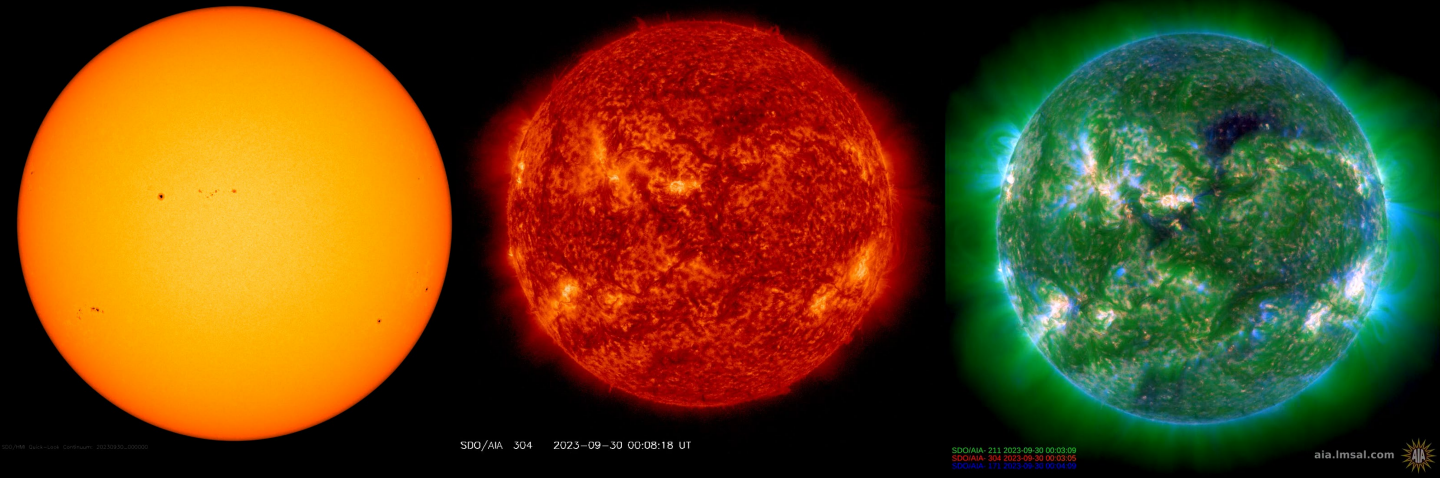
Measuring the Heavens

The Tools and People of Astronomy

Dr Jonathan Crass

The Ohio State University

Royal Astronomical Society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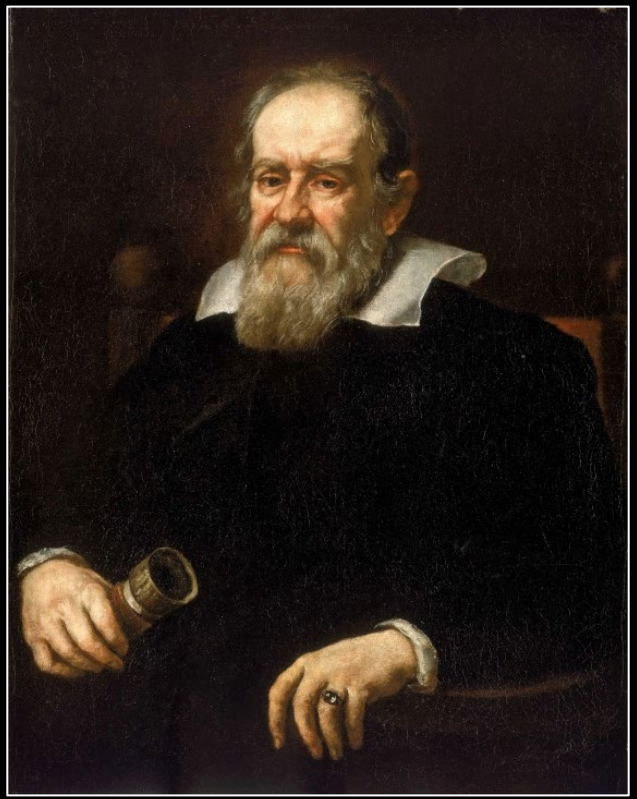

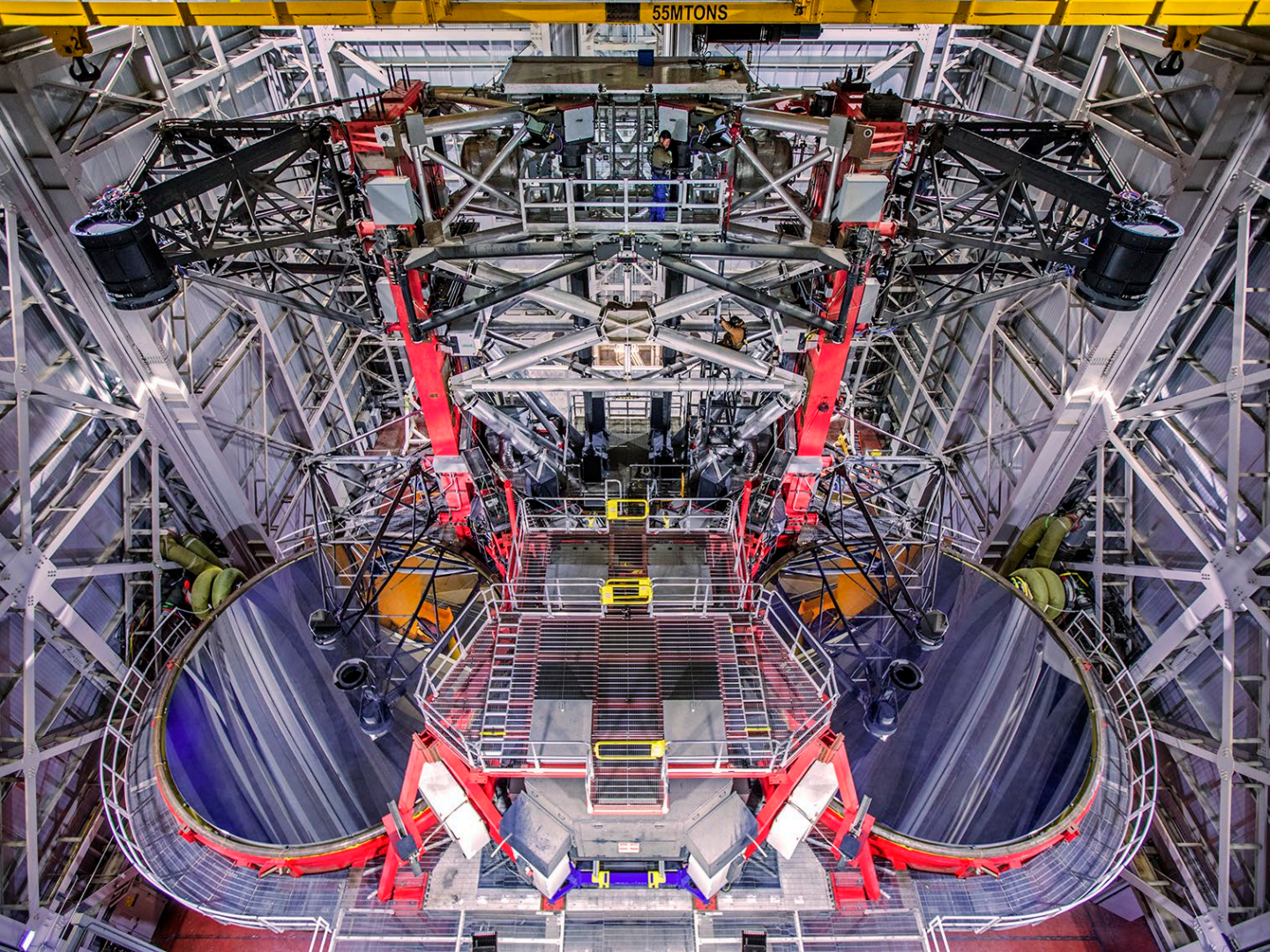
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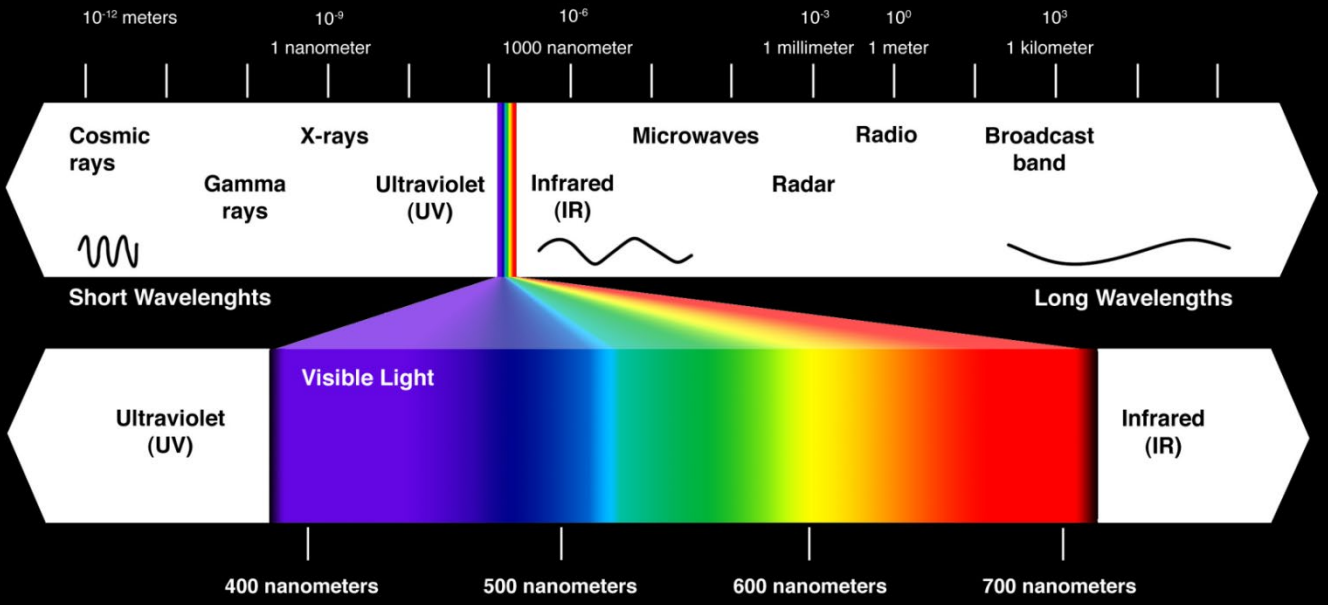
How do we answer those questions?

- We need to be able observe the Universe around us
- We need to understand what we see
- We need make testable predictions about what is going to happen

Observing the Universe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1 kilometer
Cosmic rays
X-rays
Gamma rays
Ultraviolet (UV)
Infrared (IR)
Microwaves
Radar
Radio
Broadcast band
Short Wavelenghts
Long Wavelengths
Ultraviolet (UV)
Visible Light
Infrared (IR)
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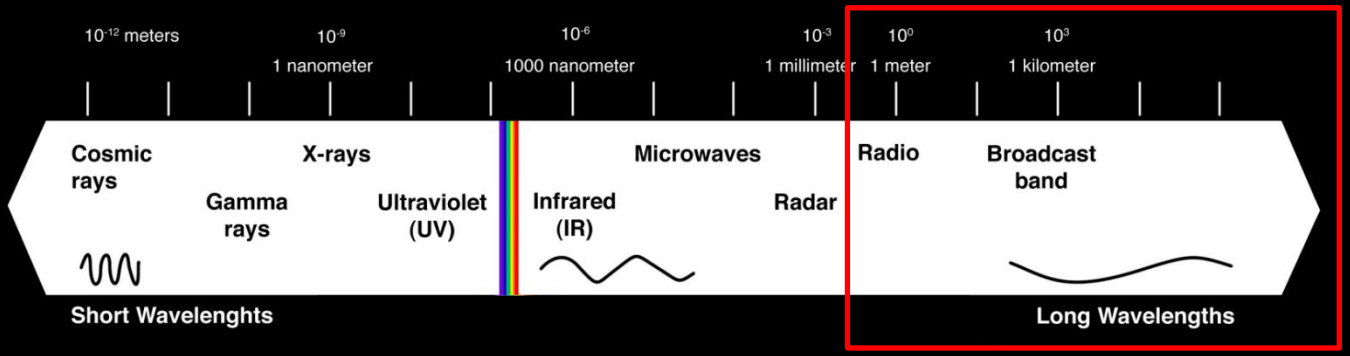
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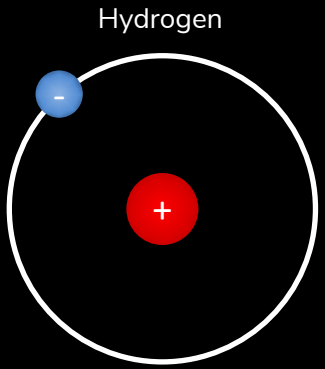
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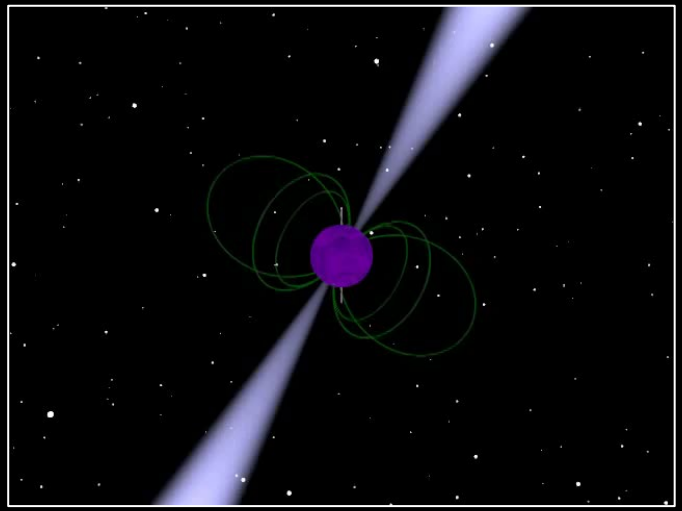

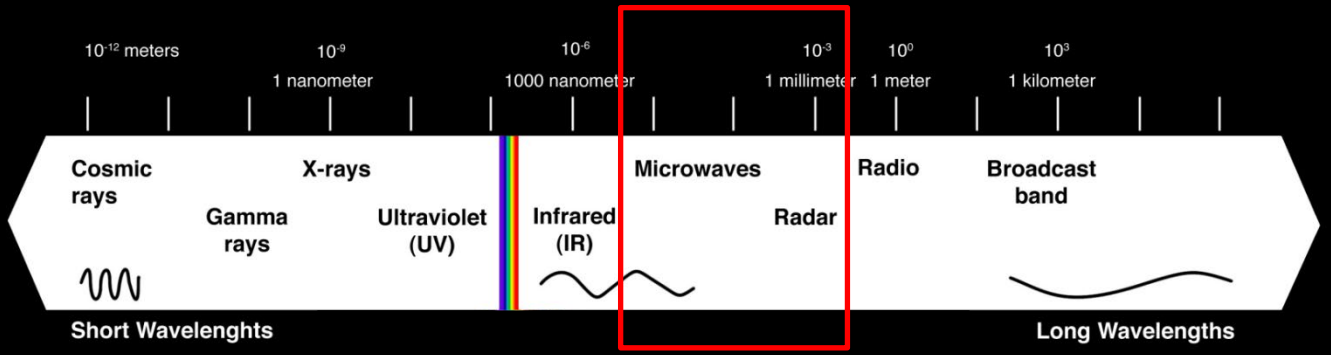
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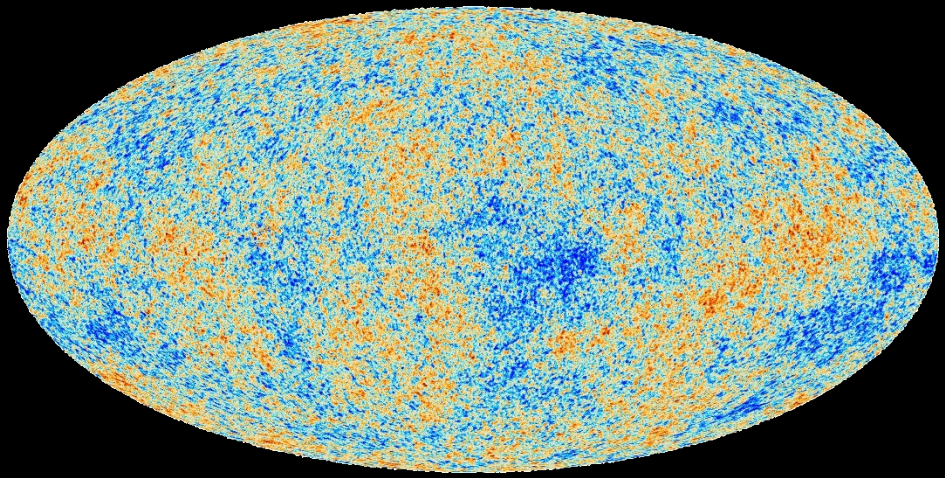

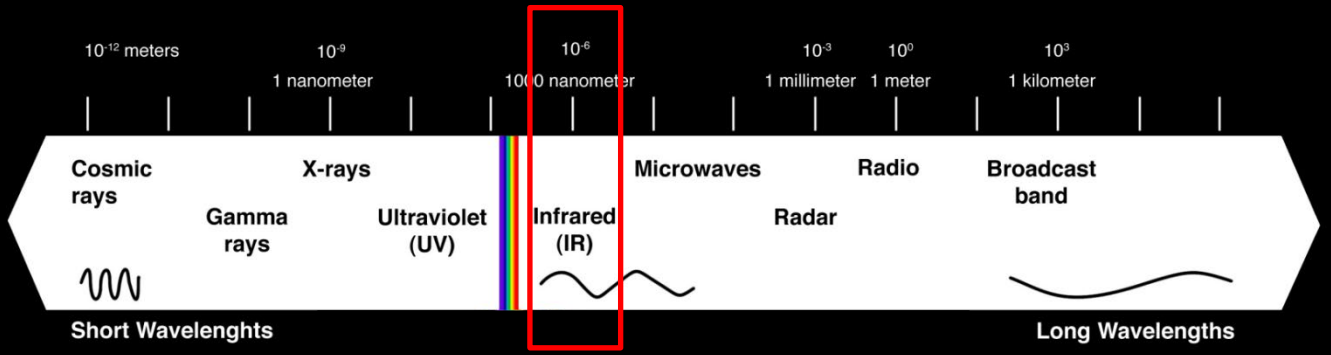
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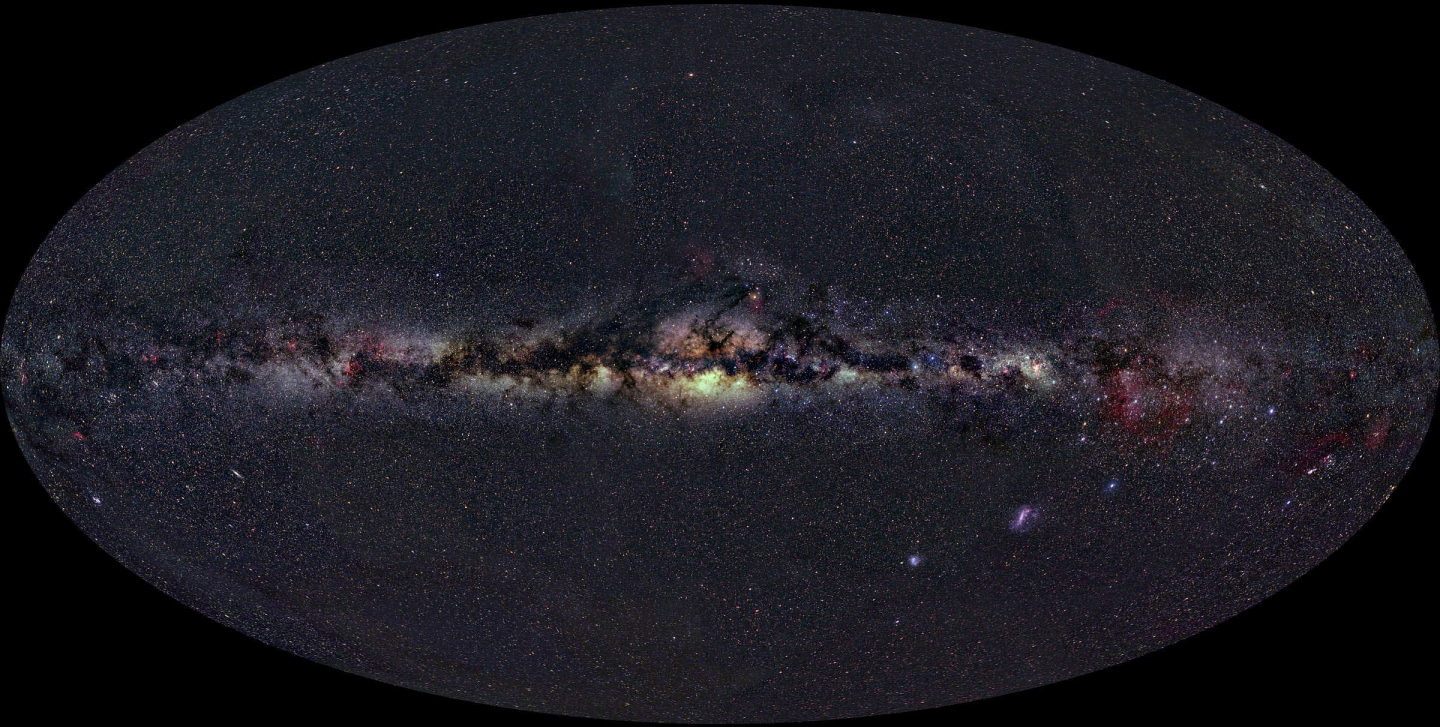

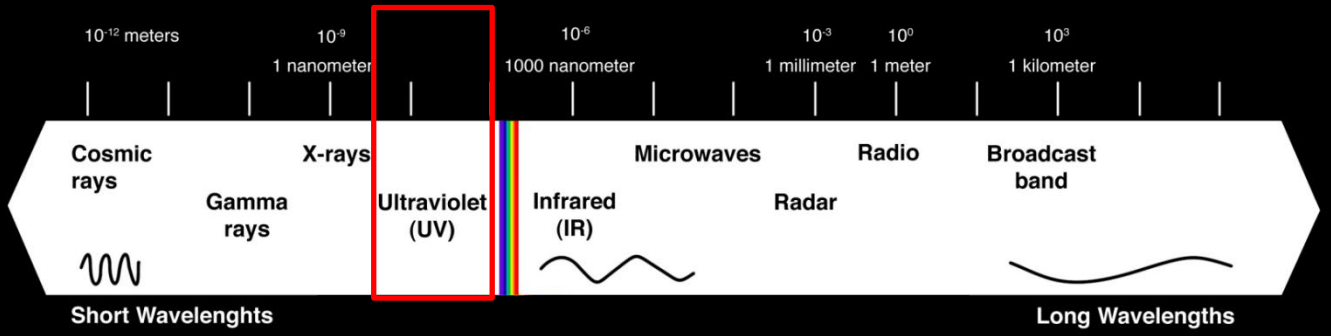
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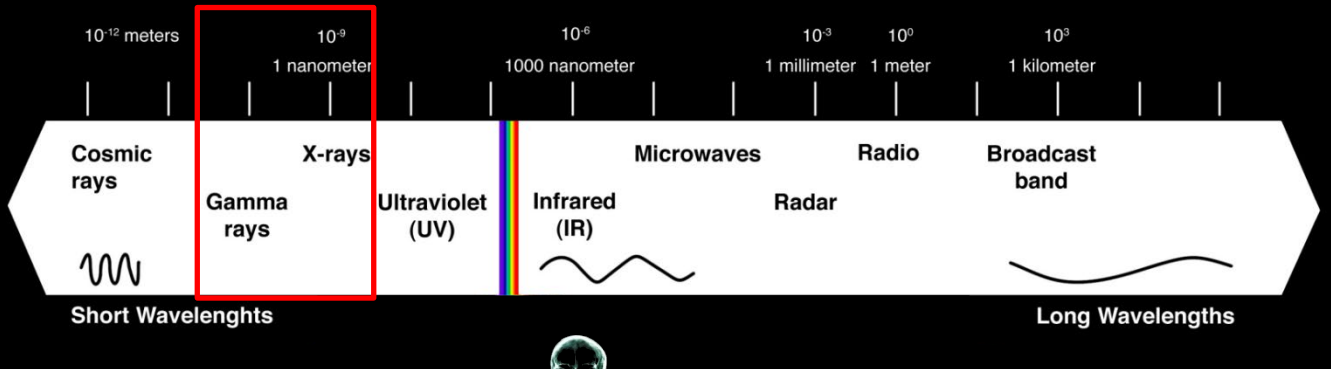
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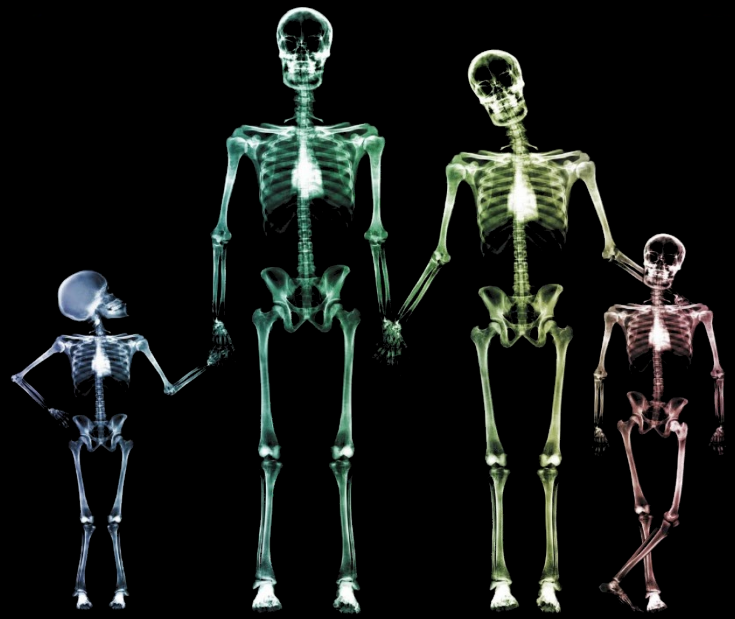
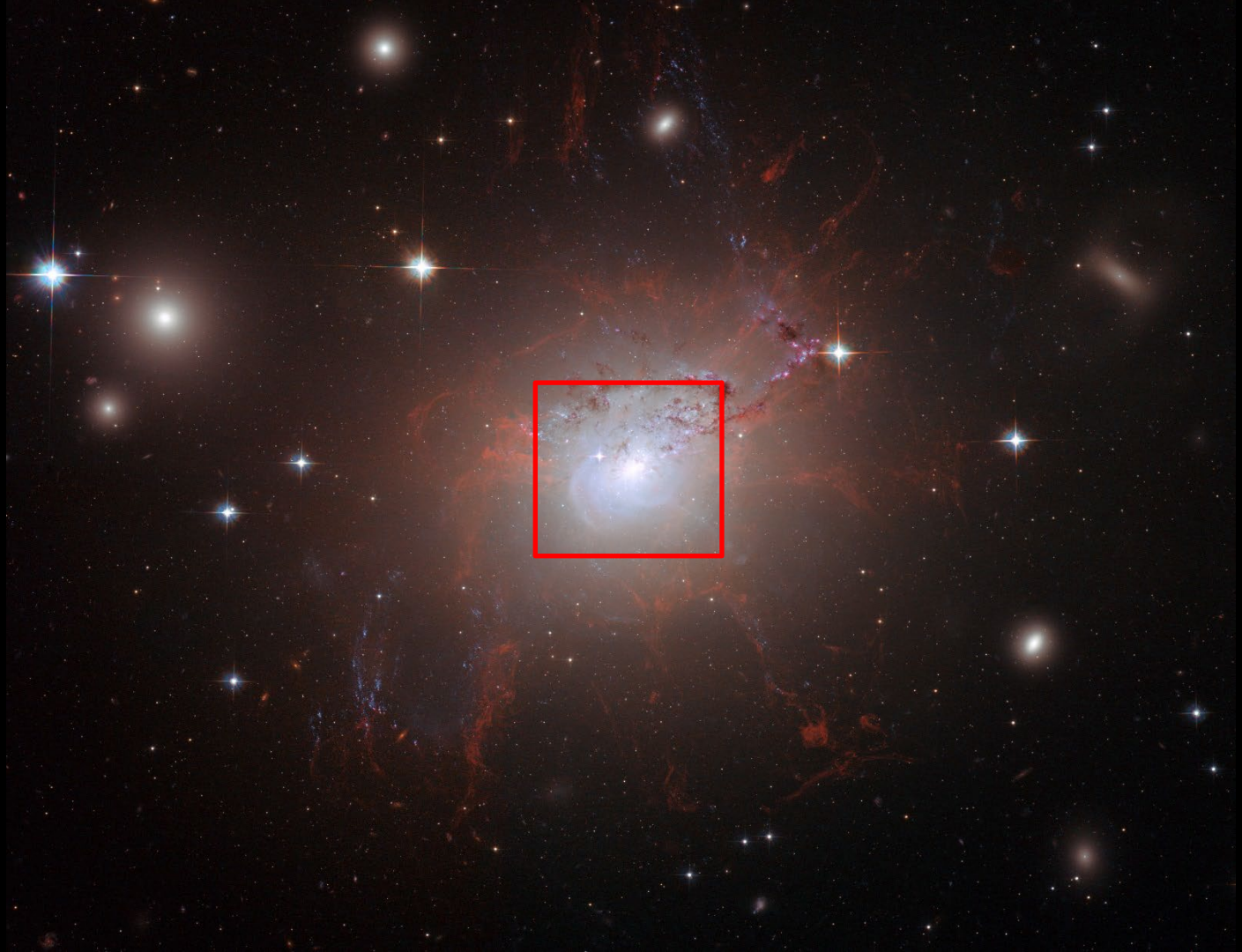
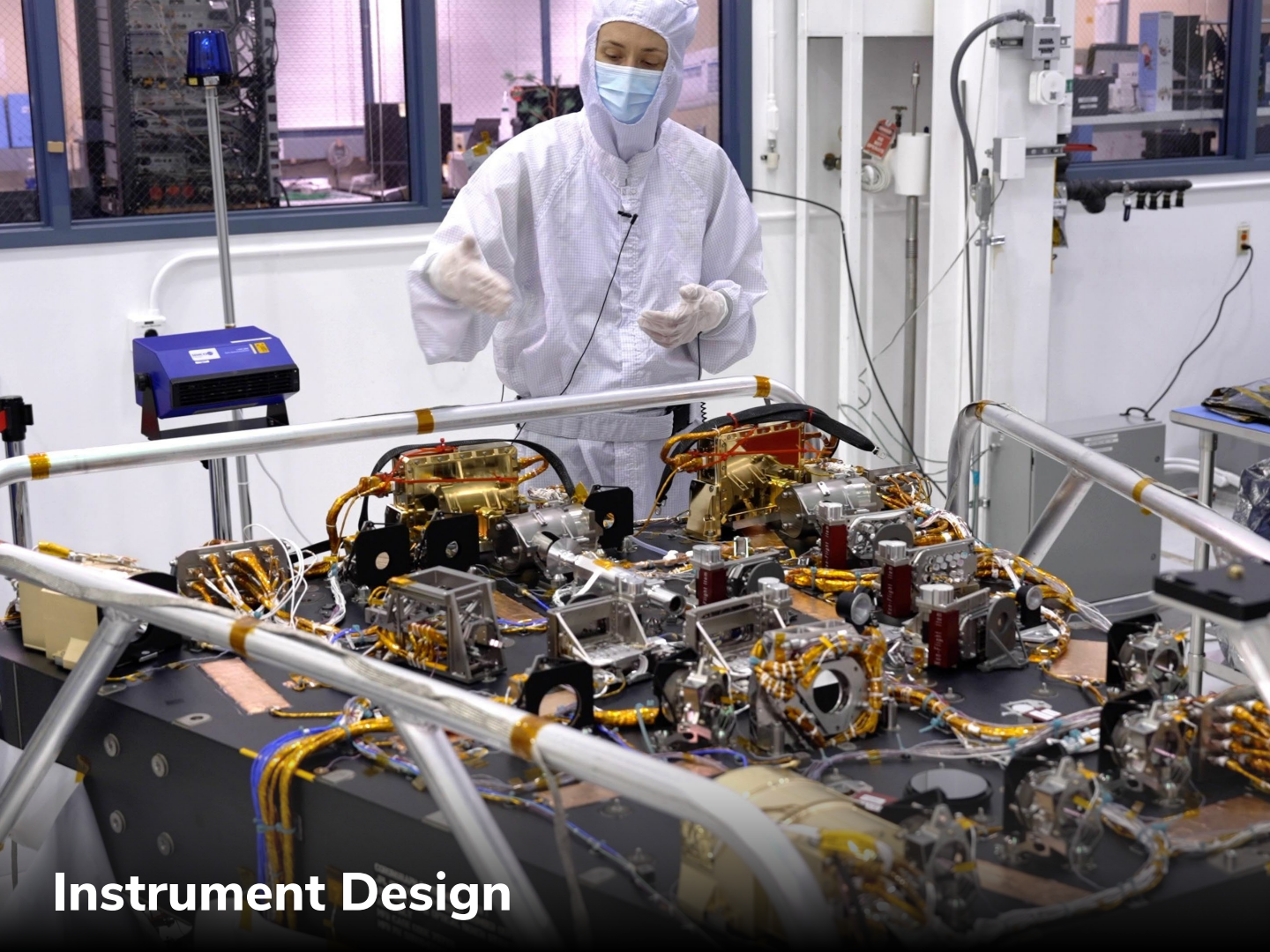




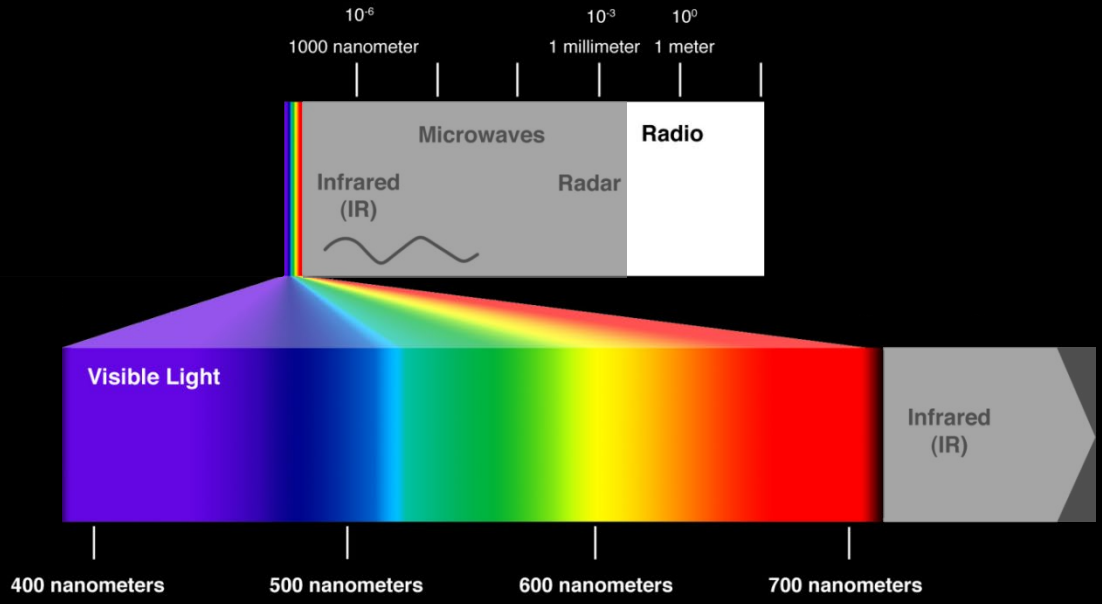


Instrument Design

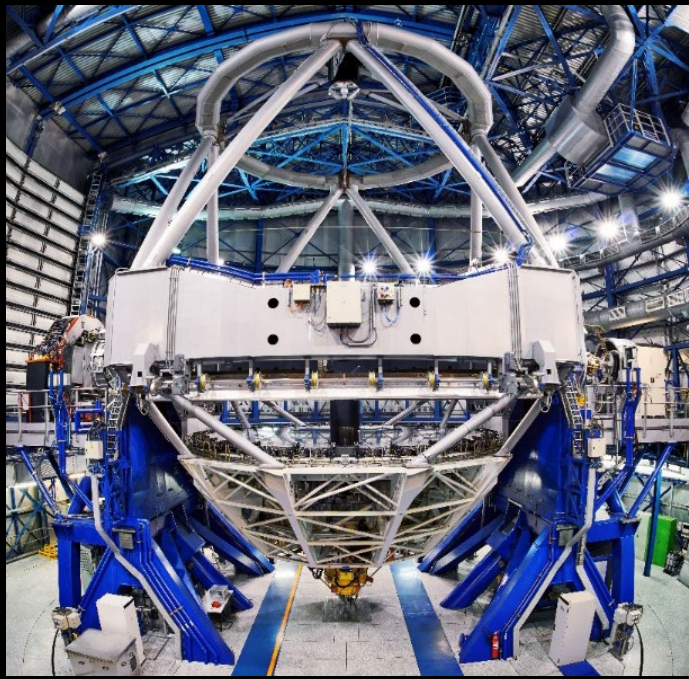
Instrument Design

- **What exactly are we measuring?**
  - **What wavelength of light?**
  - **How bright is the object?**
  - **How big does it appear?**
  - **How fast does it change?**

What can we see on the ground?



How big a telescope?



Ground-based telescopes

Why build ground-based telescopes?

1. They're "cheap"
2. They're easier to maintain
3. You can upgrade them
4. You can use different instruments for different types of science


Lovell Telescope – 76.2m

Why are radio telescopes so large?

- Sensitivity

Why are radio telescopes so large?

- All telescopes are limited in resolution

$$\text{Resolution} = 1.22 \times \frac{\text{Wavelength}}{\text{Telescope Diameter}}$$

- Depends on:
  - Telescope diameter
  - Wavelength

Largest Fully Steerable Green Bank Telescope – 100x110m

Largest Filled Aperture Five hundred meter Aperture Spherical Telescope – 500m

Event Horizon Telescope (EHT)

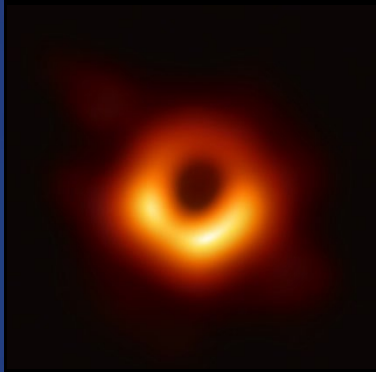
A Global Network of Radio Telescopes

2018 Observatories

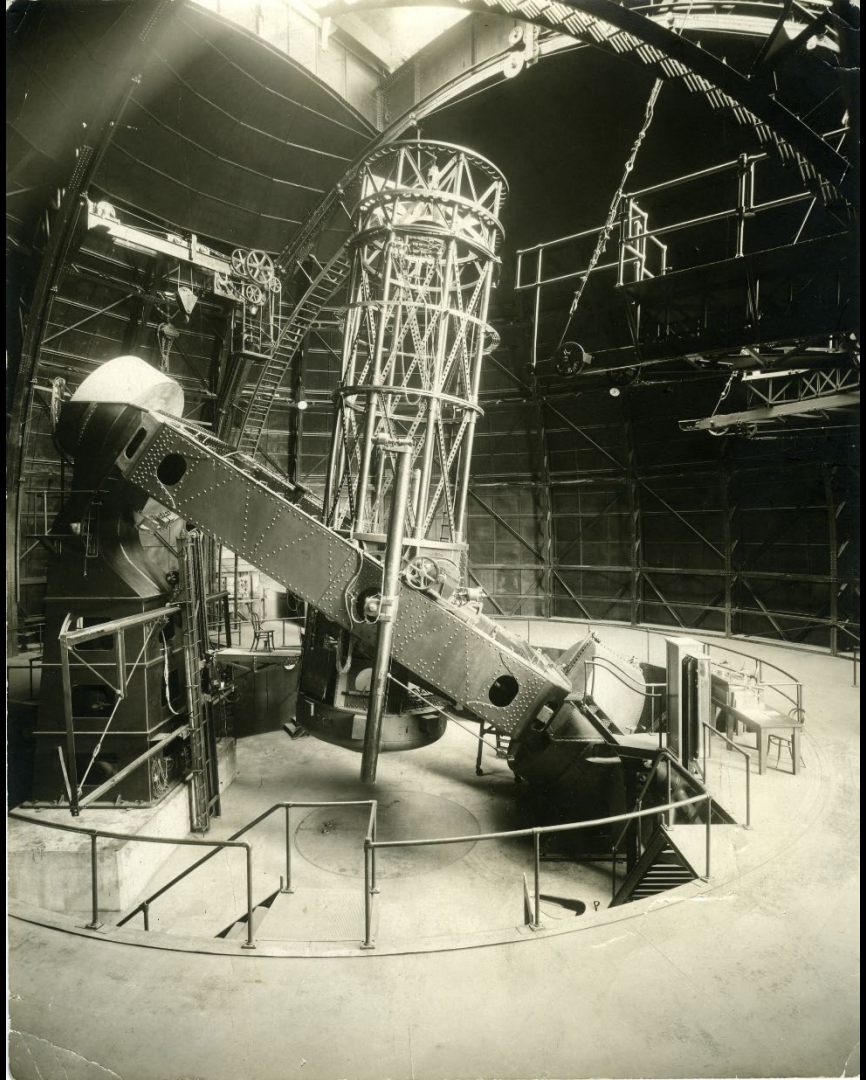
- ALMA — Atacama Large Millimeter/submillimeter Array, CHAJNANTOR PLATEAU, CHILE
- APEX — Atacama Pathfinder EXperiment, CHAJNANTOR PLATEAU, CHILE
- 30-M — IRAM 30-M Telescope, PICO VELETA, SPAIN
- JCMT — James Clerk Maxwell Telescope, MAUNAKEA, HAWAII
- LMT — Large Millimeter Telescope, SIERRA NEGRA, MEXICO
- SMA — Submillimeter Array, MAUNAKEA, HAWAII
- SMT — Submillimeter Telescope, MOUNT GRAHAM, ARIZONA
- SPT — South Pole Telescope, SOUTH POLE STATION
- GLT — The Greenland Telescope, THULE AIR BASE, GREENLAND, DENMARK

Observing in 2020

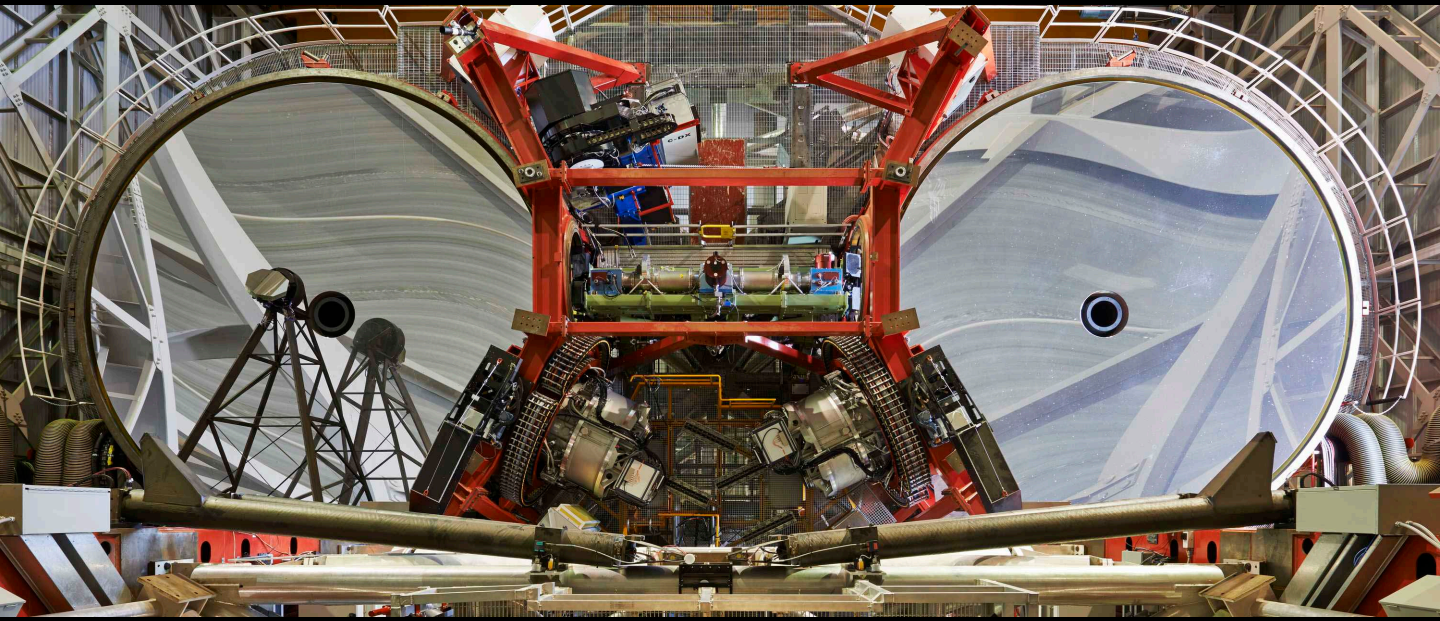
- Kitt Peak — Kitt Peak 12-meter Telescope, KITT PEAK, ARIZONA, USA
- NOEMA — NOEMA Observatory, PLATEAU DE BURE, FRANCE



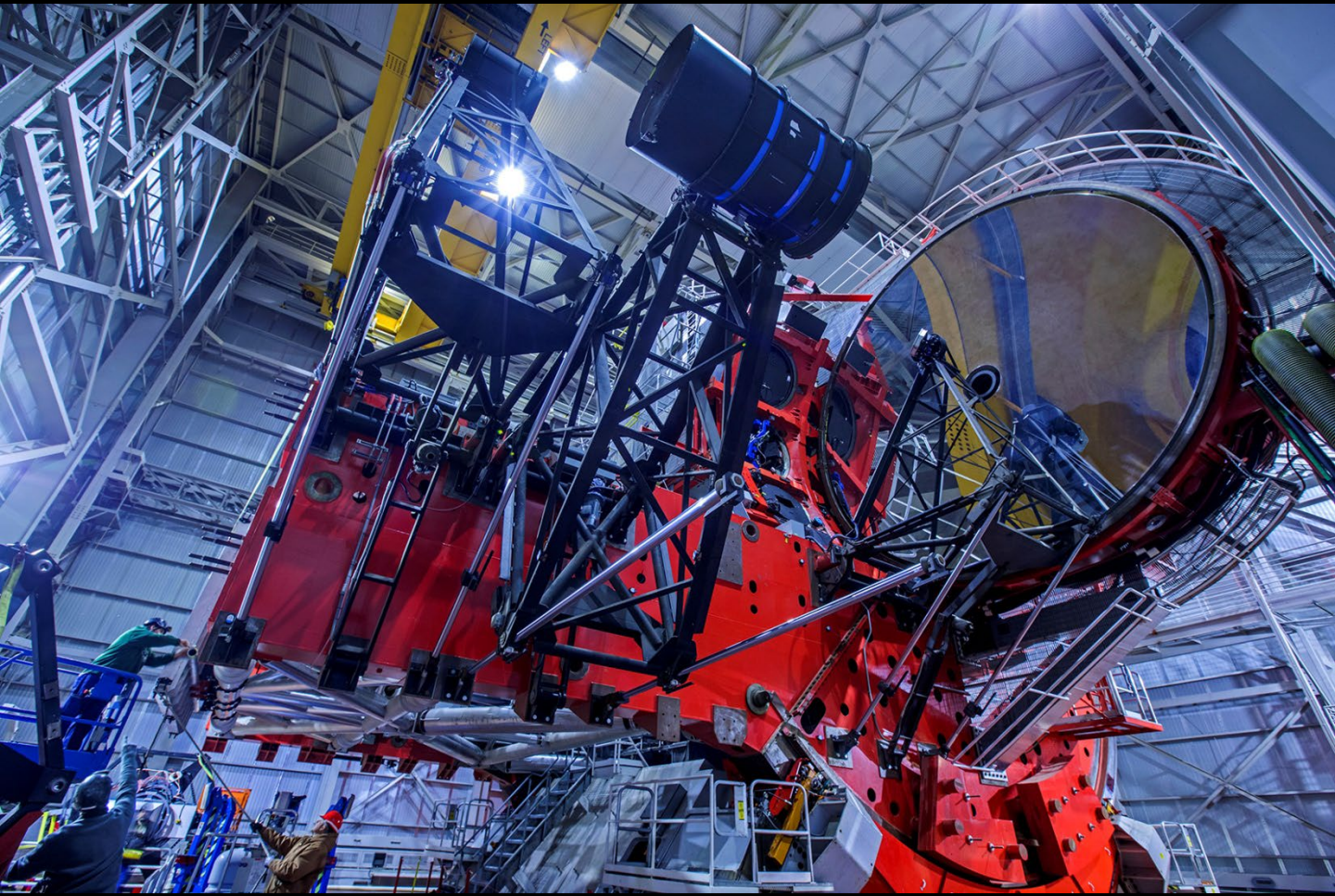
Northumberland Telescope,
University of Cambridge, 11.6in



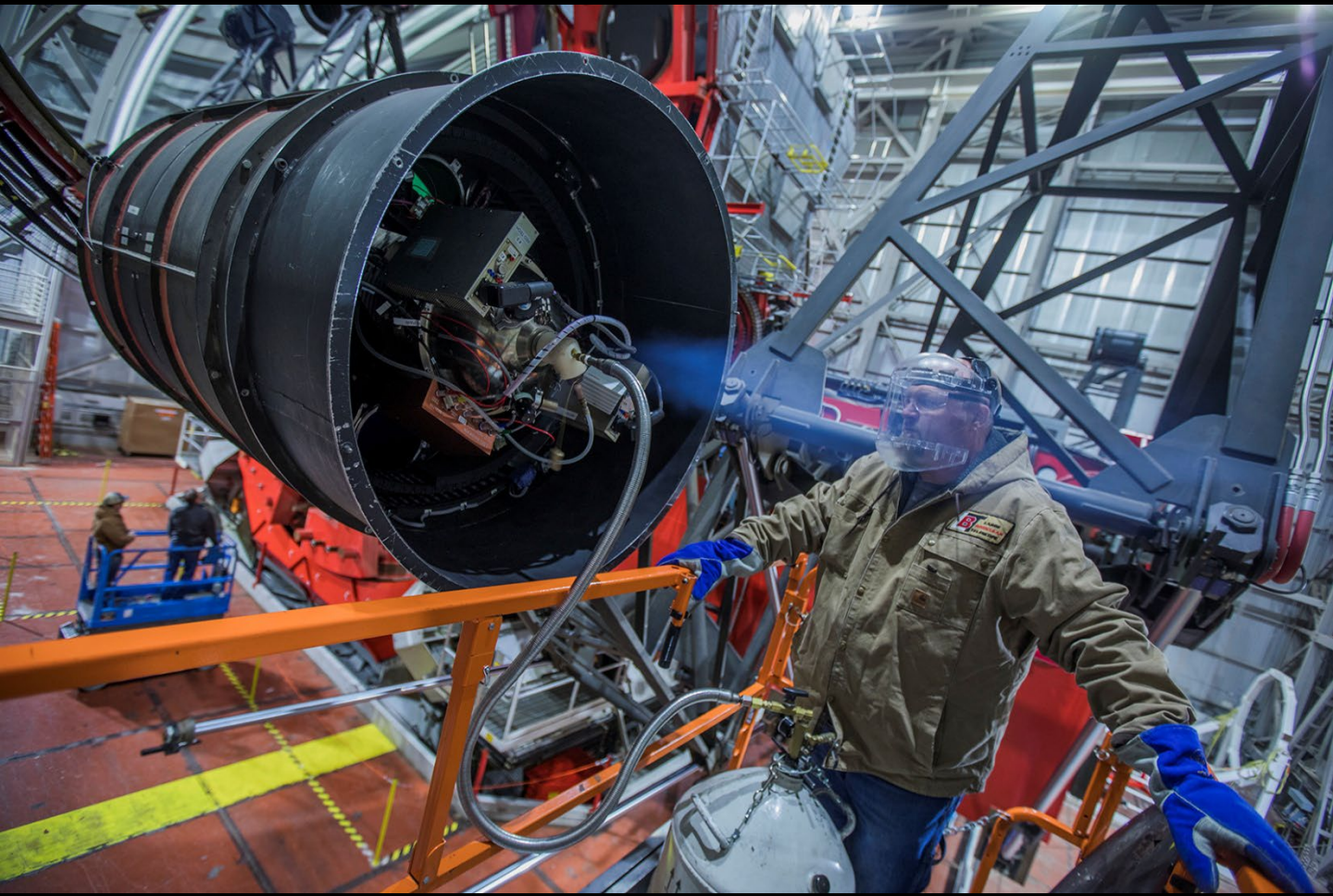
Hale Telescope,
CA, USA – 60in

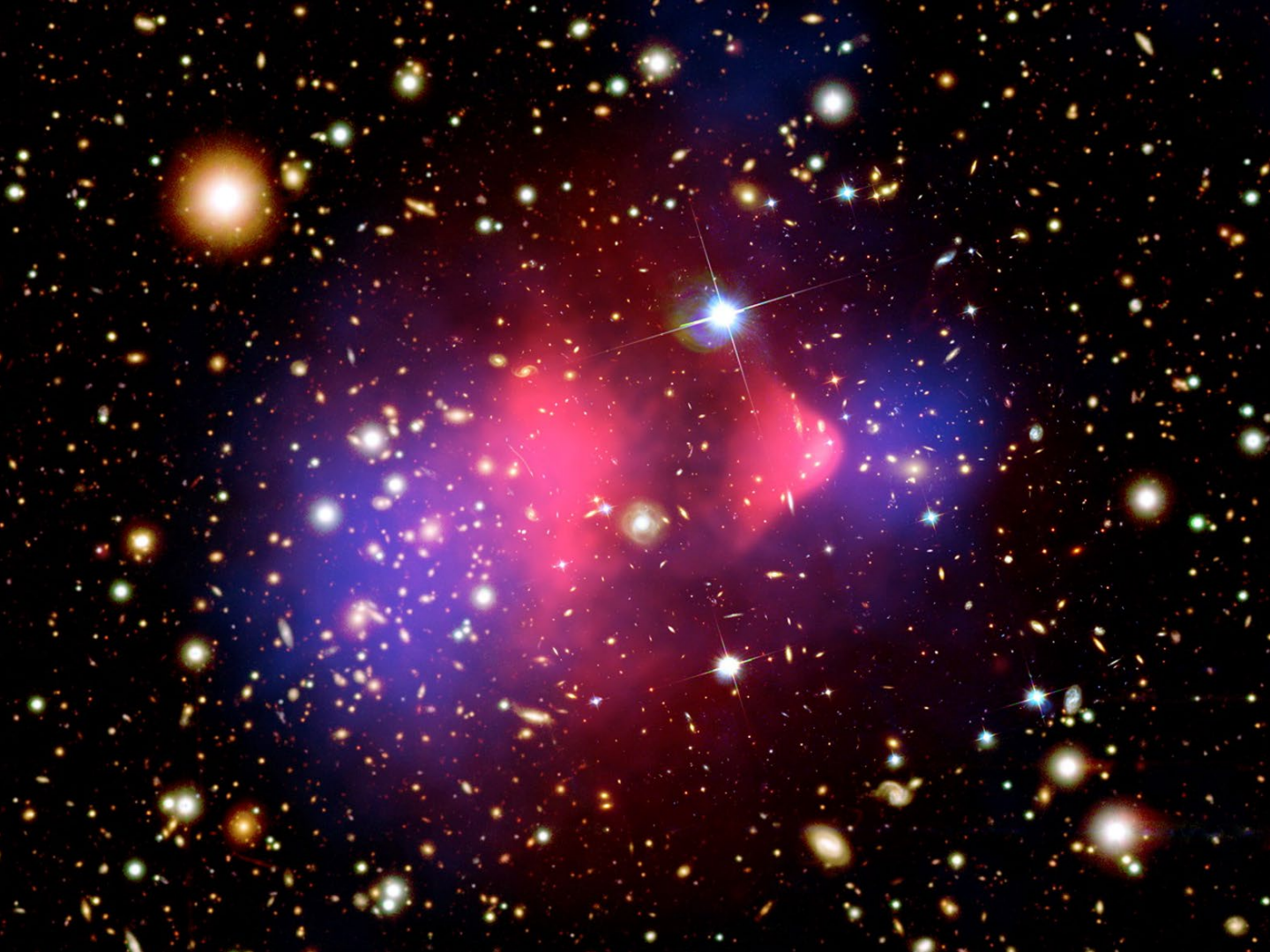


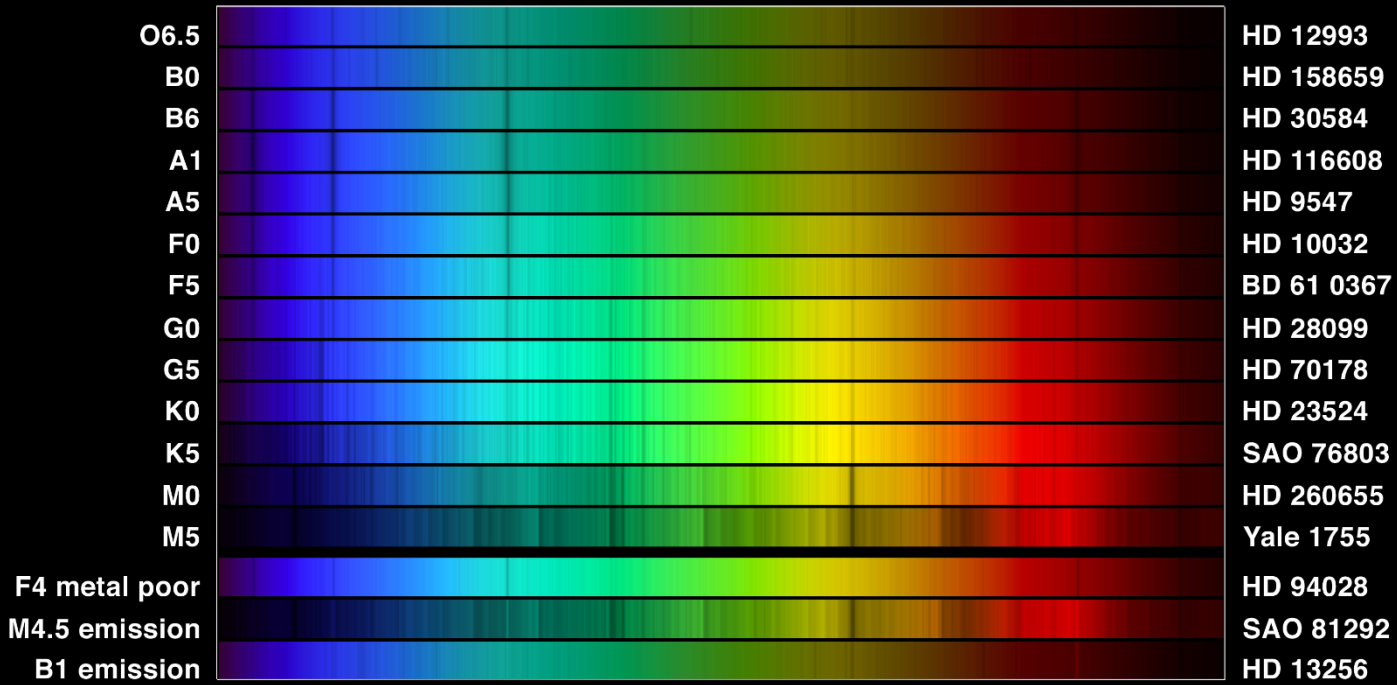
Large Binocular Telescope, AZ, USA – 2 × 8.4m




OVERSIZE LOAD



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B6
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M5
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M4.5 emission
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HD 28099
HD 70178
HD 23524
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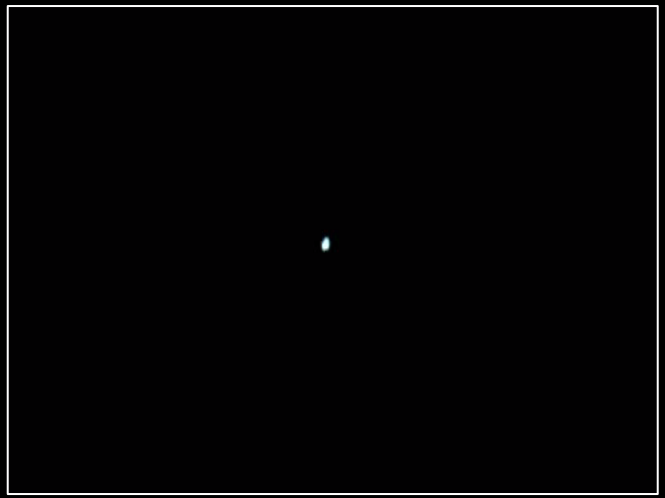
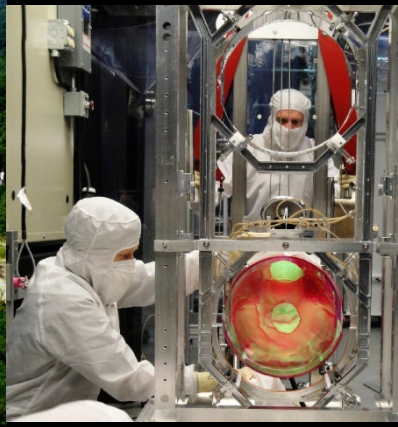
HD 260655
Yale 1755
HD 94028
SAO 81292
HD 13256

The problem with ground-based telescopes

- We have an atmosphere...





BBC NEWS

Science & Environment

Einstein's waves win Nobel Prize in physics

By Paul Rincon and Jonathan Amos
BBC Science News

3 October 2017 | Science & Environment

Weiss (L) tak … Thorne (C) and Barish (R) share the other half

The 2017 N… the detecti…

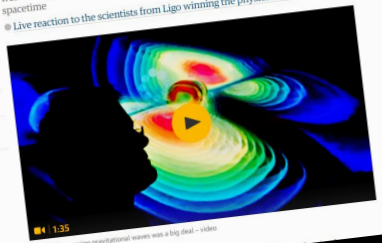
theguardian

Nobel prizes

Nobel prize in physics awarded for discovery of gravitational waves

£825,000 prize awarded to Rainer Weiss, Barry Barish and Kip Thorne for their work on Ligo experiment which was able to detect ripples in the fabric of spacetime

Live reaction to the scientists from Ligo winning the physics Nobel



20,397 283

Hannah Devlin and Ian Sample

Tuesday 3 October 2017 11.31 EDT

Nobelprize.org

The Official Web Site of the Nobel Prize

Nobel Prizes and Laureates

The Nobel Prize in Physics 2017

Rainer Weiss, Barry C. Barish, Kip S. Thorne

KUNGL. VETENSKAPS-AKADEMIEN

THE ROYAL SWEDISH ACADEMY OF SCIENCES

Press Release: The Nobel Prize in Physics 2017

3 October 2017

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Physics 2017 with one half to

Rainer Weiss
LIGO/VIRGO Collaboration

and the other half jointly to

Barry C. Barish
LIGO/VIRGO Collaboration

and

Kip S. Thorne
LIGO/VIRGO Collaboration

"for decisive contributions to the LIGO detector and the observation of gravitational waves"

Gravitational waves finally captured

On 14 September 2015, the universe's gravitational waves were observed for the very first time. The waves, which were predicted by

2017 Nobel Laureates

2017 PHYSICS PRIZE QUESTION

Did you know that gravitational waves were predicted by Albert Einstein a hundred years ago?

Yes No

Nobel Prize Lessons

Discover features and trivia about the Nobel Prize

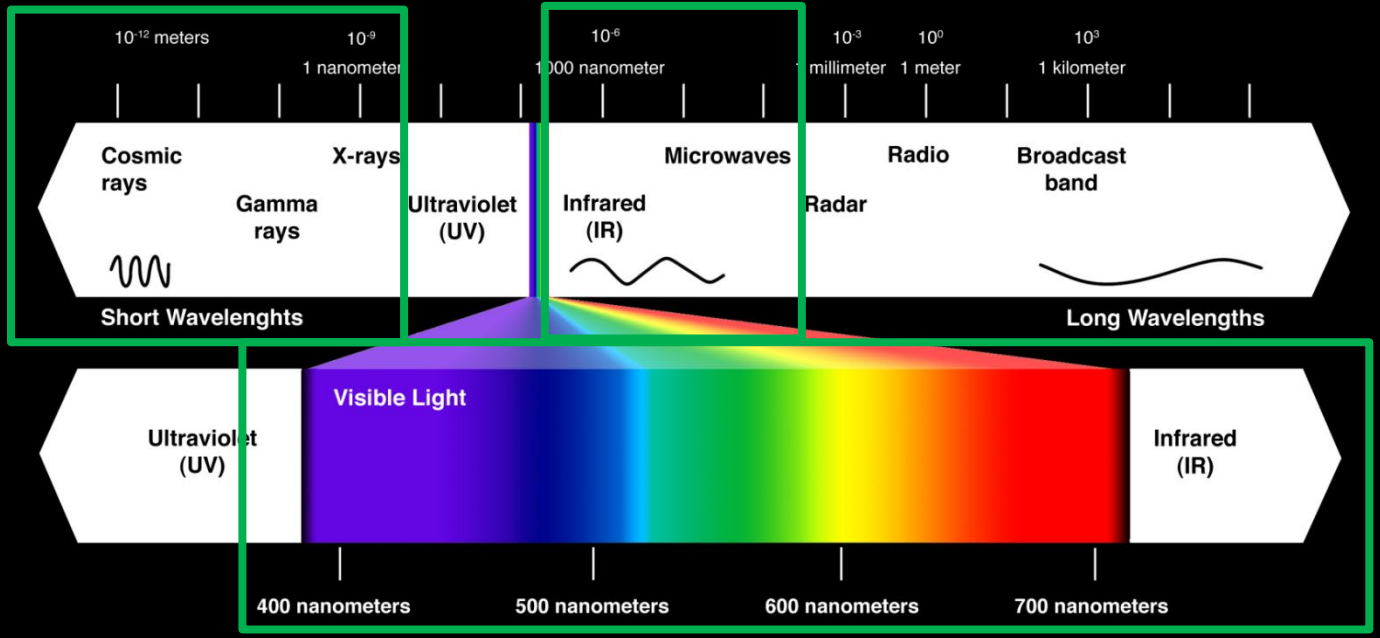
Sign up for Nobelprize.org Monthly

The New York Times

2017 Nobel Prize in Physics Awarded to LIGO Black Hole Researchers

Rainer Weiss, a professor at the Massachusetts Institute of Technology, and Kip Thorne and Barry Barish, both of the California Institute of Technology, were awarded the Nobel Prize in Physics on Tuesday for the discovery of ripples in space-time known as gravitational waves, which were predicted

Space Telescopes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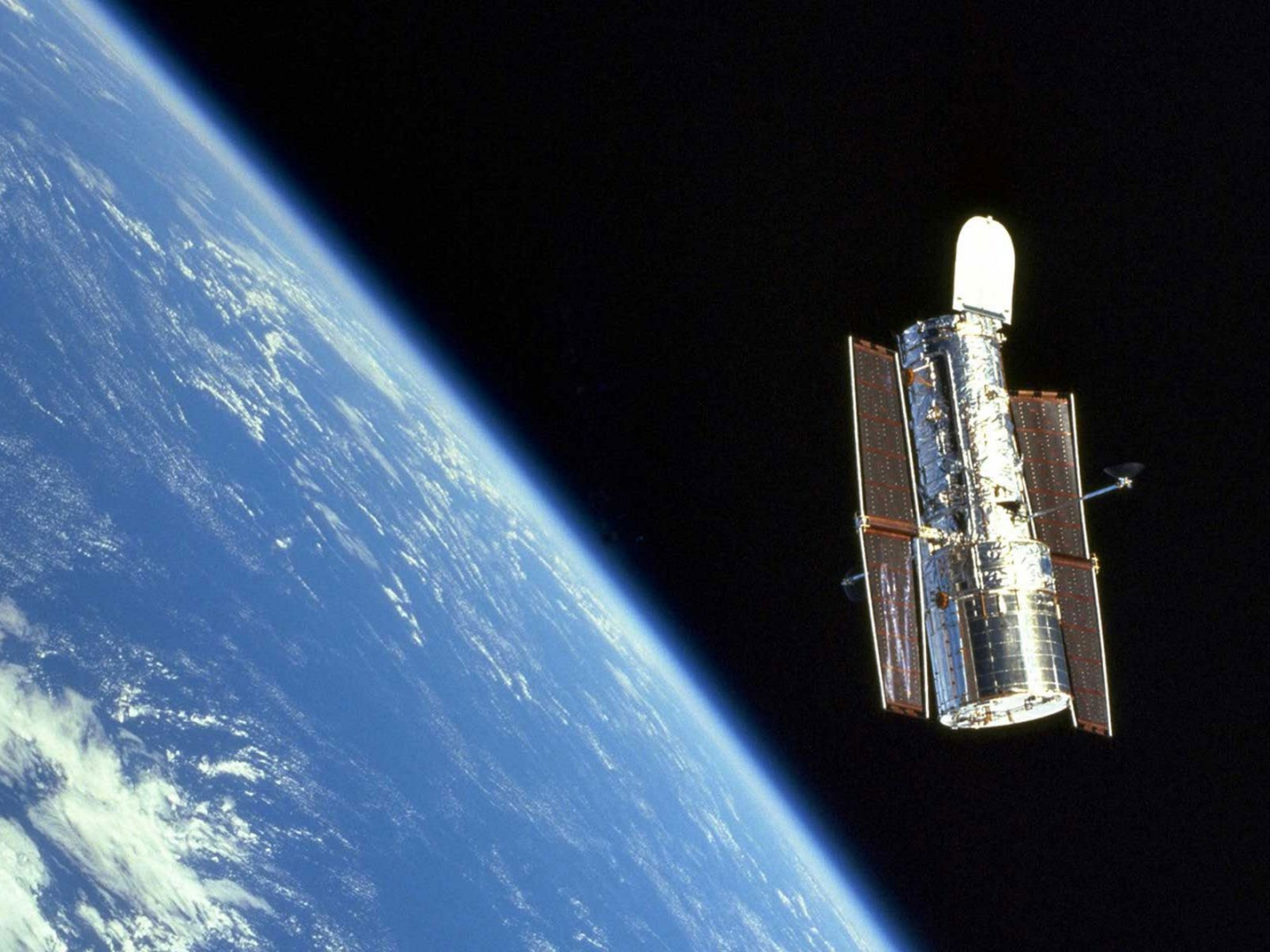

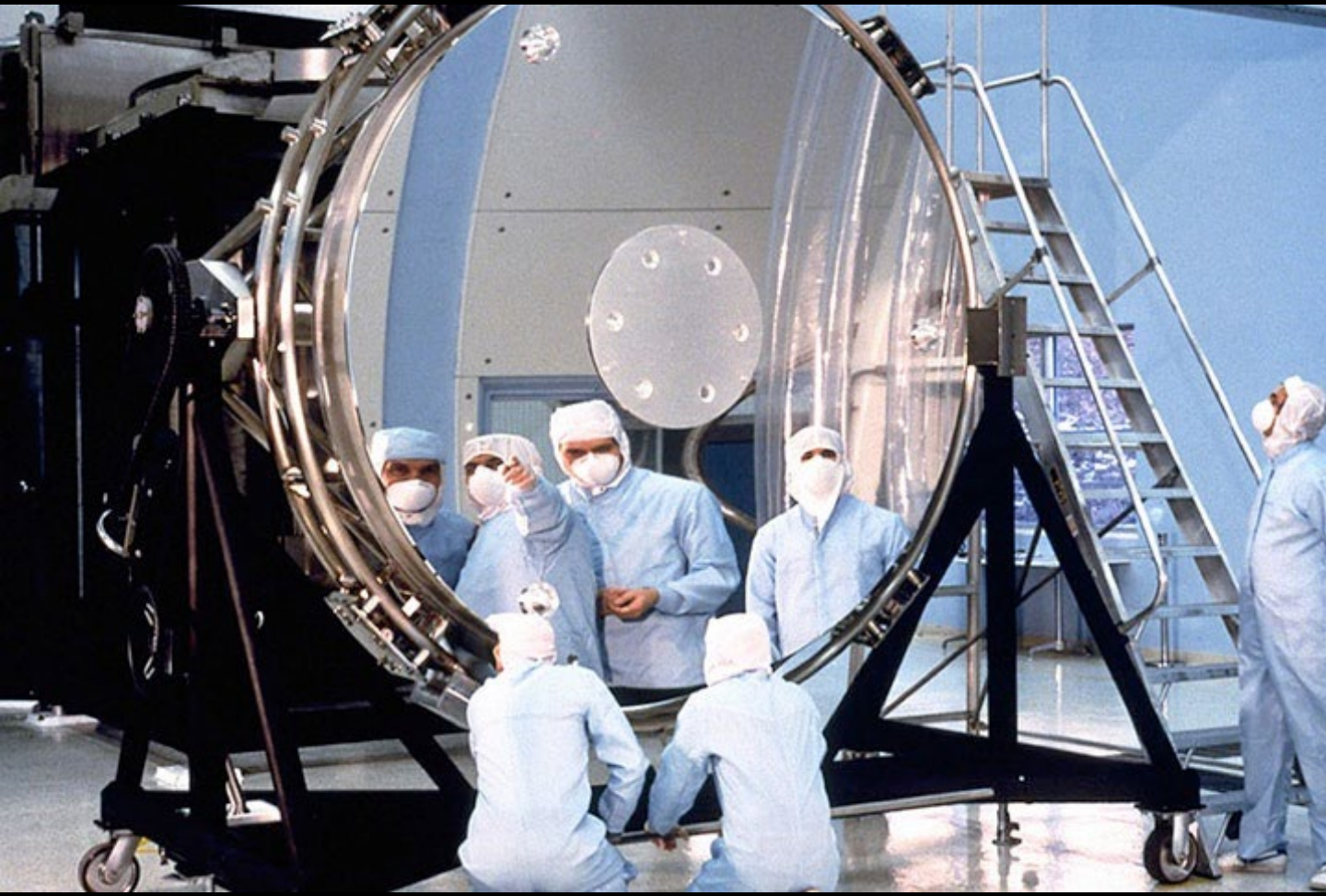

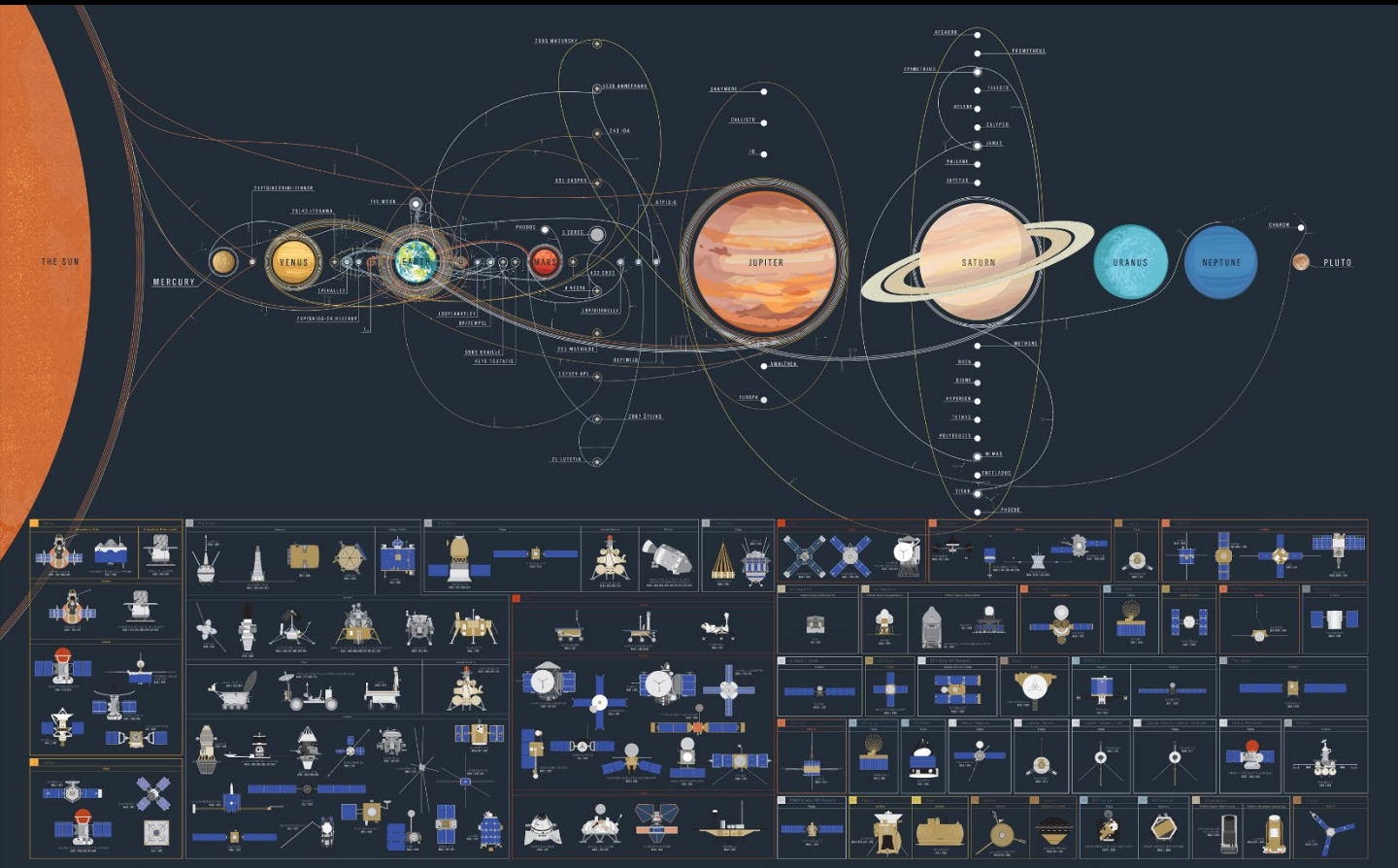
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ACHAEON
PROMETHEUS
PANDORA
TELESTO
HELENE
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PALLENE
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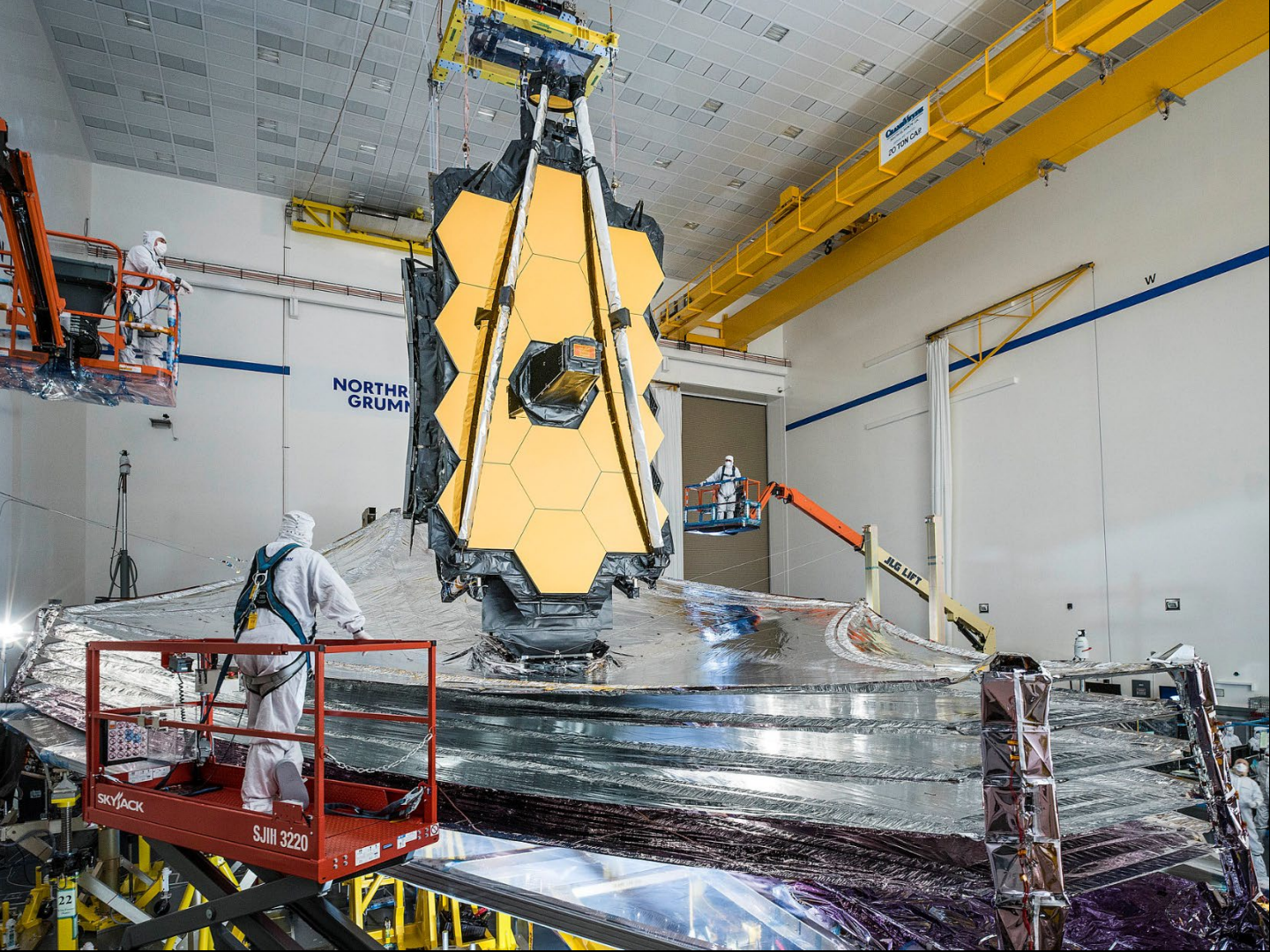
POLYDEUCES
MIMAS
ENCELADUS
TITAN
PHOEBE
URANUS
NEPTUNE
CHARON
PLUTO
THE CHART OF COSMIC EXPLORATION

The James Webb Space Telescope (JWST)


JAMES WEBB SPACE TELESCOPE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JLG LIFT

Measuring the Heavens

The Tools and People of Astronomy

Dr Jonathan Crass

The Ohio State University

Royal Astronomical Society