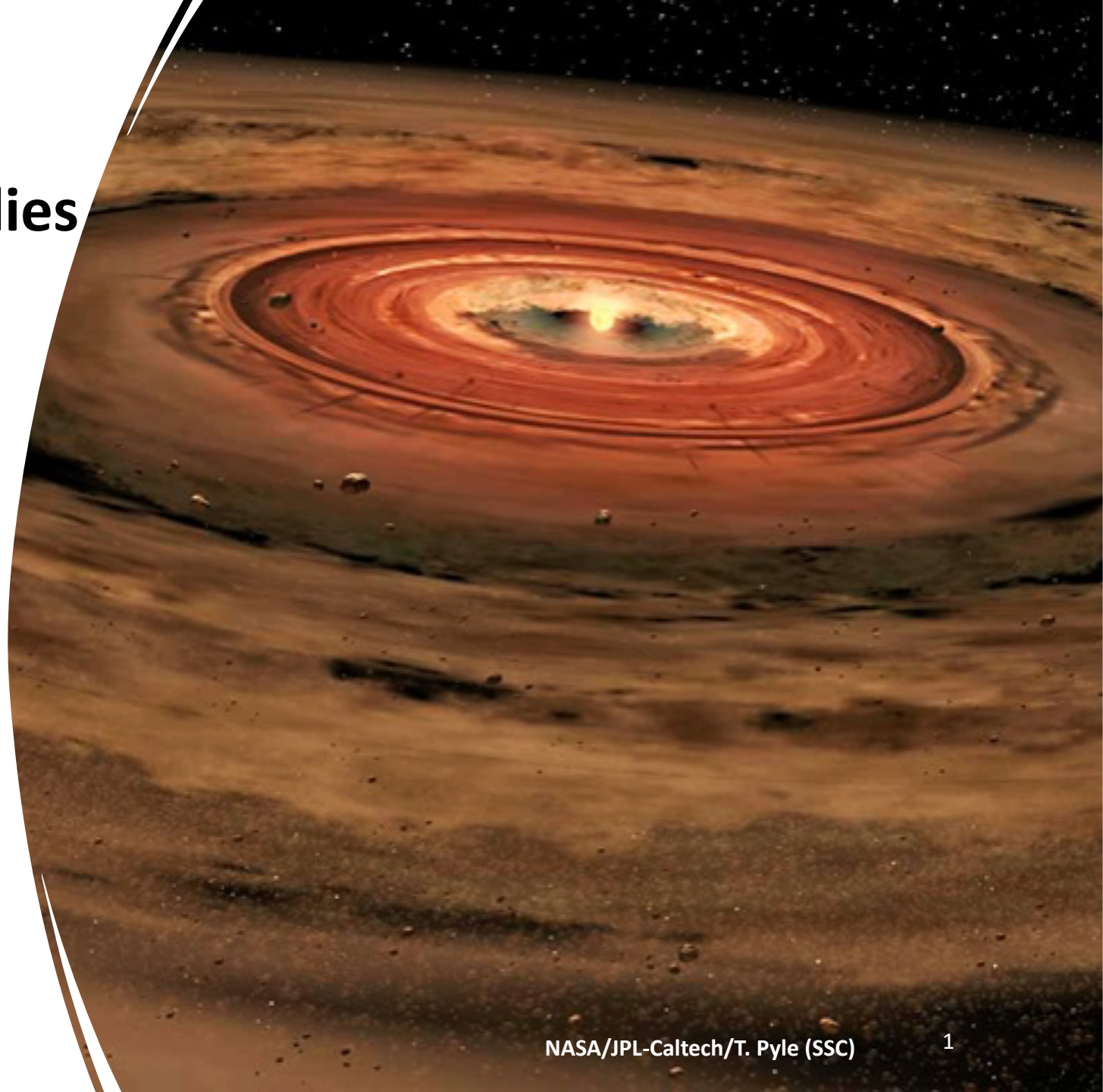


Star and planet formation studies with modern Telescopes

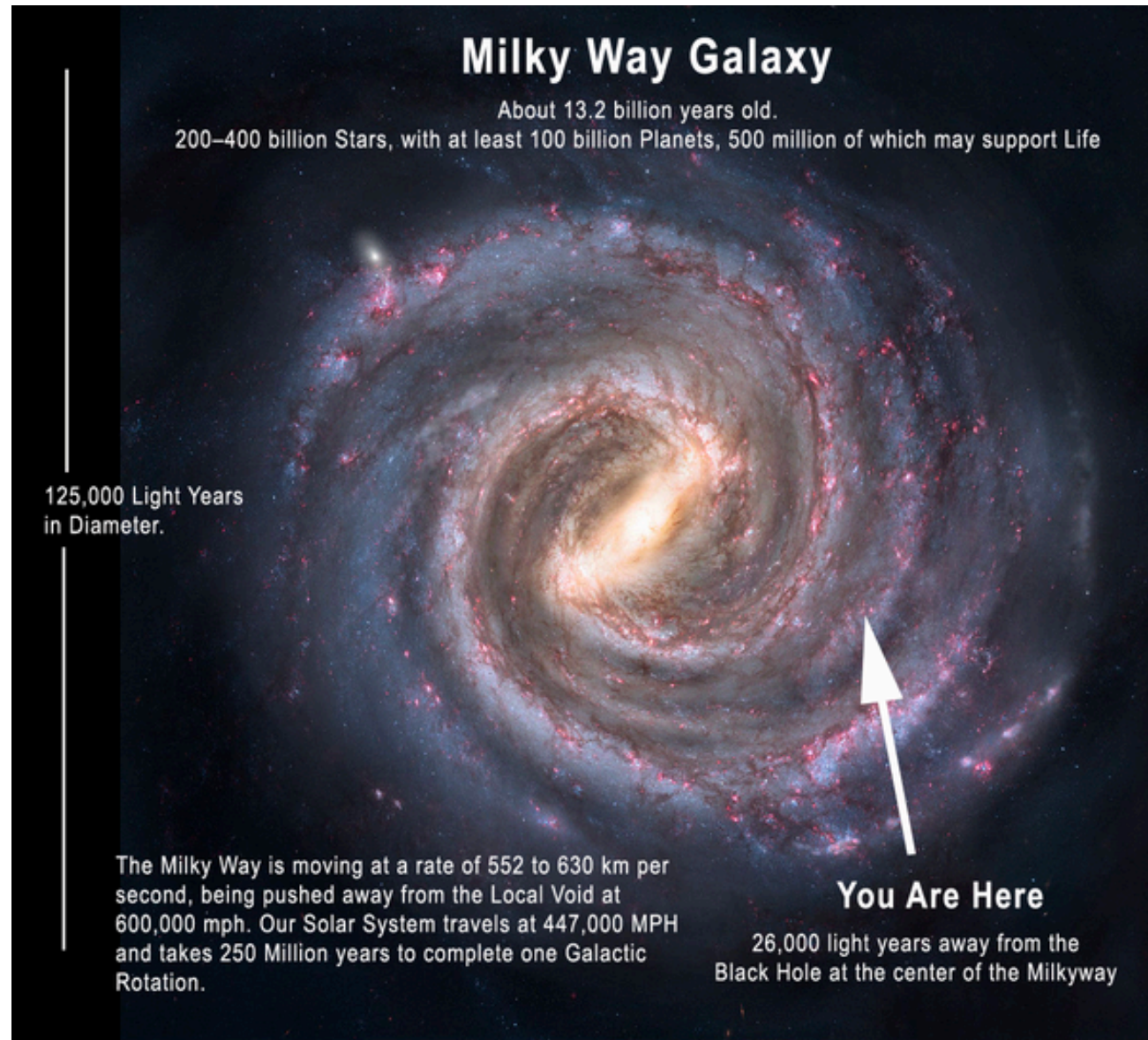
Jessy Jose
Associate Professor
IISER Tirupati



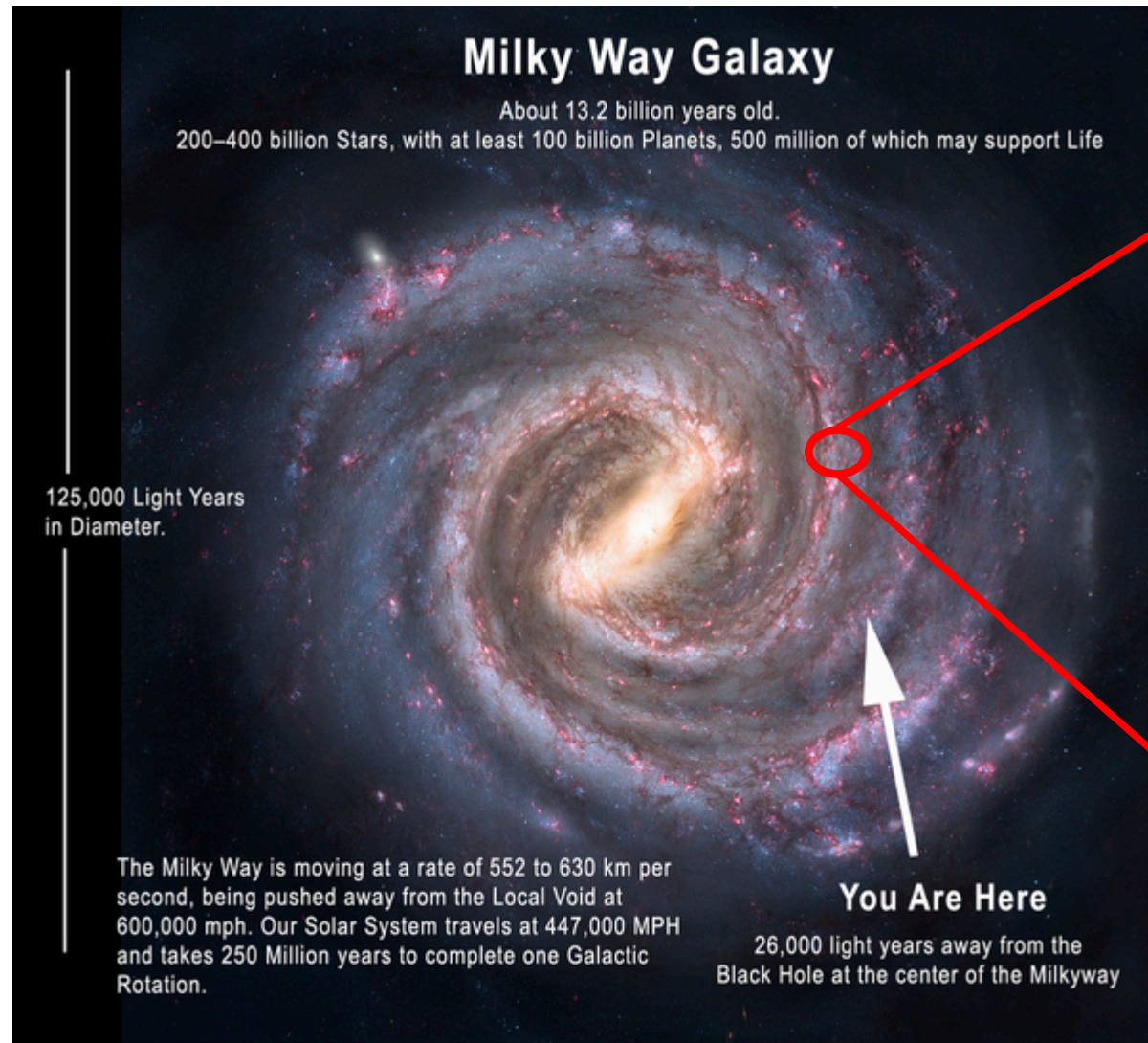
Twinkle Twinkle Little Star....Do you wonder what they are ???



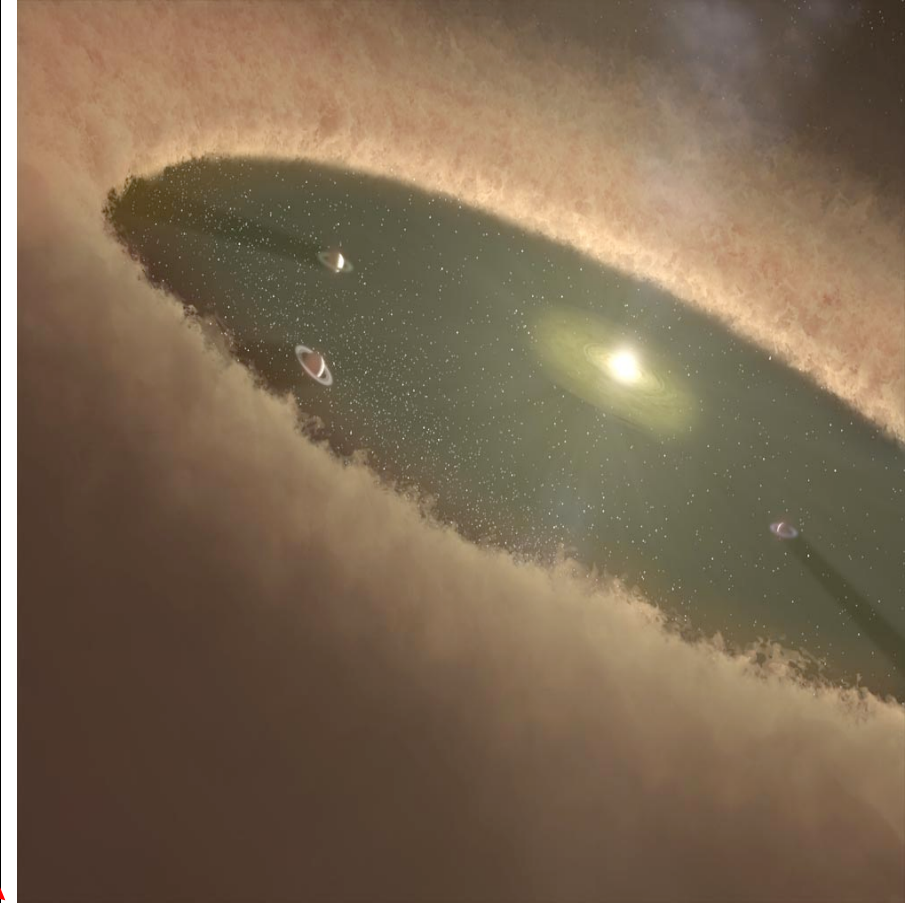
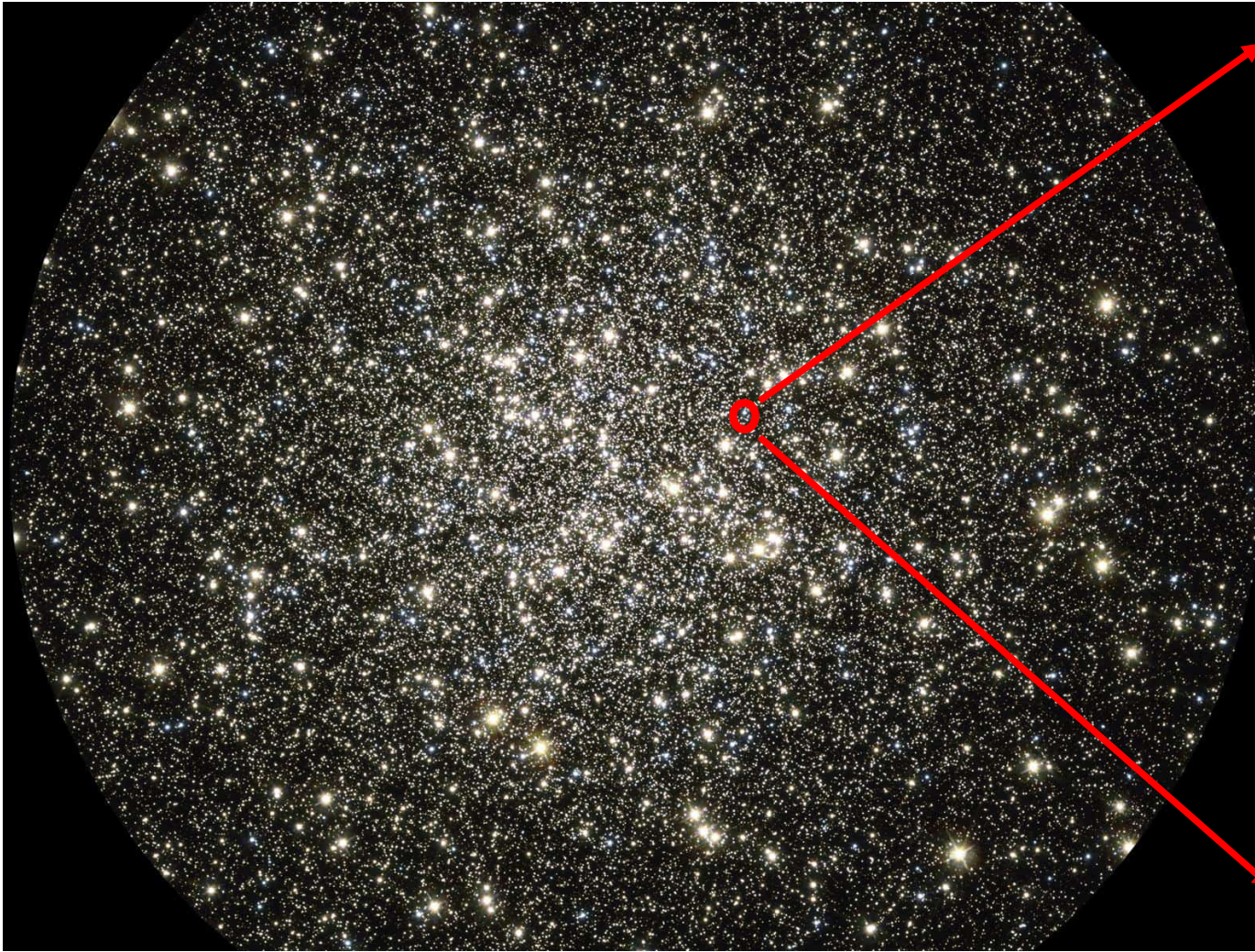
Milky Way : Our Galaxy



Milky Way : Our Galaxy contains ~ 200 billion stars



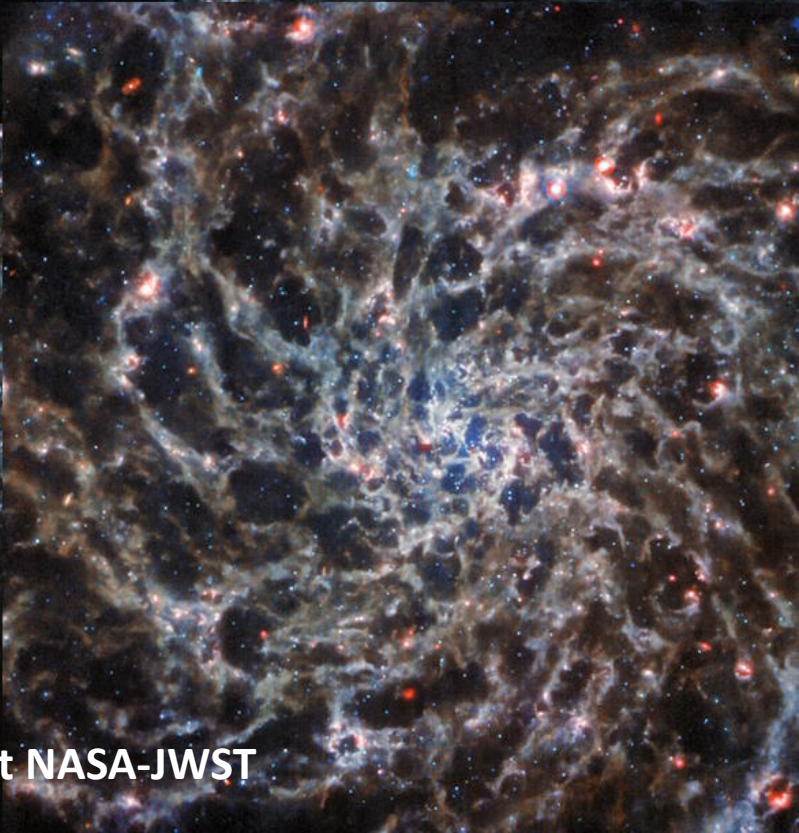
How many planets in the Universe?



Every other star has at least one planet around them



How many galaxies?



Credit NASA-JWST

~100 Billions of galaxies in the Universe



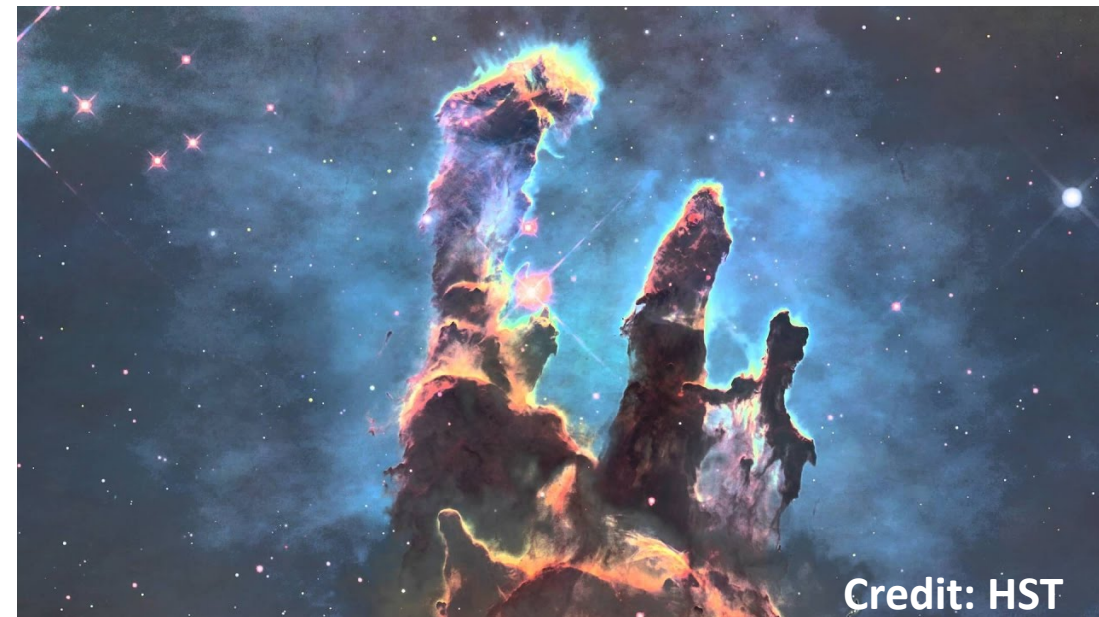
Image Courtesy :
NASA/ESA/CSA/STScI

How many planets?

Stars and planets – Where do they form and how?



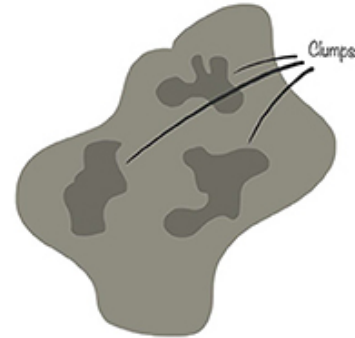
**Stars are formed at the densest interiors of interstellar medium
=> Molecular gas + dust**



Gravitational Instability => cloud fragmentation and collapse

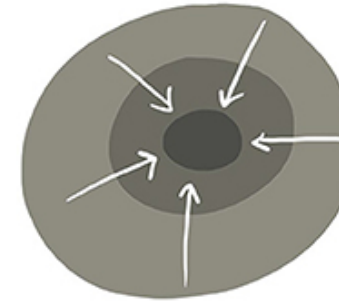


A Dark cloud



Size: 200,000 AU

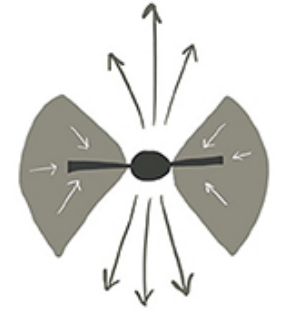
B Prestellar core



time = 0

Size: 10,000 AU

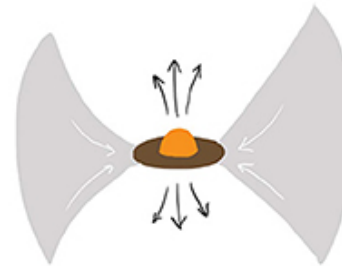
C Protostar



time = 10-100 thousand years

Size: 1,000 AU

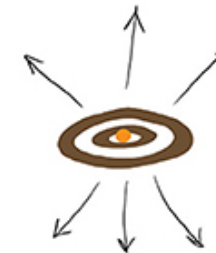
D T Tauri star



time = up to a million years

Size: 100 AU

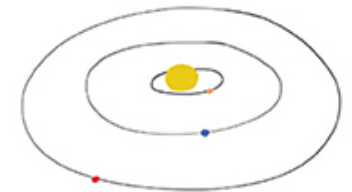
E Pre-main sequence star



time = up to 10 million years

Size: 100 AU

F Main sequence star



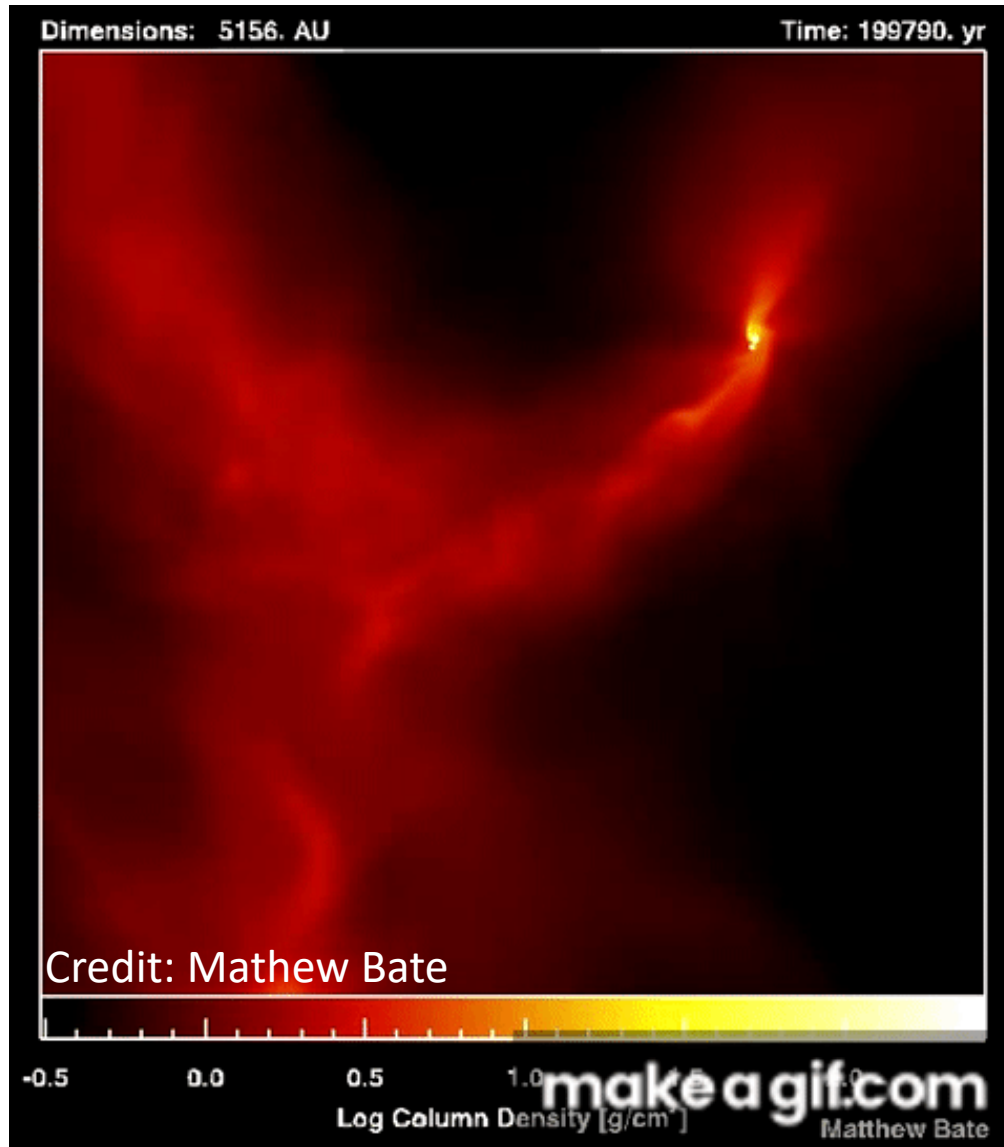
time = more than 10 million years

Size: 50 AU

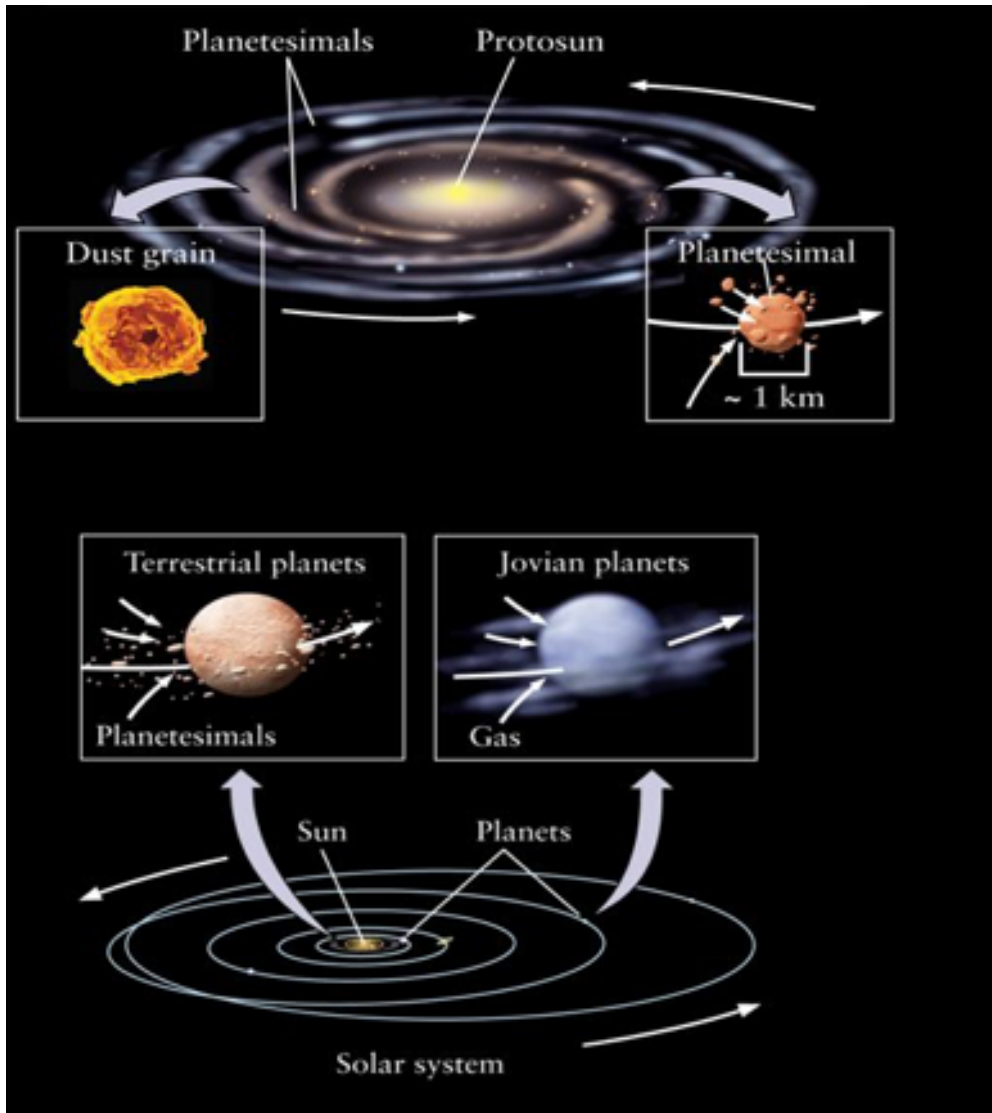
**Cloud fragmentation => Gravitational collapse of clumps=>
In fall of matter to the center => Disk formation => Star+Planets**

Credit: Christensen

Group of stars formed from a molecular cloud



Protoplanetary disk and planet formation around the protostars



- Small grains in disk collide & stick together
- Gravitationally attract particles
- Planetesimals consume dust and gas from disk

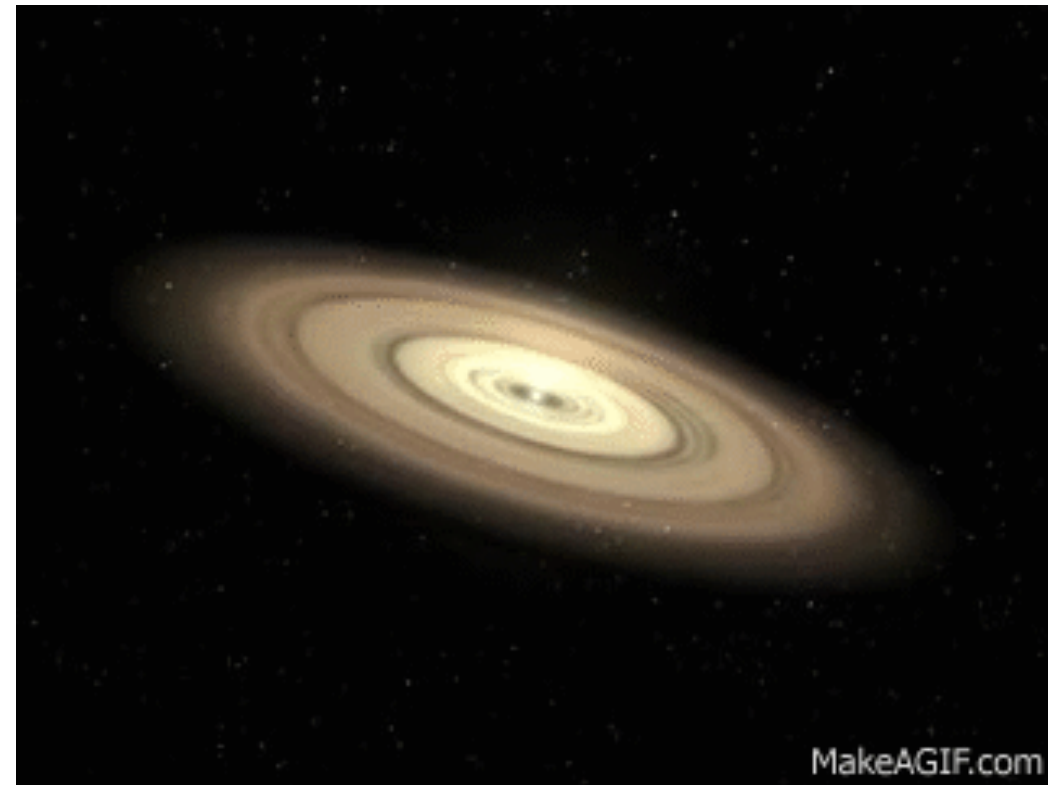
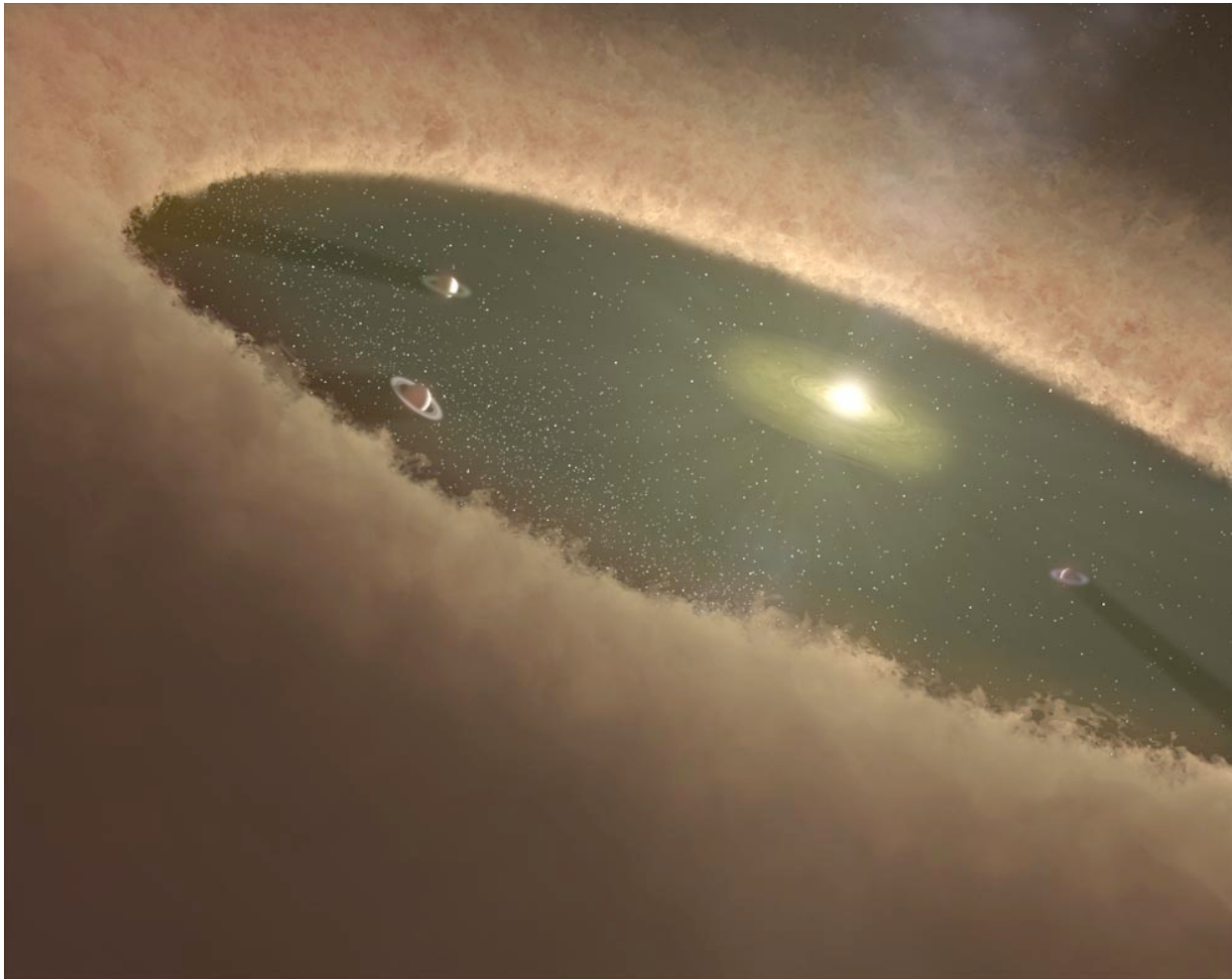
Image Credit: <https://slideplayer.com/slide/765833/>

Protoplanetary disk and planet formation around the protostars



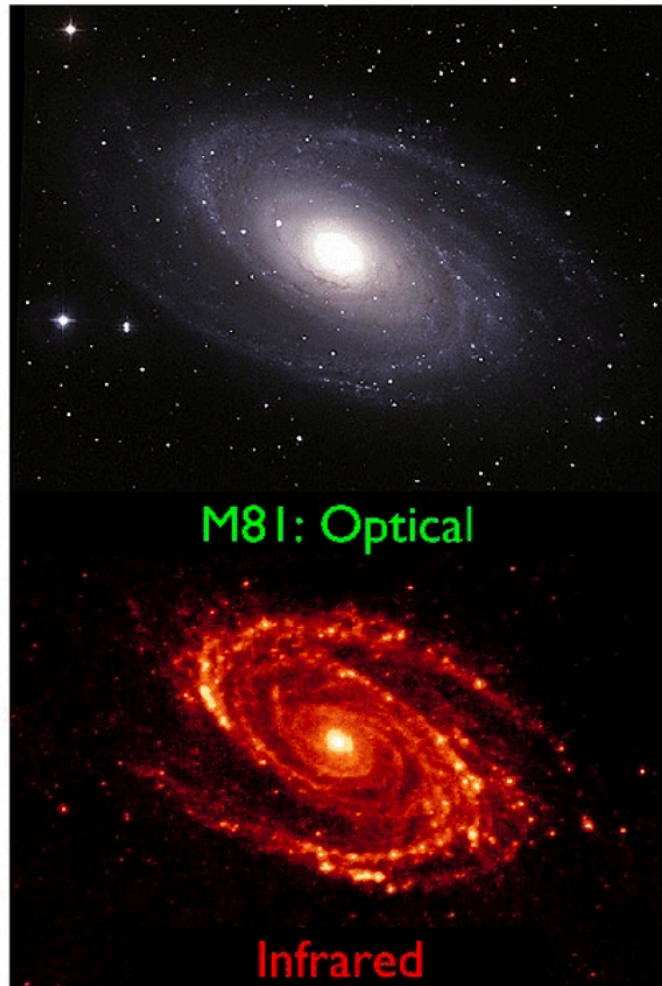
Video Credit: https://www.youtube.com/watch?v=53jrjOWwX_s

Star & Planet Formation

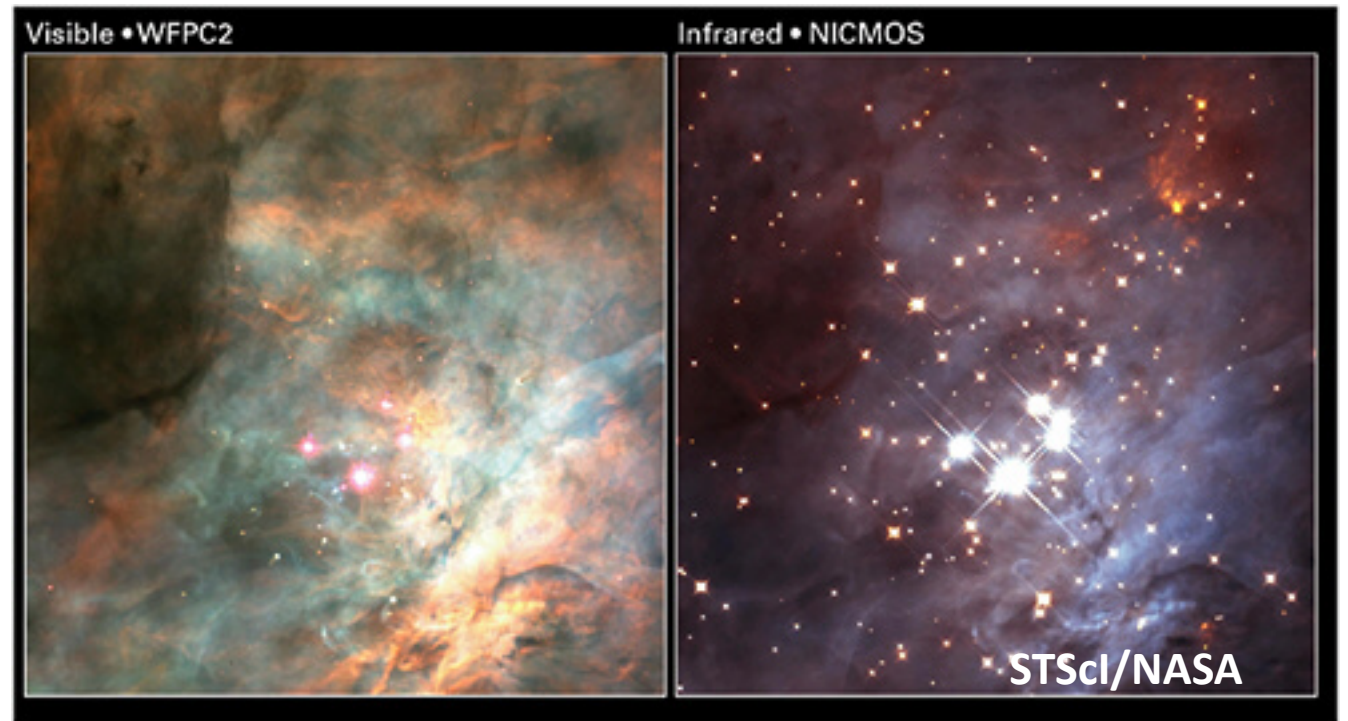


- Protostar continues contraction => Temperature in the core increases => hydrogen fuse to helium => **A star is born**

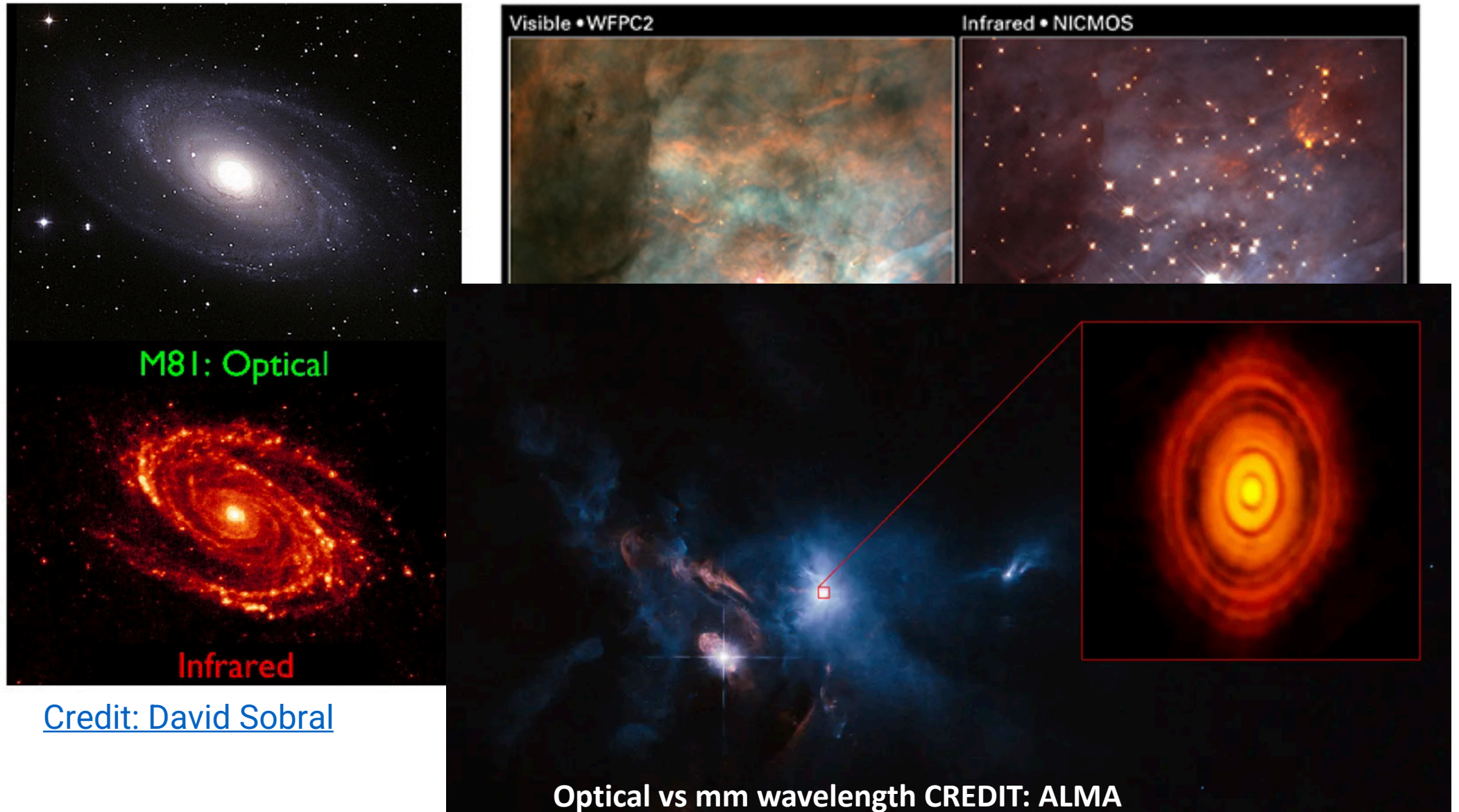
Wavelength dependent view of the COSMOS



[Credit: David Sobral](#)

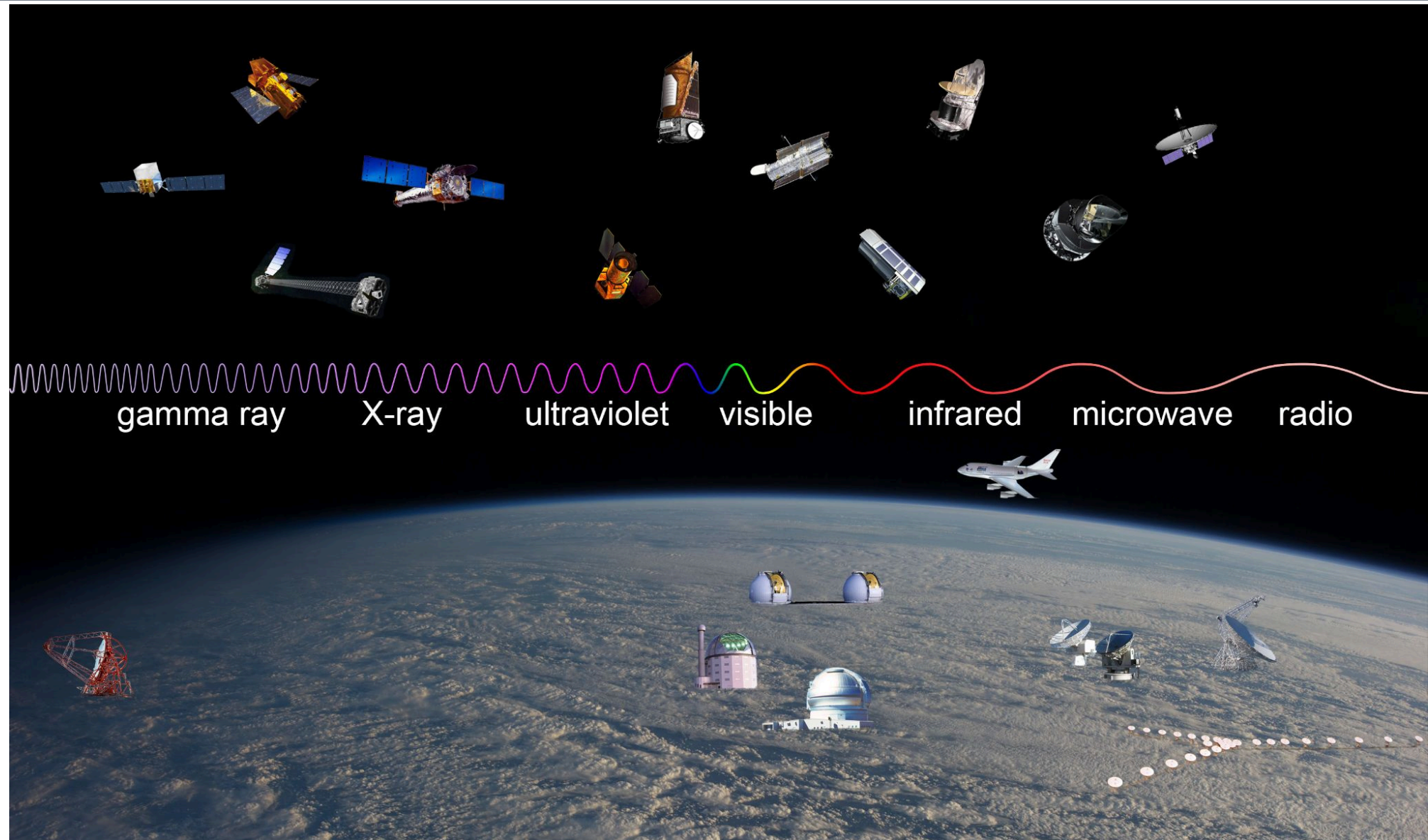


Wavelength dependent view of the COSMOS

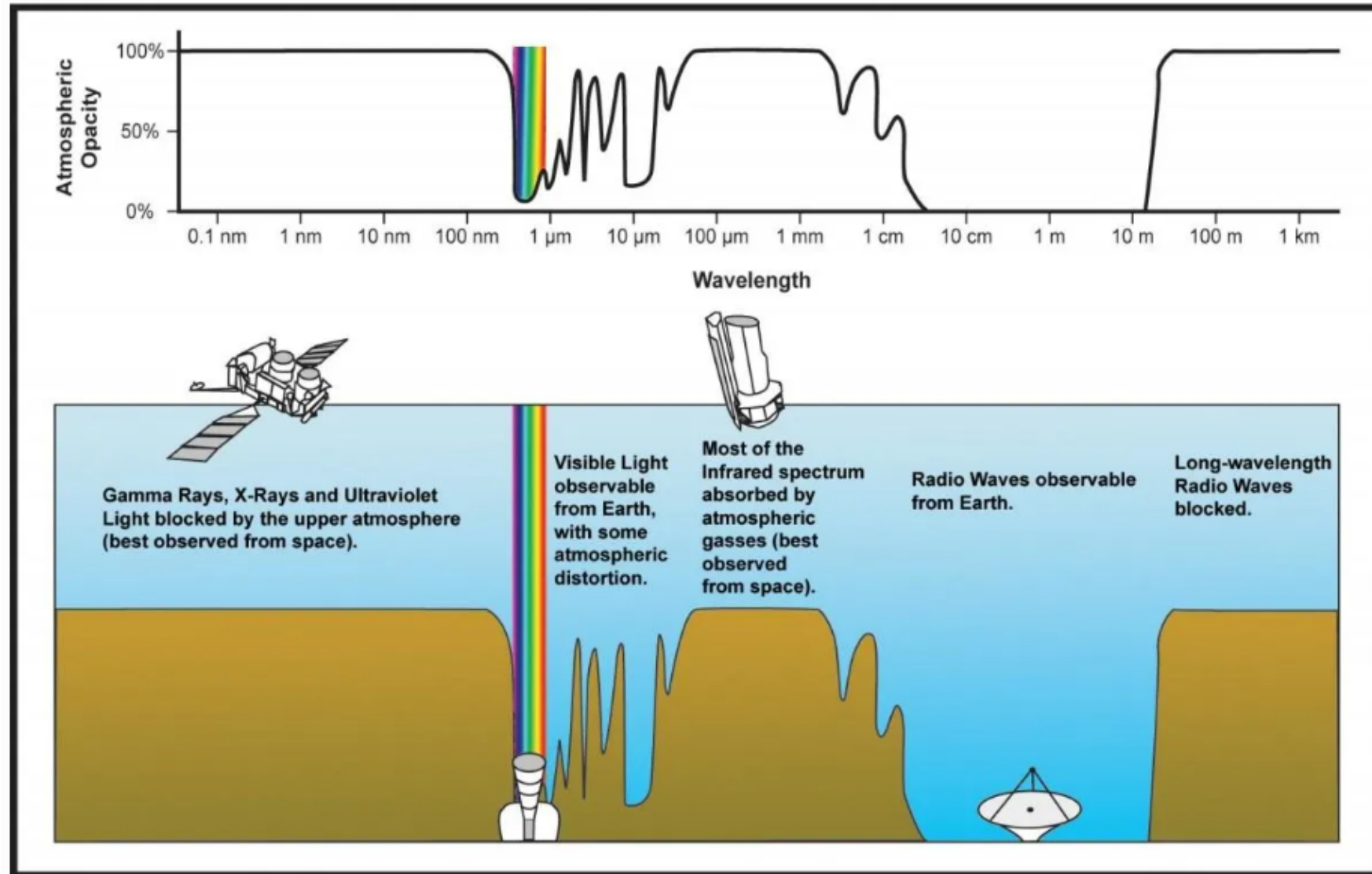


[Credit: David Sobral](#)

Telescopes in every Hue



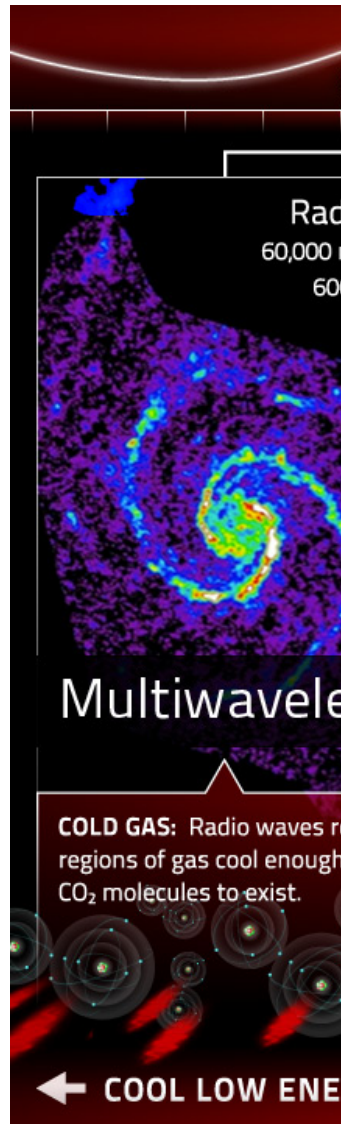
Telescope Tango: Ground vs. Space



Multiwavelength Astronomy: Complete picture of cosmos

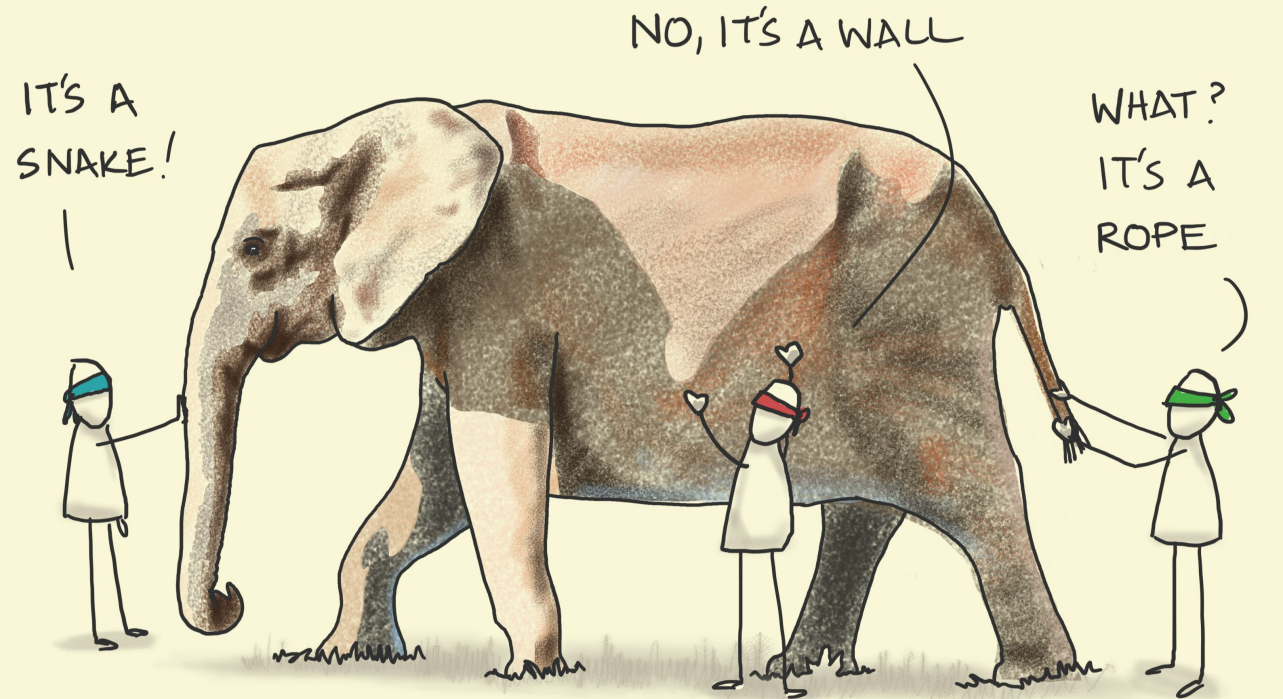


Multiwavelength Astronomy: Complete picture of cosmos

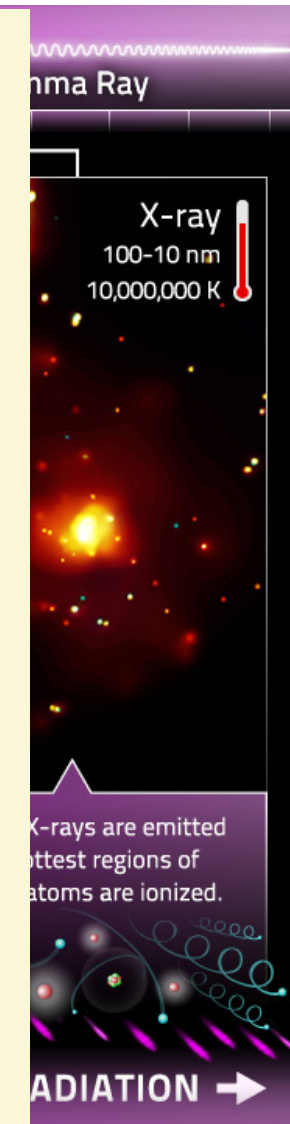


THE BLIND AND THE ELEPHANT

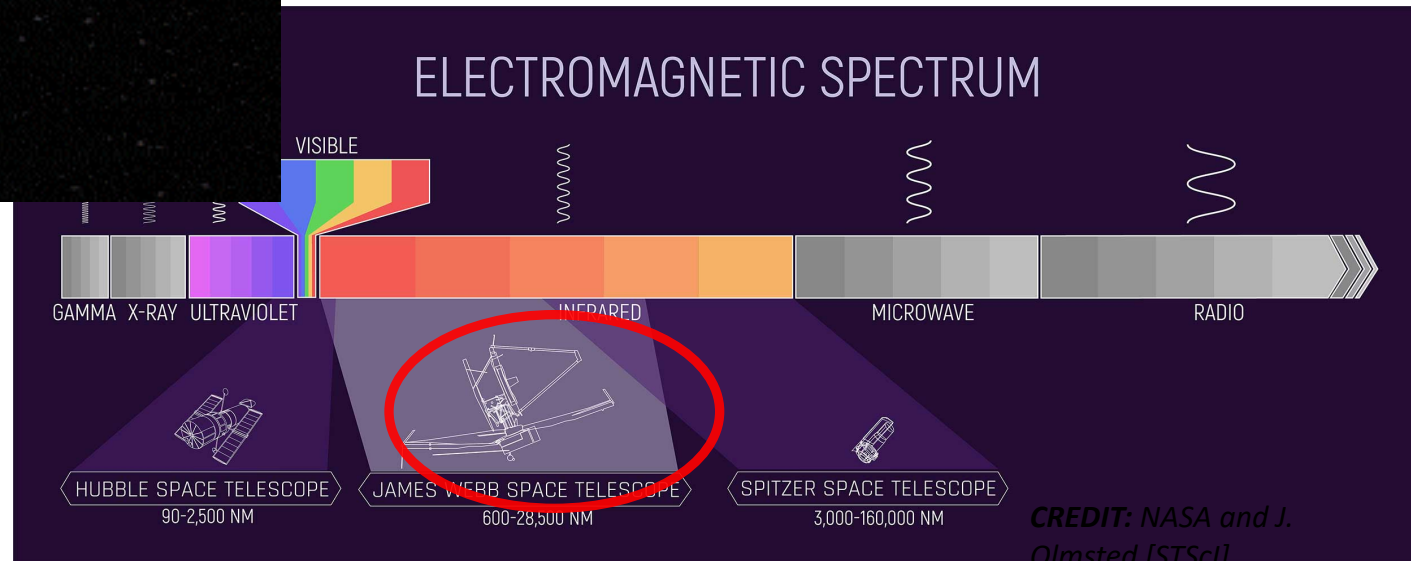
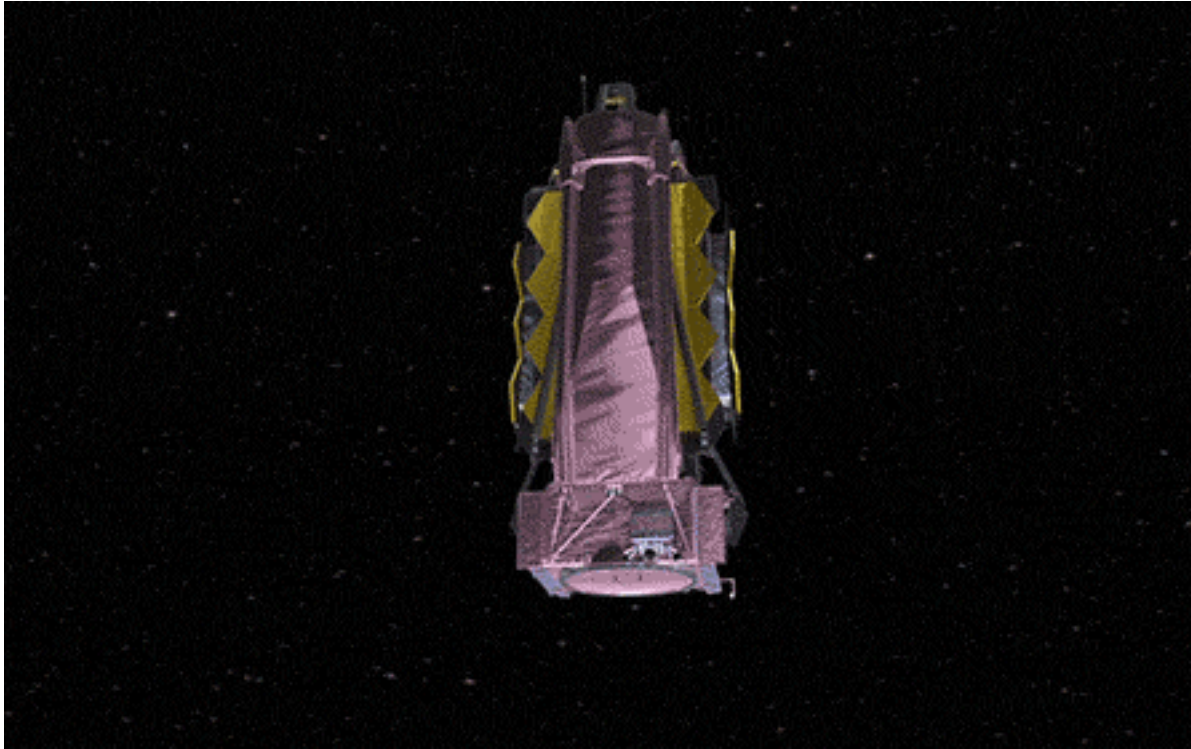
OUR OWN EXPERIENCE IS RARELY THE WHOLE TRUTH



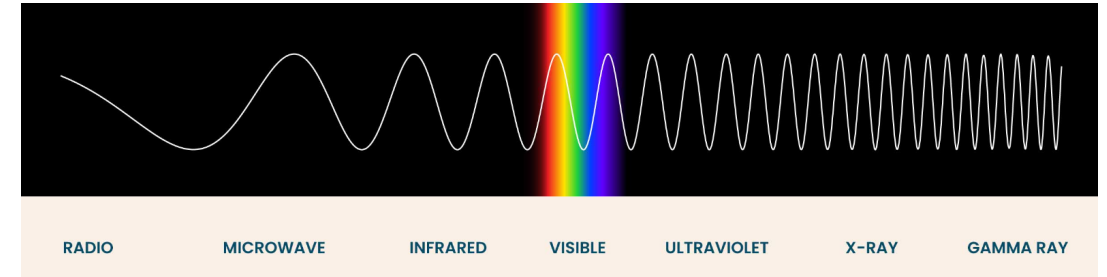
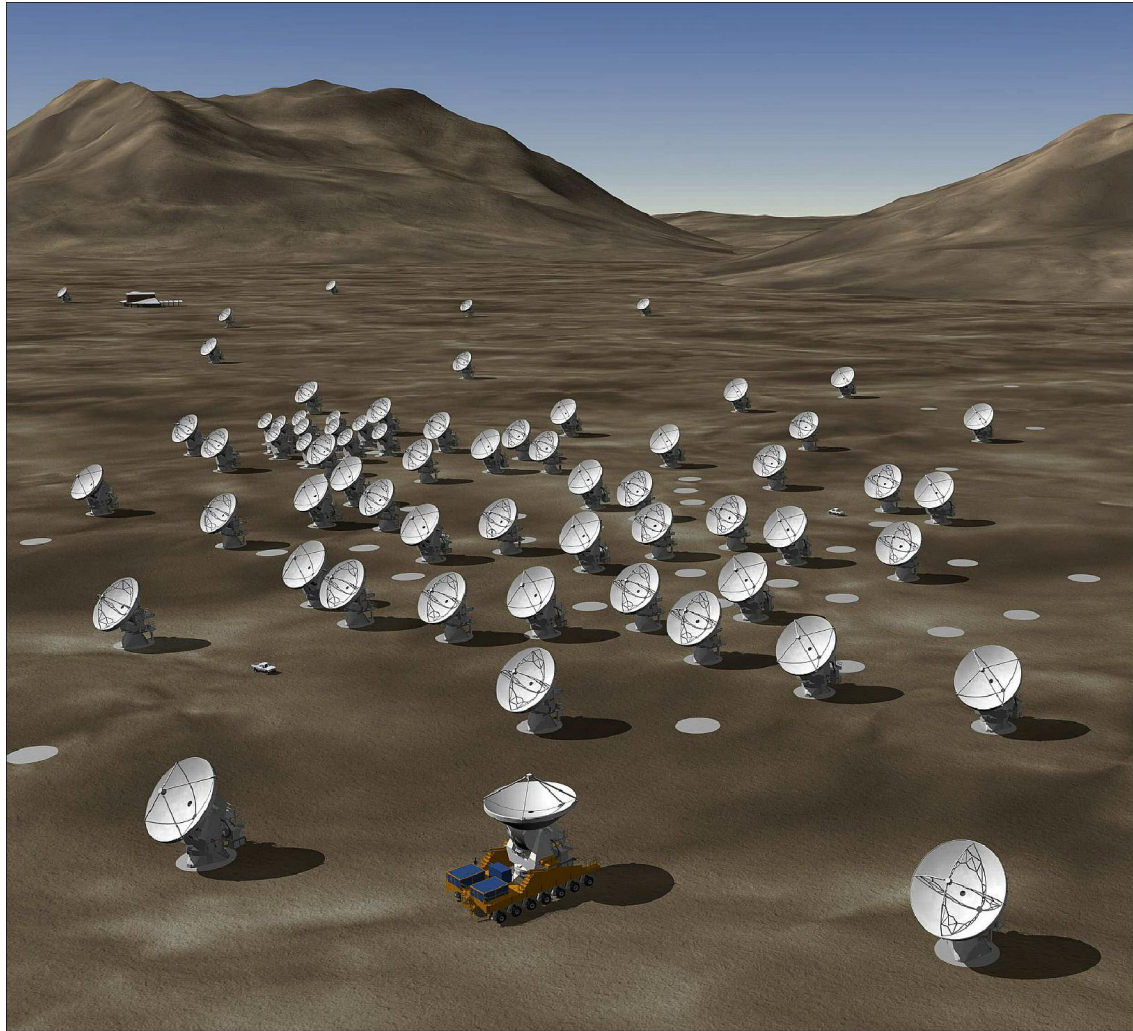
sketchplanations



JWST: Golden, Infrared eye in space



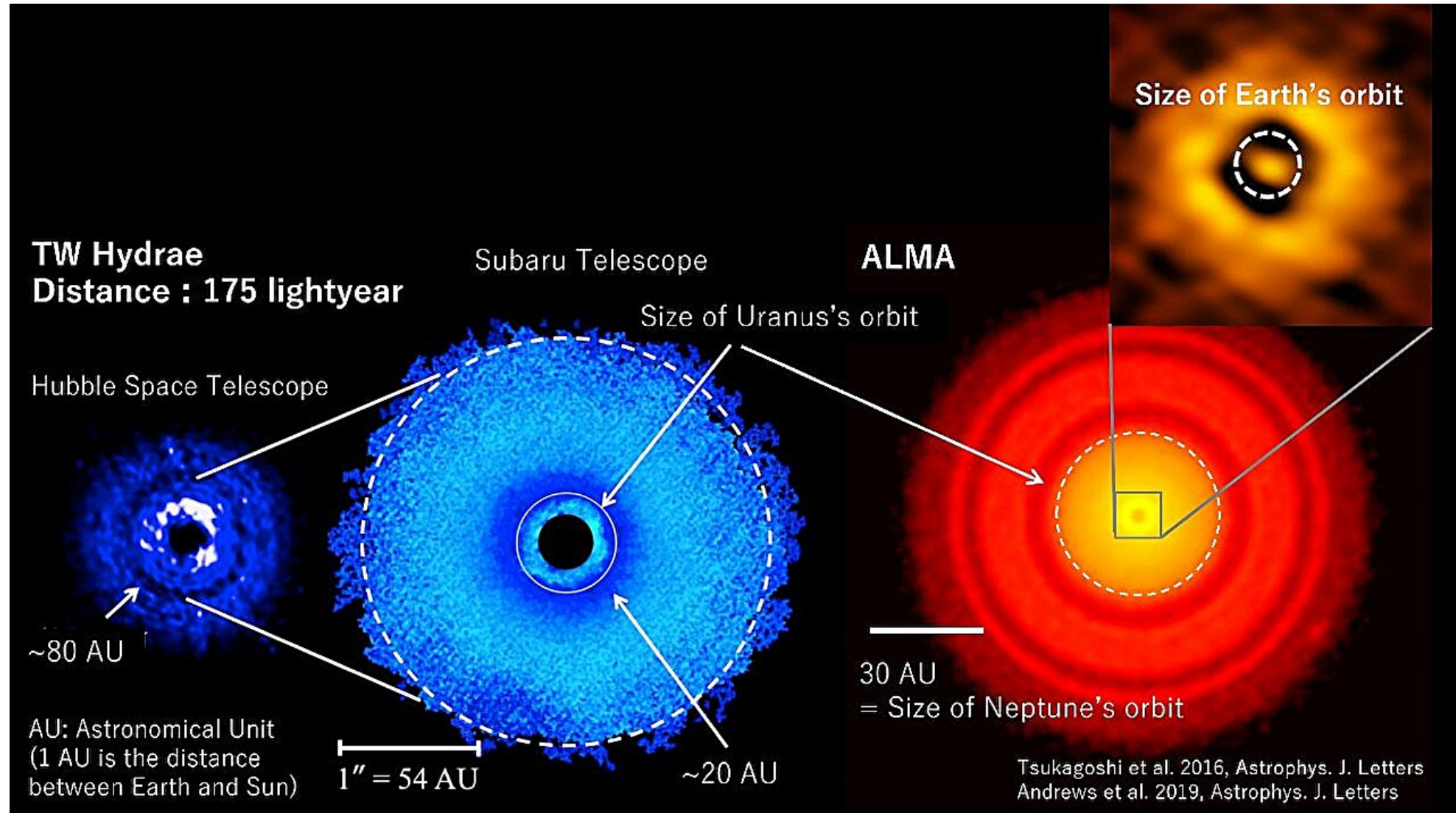
Atacama Large Millimeter Array (ALMA)



Credit: ALMA

ALMA Large Array Looks Through Dust To See Starbirth Space

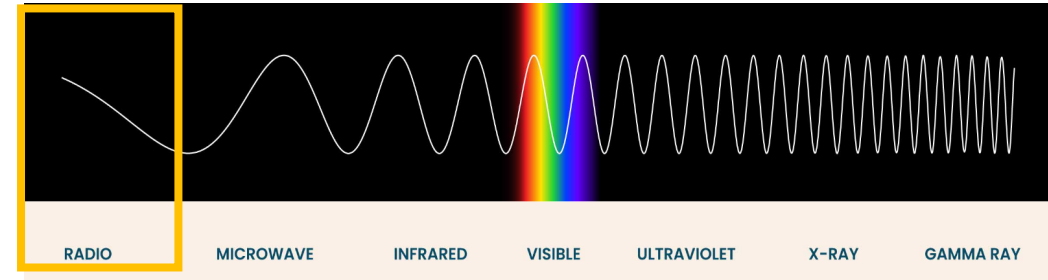
With highest possible resolution



Credit: NAOJ, ALMA (ESO/NAOJ/NRAO), Tsukagoshi et al., Andrews (Harvard-Smithsonian CfA)

India's contribution

World Class Radio Telescope

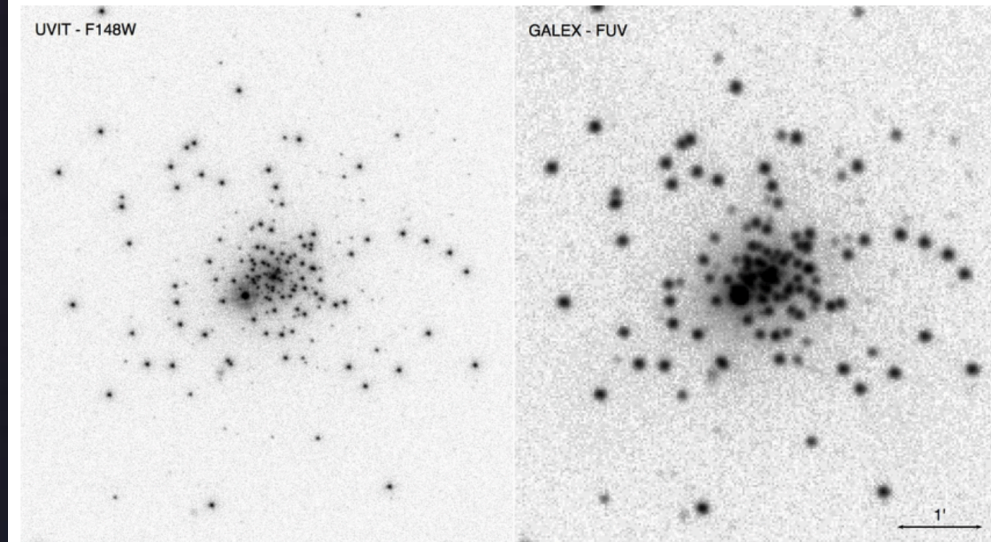
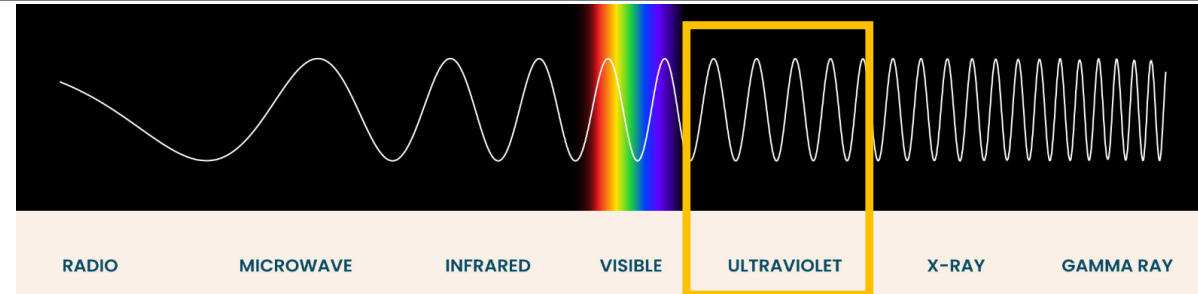


Interferometry

**Giant Meter Radio Telescope
NCRA-TIFR, Pune, since 1990**

Shortest spacing $\sim 100\text{m}$; largest spacing $\sim 25\text{km}$

ASTROSAT India's Pride

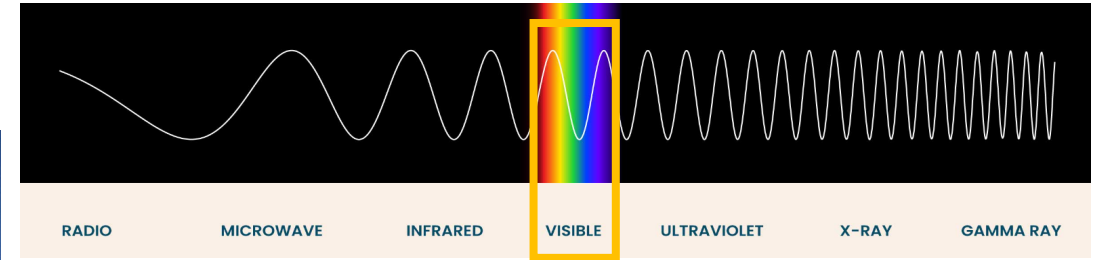


ISRO+IIA+IUCAA+TIFR

Mission since 2015

Various Optical Telescopes across the country

3.6m Devasthal Optical Telescope

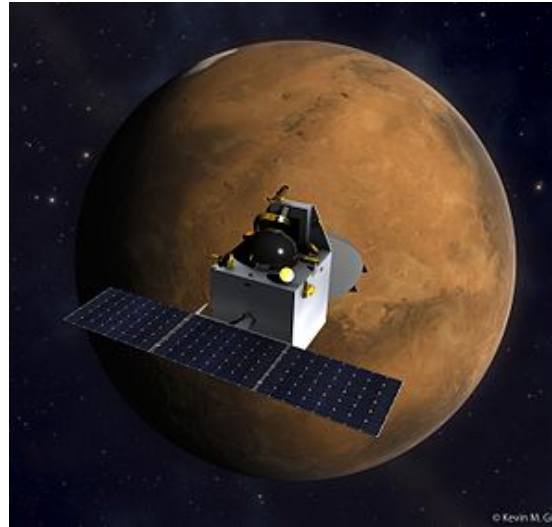


ARIES, Nainital

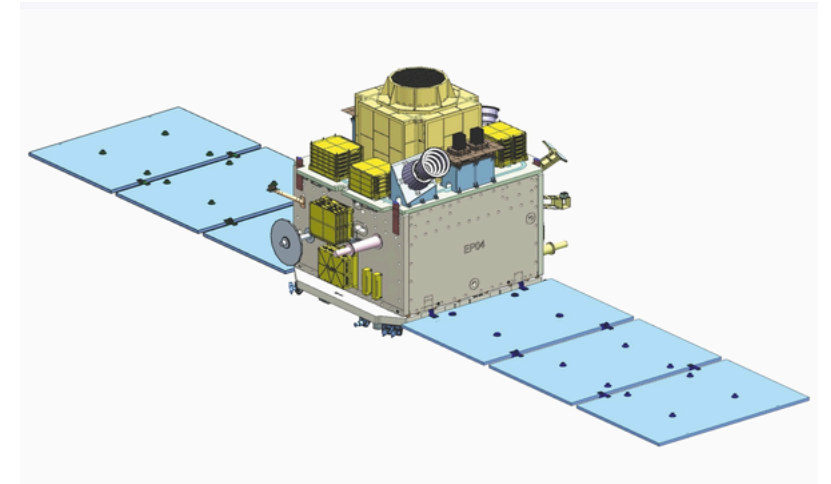
Indian Space Sector: Several successful missions



Chandrayaan-3



Mars Orbiter Mission



X-ray Polarimeter satellite (XPoSat)



ASTROSAT



+ Many More

Future Space Exploration: India's Role

Multi-National Projects



LIGO-India



TMT-India

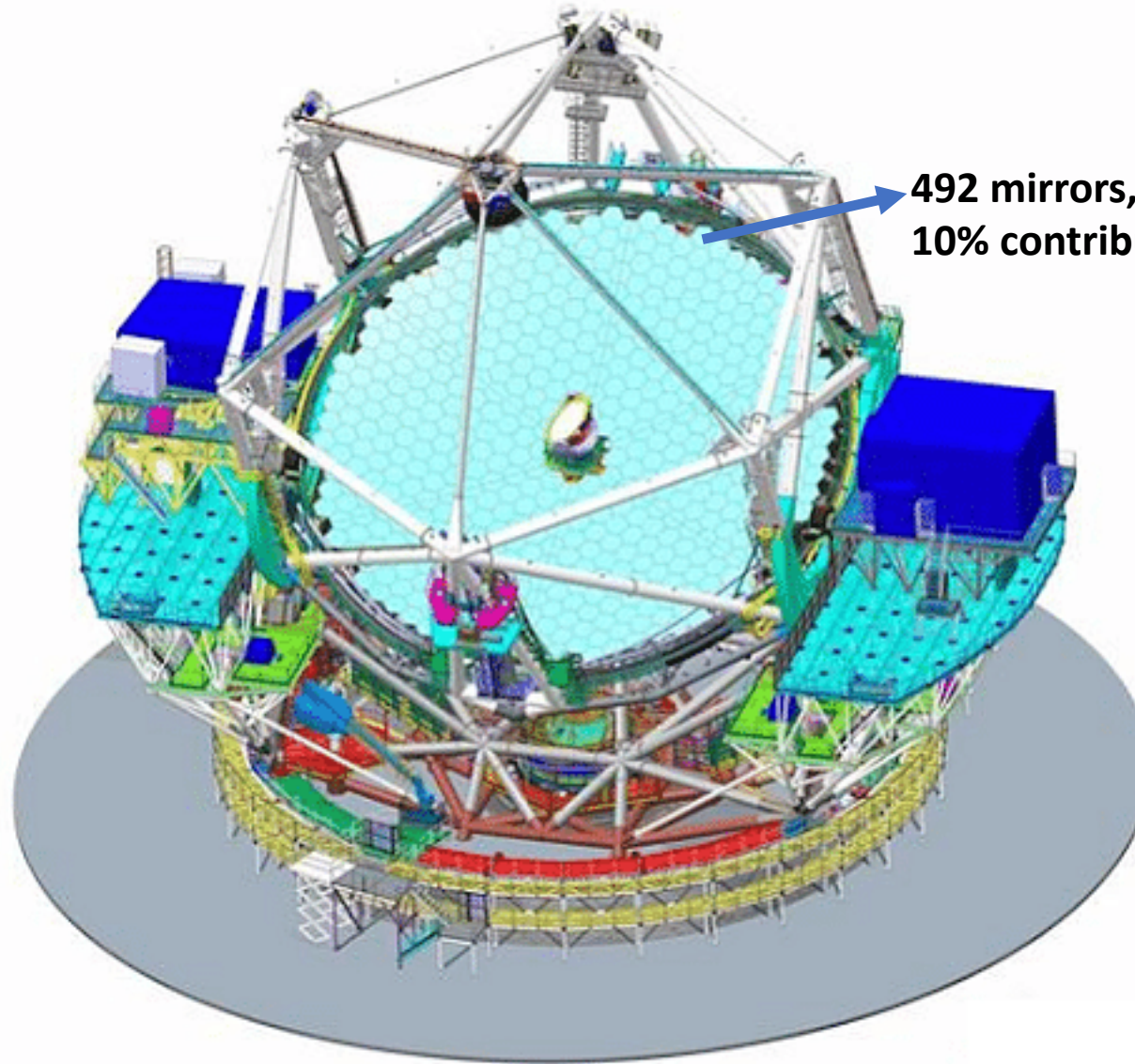


SKA

Future Space Exploration: India's Role



LIGO-India

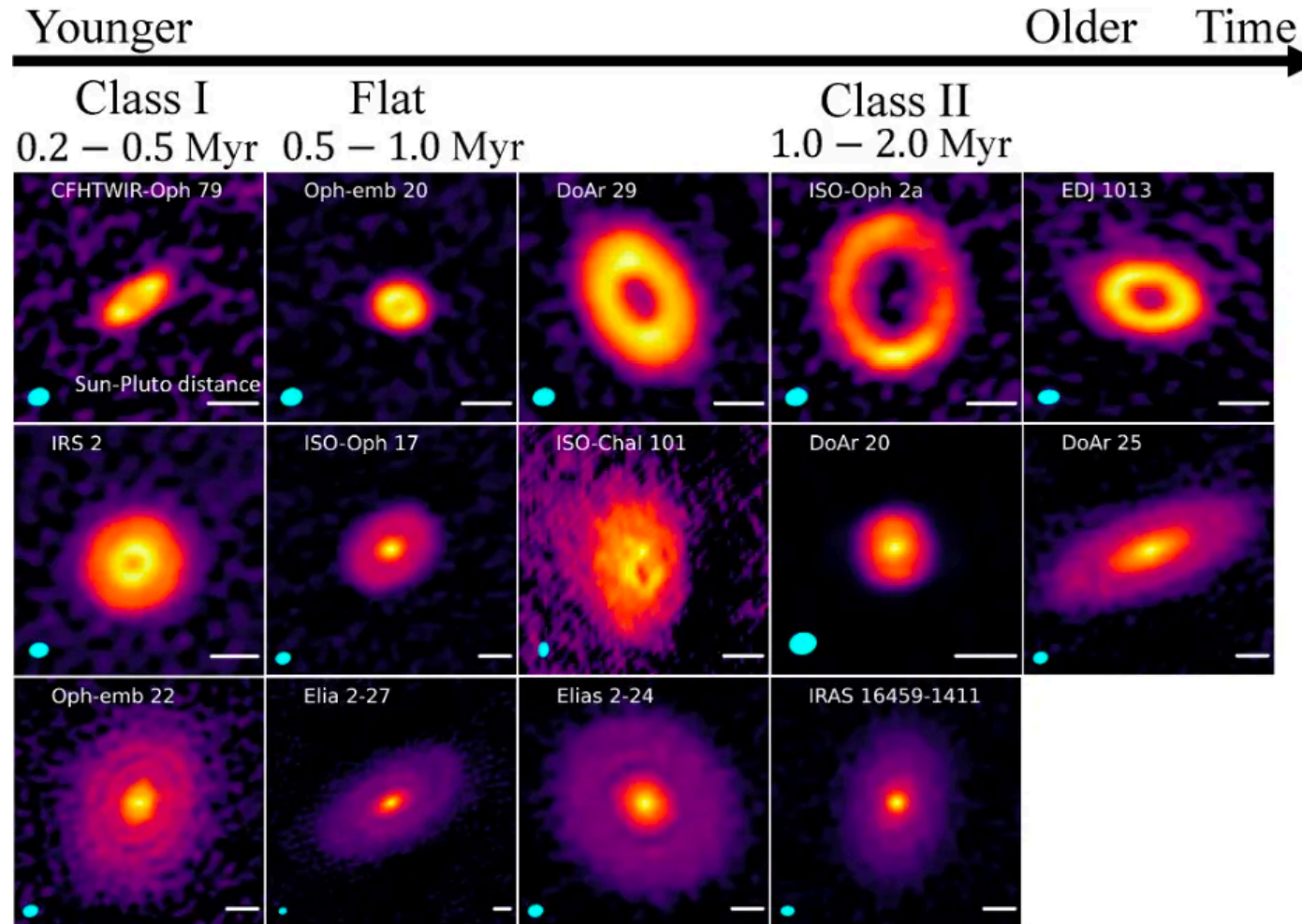


492 mirrors, 1/3 by India+Science instruments
10% contribution to the whole project



SKA

Stellar disks reveal how planets get made



The evolutionary sequence of protoplanetary disks with substructures, Credit: ALMA/Hsieh et al. in prep.

Big Question - Are We Alone?



Are there Earth-like planets?

Are they common?

Do they harbour life?

Summary

- **Modern Telescopes are changing the way we study the Cosmos**
- **However, we are still like a child playing on the beach while the vast oceans of truth lay undiscovered before us (Sir Issac Newton)**
- **We can all be proud that we are living at a time when India is emerging as a force to be reckoned with in Space Science studies**

Indian Institute of Science Education and Research (IISERs)



Location of the 7 IISERs offering admission

Indian Institute of Science Education and Research (IISERs)

Major Programs at IISER Tirupati

- 1) **5 year Integrated BSMS (after plus two)**
Admission through IISER Admission Test
(<https://www.iiseradmission.in/>)
Fellowships for INSPIRE scholars
- 2) **6 year Integrated PhD with fellowship**
(Physics, Chemistry, Biology, Maths, Earth Science)
Eligibility : 60% marks, B.Sc./B.Tech/B.E. or any equivalent degree
(Final year students are also eligible to apply).
JAM, JEST, followed by interview
- 3) **PhD with fellowship**
(MSc/B.E./BTech/M.E./MTech, BSMS or any equivalent degree)
JEST, GATE, CSIR-UGC (JRF/NET-LS), INSPIRE scholars
followed by interview
- 4) **Post-doctoral programs**

Check the website : <http://www.iisertirupati.ac.in/admissions/>