# History of Infrared Astronomy

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# Outline

Introduction: Why Infrared Matters

NVG IR Demo

False Starts

Problems Overcome During Implementation

Breakthrough in the 1960s

Basic Technology Involved

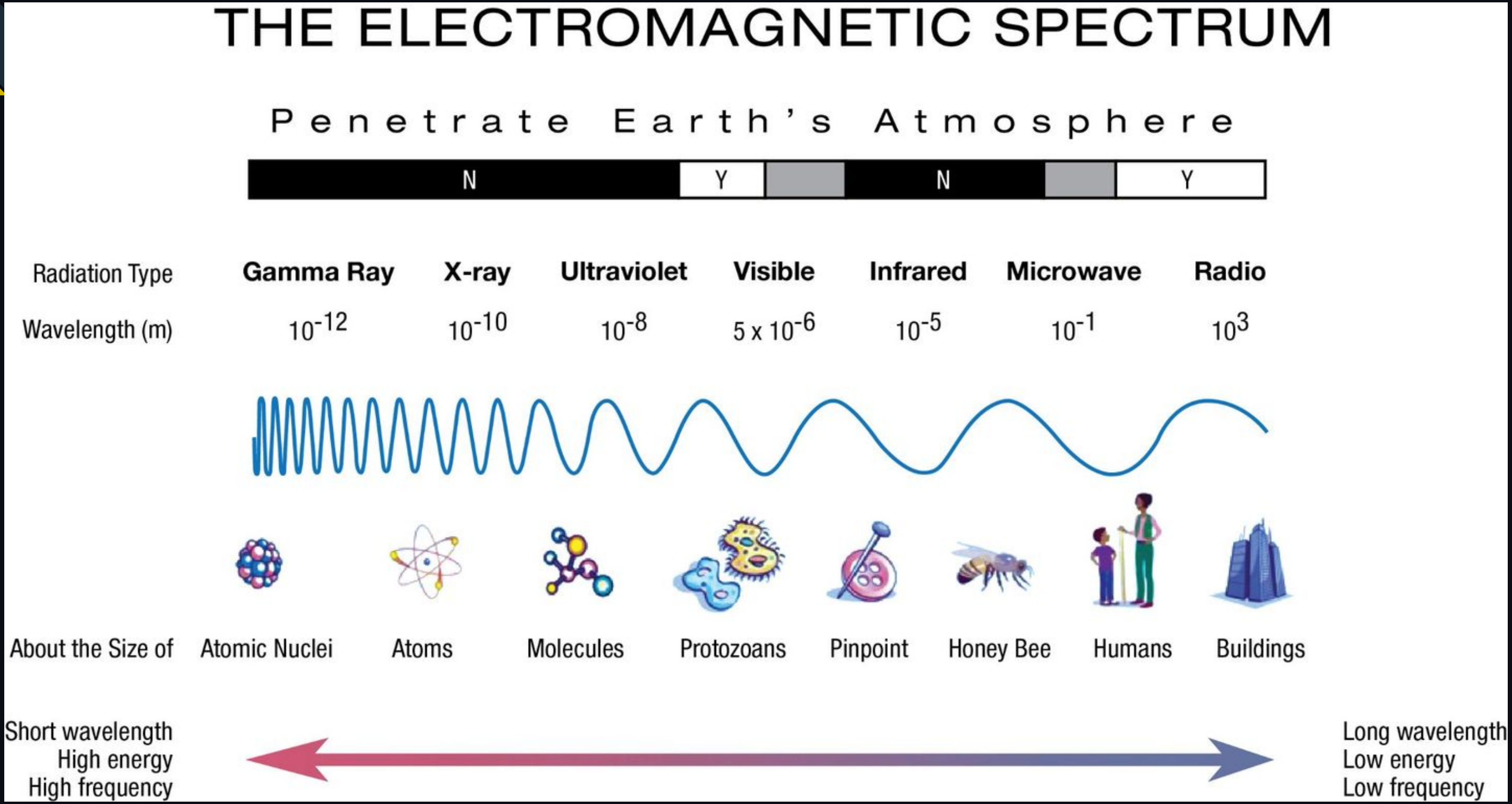
Expanding the Field (1970s–1990s)

Modern Missions

The Impact of Infrared Astronomy

Conclusion

# Introduction: What is Infrared?




https://mynasadata.larc.nasa.gov/basic-page/electromagnetic-spectrum-diagram

# Introduction: Why does Infrared matter?

- By detecting objects in the infrared spectrum we can see objects we wouldn’t normally be able to see (distant, cool, dust obscured) [1]
- EM radiation wavelengths get longer when objects cool or are red-shifted
- Any objects between 3K and ~3700K have a peak wavelength in the infrared (By Wien’s Displacement Law)

# NVG IR Demonstration

- Visible vs infrared light
- Night vision shows reflected near-IR
- Demonstrates how IR reveals what visible spectrum can’t

# NVG IR Demonstration

# Infrared timeline 1800s

1800

**Herschel**

Discovered infrared radiation using a prism and thermometers [3]

1820-30s

**Nobili & Melloni**

Create a device to measure heat from distance (Thermomultiplier) [4]

1856

**Charles Piazzi Smyth**

Determines that detection is easier from higher elevations[3]

1869

**Huggins**

Uses very sensitive thermomultplier to measured the moon successfully, stars potentially [5]

1870

**4th Earle of Rosse**

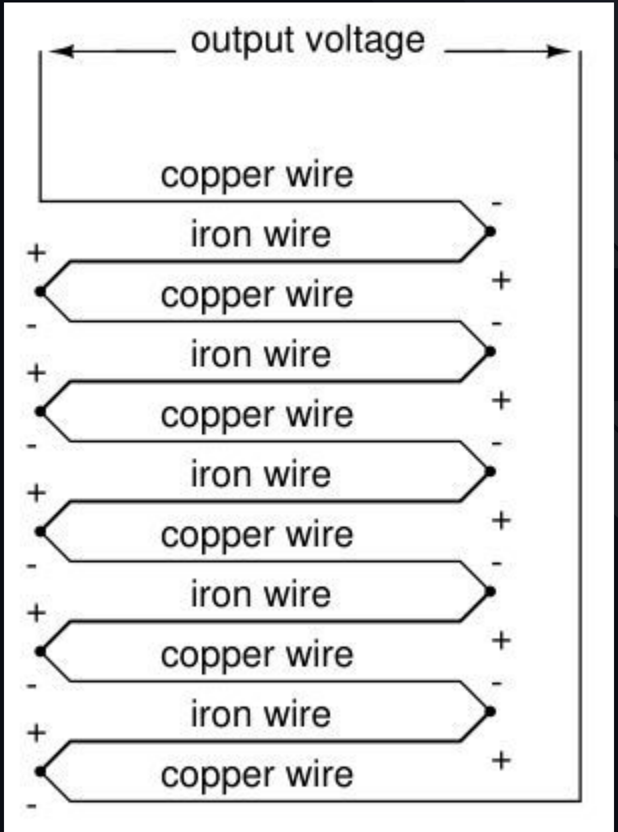
Estimates Moons surface temperature using infrared detections during phases [6]

1878-80

**Langley, Edison**

Invents the bolometer, a resistance based IR detector [7], also edison and his tasimeter[8]

# Thermopile




https://en.wikipedia.org/wiki/Thermopile

# Infrared timeline 1800s

| 1800 | 1820-30s | 1856 | 1869 | 1870 | 1878-80 |
|---|---|---|---|---|---|
| Herschel | Nobili & Melloni | Charles Piazzi Smyth | Huggins | 4th Earle of Rosse | Langley, Edison |
| Discovered infrared radiation using a prism and thermometers [3] | Create a device to measure heat from distance (Thermomultiplier) [4] | Determines that detection is easier from higher elevations[3] | Uses very sensitive thermomultplier to measured the moon successfully, stars potentially [5] | Estimates Moons surface temperature using infrared detections during phases [6] | Invents the bolometer, a resistance based IR detector [7], also edison and his tasimeter[8] |

# Infrared timeline (1900-1960)

1900

### Astronomers

Able to calculate planet diameters,temperature of sunspots, still using thermomultipliers

1913-1915

### Coblentz

Made vast improvements to thermocouple detectors also laid the foundation for infrared spectroscopy [2]

1920-30s

### Pettit & Nicholson

Use vacuum thermocpuples with telescope and photographic plates[2]

1939-44

### WW2

WW2 brings in technological advances like night vision and lead sulphide detectors [2]

1950s

### PbS Detectors

Lead Sulphide detectors reach the hands of civialians after ww2 [2]

1960s-onwards

### The Beginning

Field takes off and expands rapidly into what we now know today as infrared astronomy

# False Starts

01 Huggins and Stone’s thermopile stellar detections

02 Edison’s Tasimeter

03 Boys radiometer and IR-optimized telescope

04 Nichols, Coblentz, Pettit and Nicholson

# Problems Overcome During Implementation

01 Detector Thermal Noise

02 Earth’s Atmosphere Blocks Most IR

03 Early Detectors Were Extremely Insensitive

04 Calibration and Standardization Problems

05 Mechanical Instability

06 Data Processing and Atmospheric Correction

# Technological Advances

- Photon vs thermal detectors
- Photoconductivity and the photoelectric effect
- Semiconductor materials define the wavelength
- Military tech → astronomy
- Band-gap engineering (HgCdTe)
- IR arrays → Moore's law trend

Rieke, G.H. 'History of infrared telescopes and astronomy'. Experimental Astronomy, 2009, vol. 29, p. 125-141.
Rogalski, A. 'History of infrared detectors'. Opto-Electronics Review, 2012, Vol. 20(3), p. 279-308

# Breakthrough in the 1960s

- “New Start” inspired by radio astronomy
- Johnson’s 1962 IR photometry system
- Wildey & Murray’s 1963 differential measurements
- First protostar discovered via IR (1967)
- IR discovery of the Galactic Center (1968)
- 2-micron sky survey (1969)
- First airborne and space IR attempts

Rieke, G.H. ‘History of infrared telescopes and astronomy’. Experimental Astronomy, 2009, vol. 29, p. 125-141.
Johnson, H.L. ‘Infrared Stellar Photometry’. Astrophysical Journal, 1962, vol. 135, p. 69-77.
Becklin, E.E., Neugebauer, G. ‘Observations of an infrared star in the Orion nebula’. Astrophysical Journal, 1967, vol. 147, p. 799-802.

# IR takes flight (1970s–1990s)

- Growth of airborne IR astronomy
- Strong community of IR researchers
- Detector technology improving rapidly
- Ground-based IR observatories expand


https://www.nasa.gov/aeronautics/history-of-airborne-astronomy-at-nasa/

# Galileo Airborne Observatory

Modified **Convair 990** aircraft

- First mission: **1965** solar eclipse, where **Jupiter's moons** were observed from the aircraft
- **Kuiper** used it for near infrared studies of **Venus & Mars**
- Aircraft lost in a **mid-air collision**, second Galileo used only briefly

https://www.nasa.gov/aeronautics/history-of-airborne-astronomy-at-nasa/

# Learjet Observatory

**Learjet 24B** with a small IR telescope flown at **13 km** altitude (42,000 feet)

- Demonstrated that high altitude aircraft could do mid infrared astronomy
- Used early gyro-stabilized telescope platforms
- Required lightweight cryogenic cooling systems

https://www.nasa.gov/aeronautics/history-of-airborne-astronomy-at-nasa/

# Kuiper Airborne Observatory (KAO)

Modified **Lockheed C-141A** carried a **0.9m** IR telescope.

- Redesigned with open telescope cavity, pressure bulkhead.
- A stabilized telescope system maintained steady pointing.
- Crew ~20 operated the aircraft, instruments, data systems.
- **Major discoveries**:
  - Pluto's atmosphere,
  - Uranus's rings,
  - ring of star formation center of Milky Way,
  - water in comets and in Jupiter's atmosphere, and more!

https://en.wikipedia.org/wiki/Airborne_observatory

# SOFIA
## Stratospheric Observatory For Infrared Astronomy


Modified **Boeing 747SP** with a **2.7m** IR telescope.

- Flew above 99% of atmospheric water vapor, enabling mid and far infrared access.
- Mobility allowed observation of rare events over oceans and remote regions.
- Studied star formation, planetary systems, molecular clouds, and galactic centers.

https://www.nasa.gov/aeronautics/history-of-airborne-astronomy-at-nasa/

# Space Infrared Astronomy (2000s–Present)

- **IRAS**: first all-sky IR survey
- **Spitzer**: cryogenic IR imaging
- **Herschel**: far-IR observatory
- **JWST**: gold standard for IR astronomy

https://www.nasa.gov/aeronautics/history-of-airborne-astronomy-at-nasa/

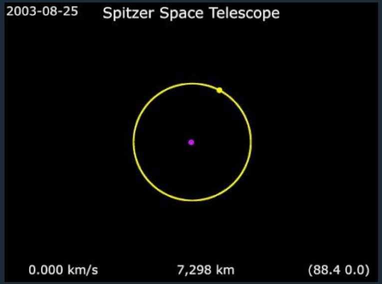
# **IRAS** (Infrared Astronomical Satellite)

First infrared space telescope to perform a full sky survey **57 cm**

- A **cryostat** to keep detectors ~10 Kelvin for ~**1 year**
- Eliminated atmospheric noise and detector self emission
- Discovered infrared galaxies and dusty disks around stars
- Pioneered early IR detector arrays for wide sky mapping

https://en.wikipedia.org/wiki/IRAS

# **Spitzer** Space Telescope

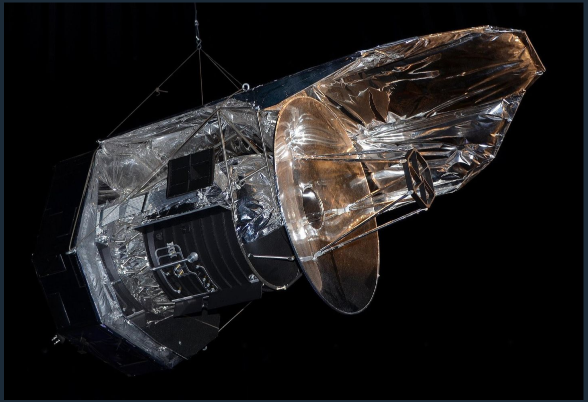



Groundbreaking mid-infrared telescope with long-duration cryogenic cooling **0.85m**

- First mission to directly detect exoplanet infrared light.
- Large format infrared arrays enabled deep observations of faint galaxies.
- Used lightweight beryllium mirrors for stability at very low temperatures.
- Continued in warm mission mode after coolant depletion.

https://en.wikipedia.org/wiki/Spitzer_Space_Telescope

# Herschel Space Observatory

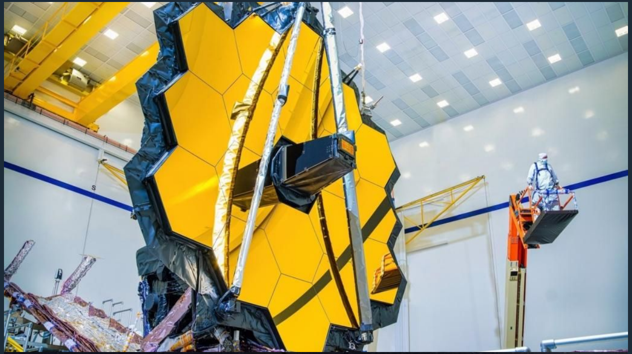


ESA mission largest space infrared mirror **3.5m**

- Operated in far-infrared and submillimeter wavelengths, revealing the universe's coldest, dustiest regions.
- Required cooling large telescope near absolute zero at L2.
- Pioneered far-infrared spectroscopy using advanced silicon bolometers.

https://en.wikipedia.org/wiki/Herschel_Space_Observatory

# **JWST** (James Webb Space Telescope)




Most powerful infrared telescope built **6.5m**

- Uses 18 segmented **gold** coated **beryllium** mirrors
- Five layer **Kapton** sunshield blocks heat and light
- Positioned at the **L2 point**
- Enables studies of early galaxies, exoplanets, and detailed star formation

https://www.planetary.org/articles/jwst-launch-guide

# The Impact of Infrared Astronomy

- Reveals objects hidden by dust
- Tracks star formation & protostars
- Maps early universe structure
- Helps measure redshift and galaxy evolution

# Conclusion

- Infrared opened an entirely new window on the universe
- Revealed objects and processes hidden from optical astronomy
- Progress came from technology and astronomy advancing together
- Today infrared observations are essential to understanding cosmos