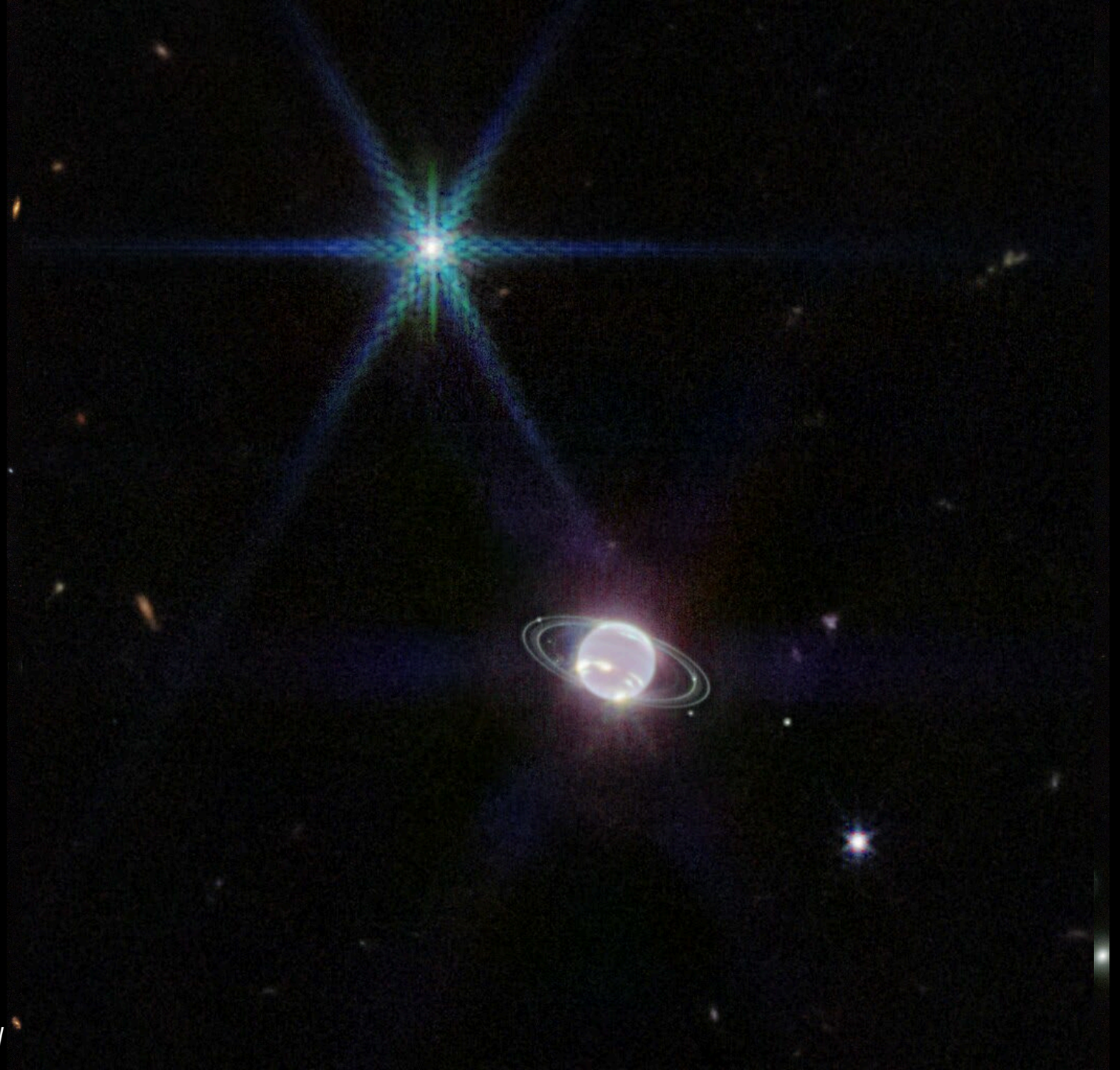
Possible explanations for observations

- *Compact atmosphere*
- *Thin like Mars?*
- *Hazy/cloudy like Titan or Venus?*



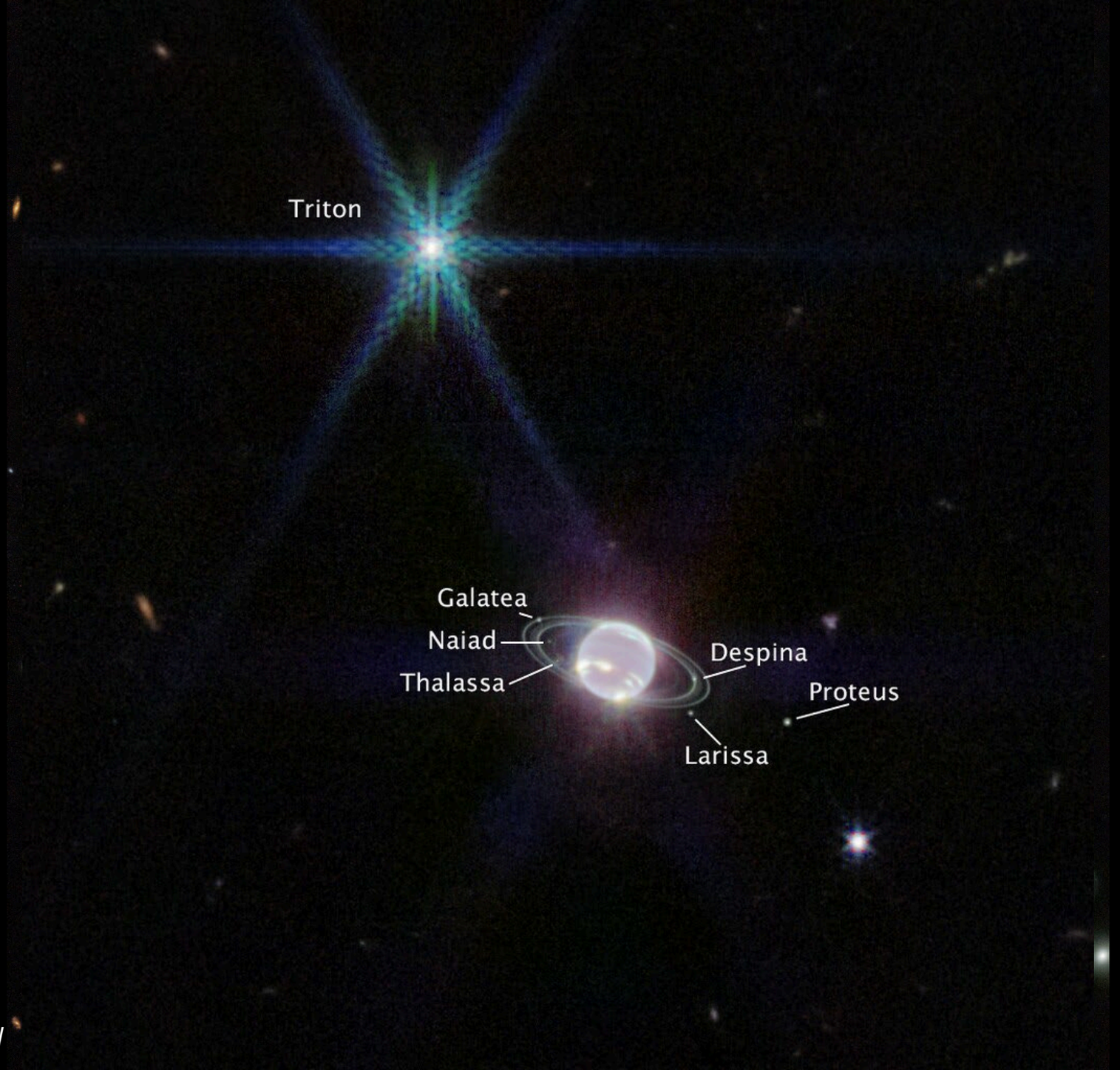
Credit: NASA/ESA/CSA

Neptune

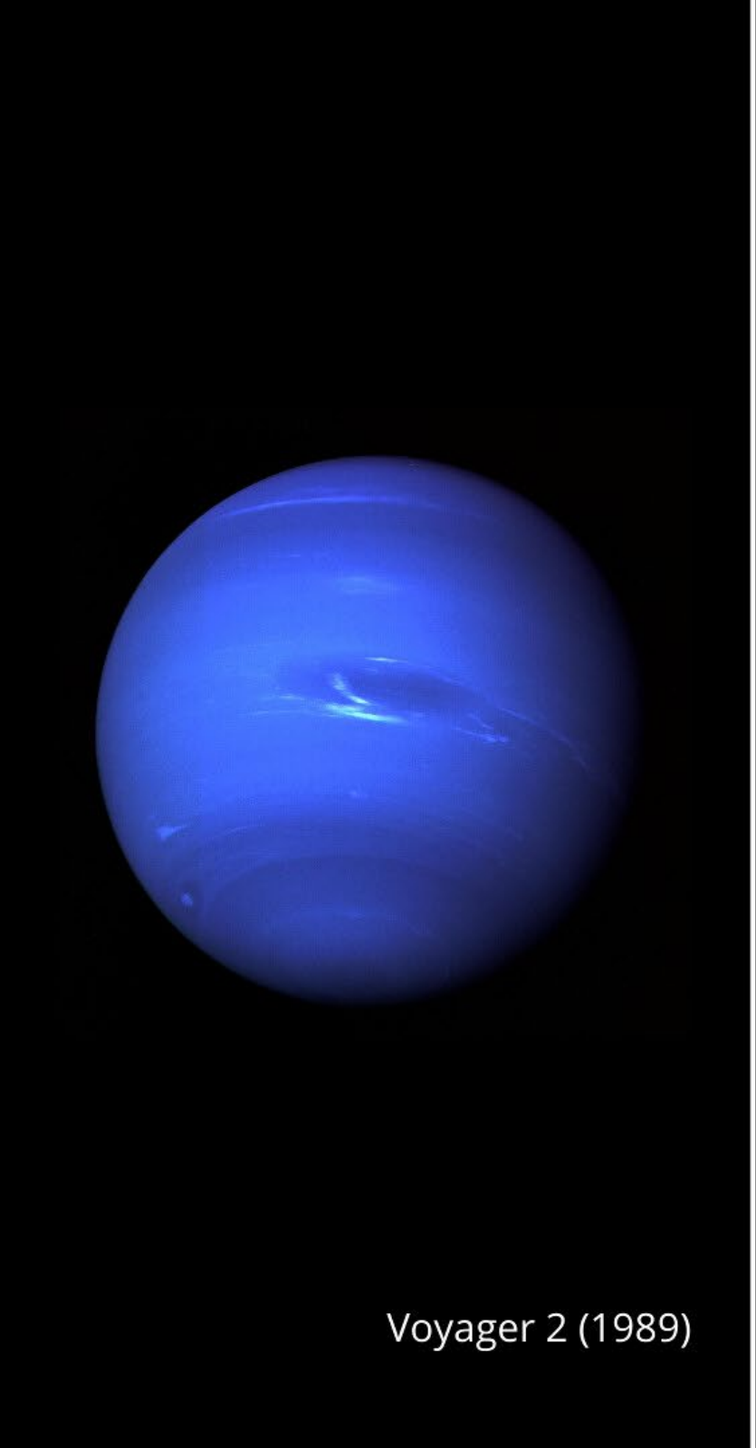


Credit: NASA/ESA/CSA/STScI

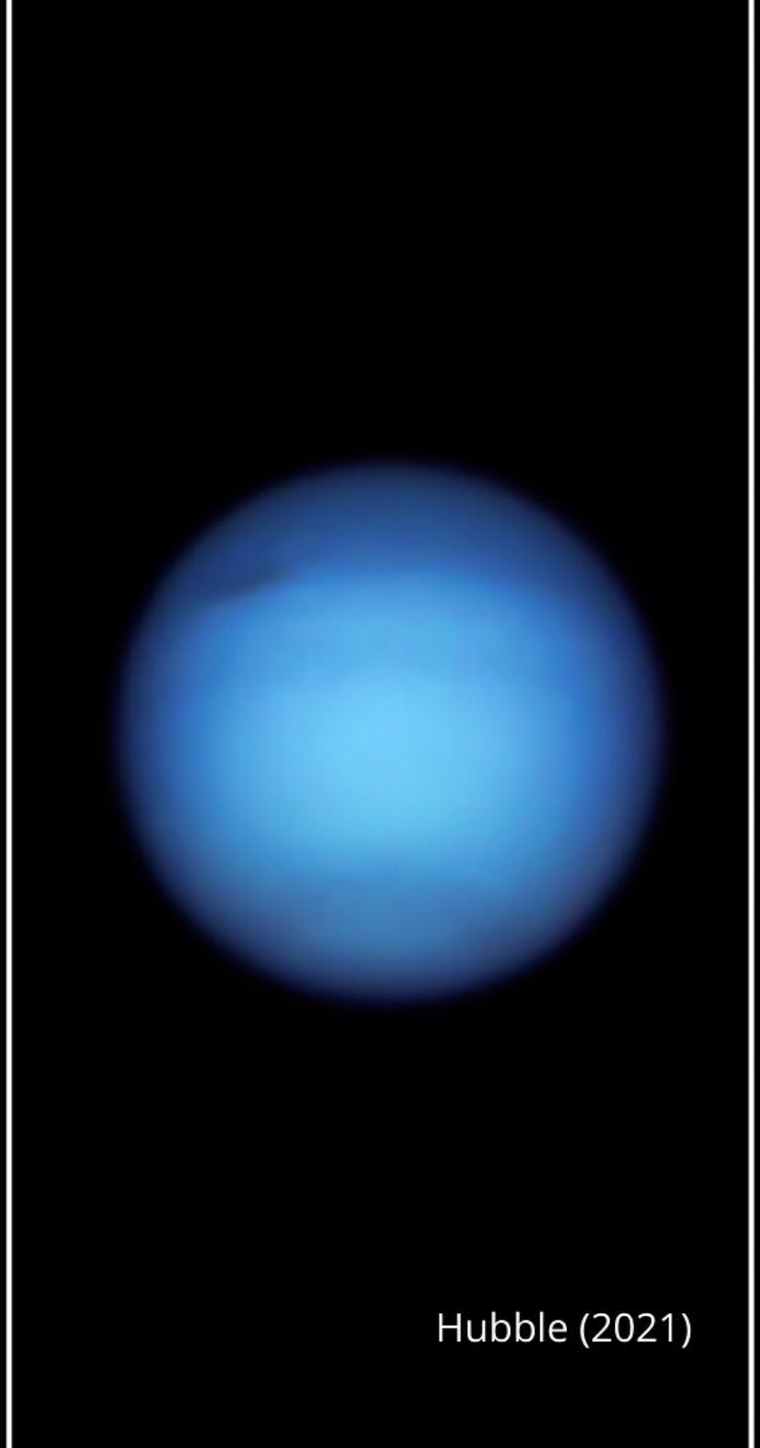
Neptune



Credit: NASA/ESA/CSA/STScI



Voyager 2 (1989)



Hubble (2021)

Webb (2022)