

Telescopes Across the Electromagnetic Spectrum:

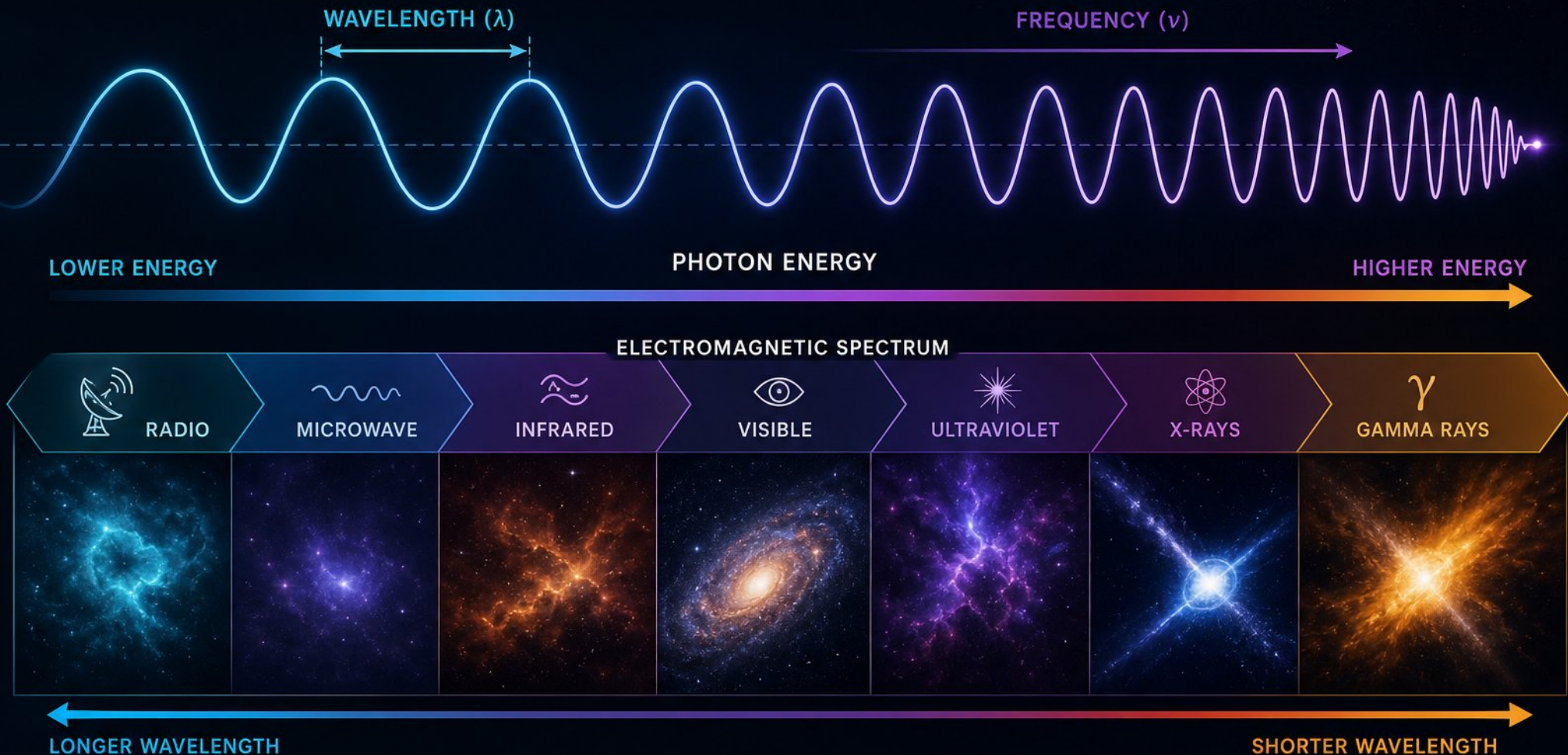
Seeing the Invisible Universe

- Electromagnetic spectrum spans radio waves to gamma rays
- Wavelength determines which physical processes are detectable
- No single telescope can observe the entire spectrum
- Seven wavebands: radio, microwave, infrared, visible, UV, X-ray, gamma
- Each section covers one waveband with real observatories



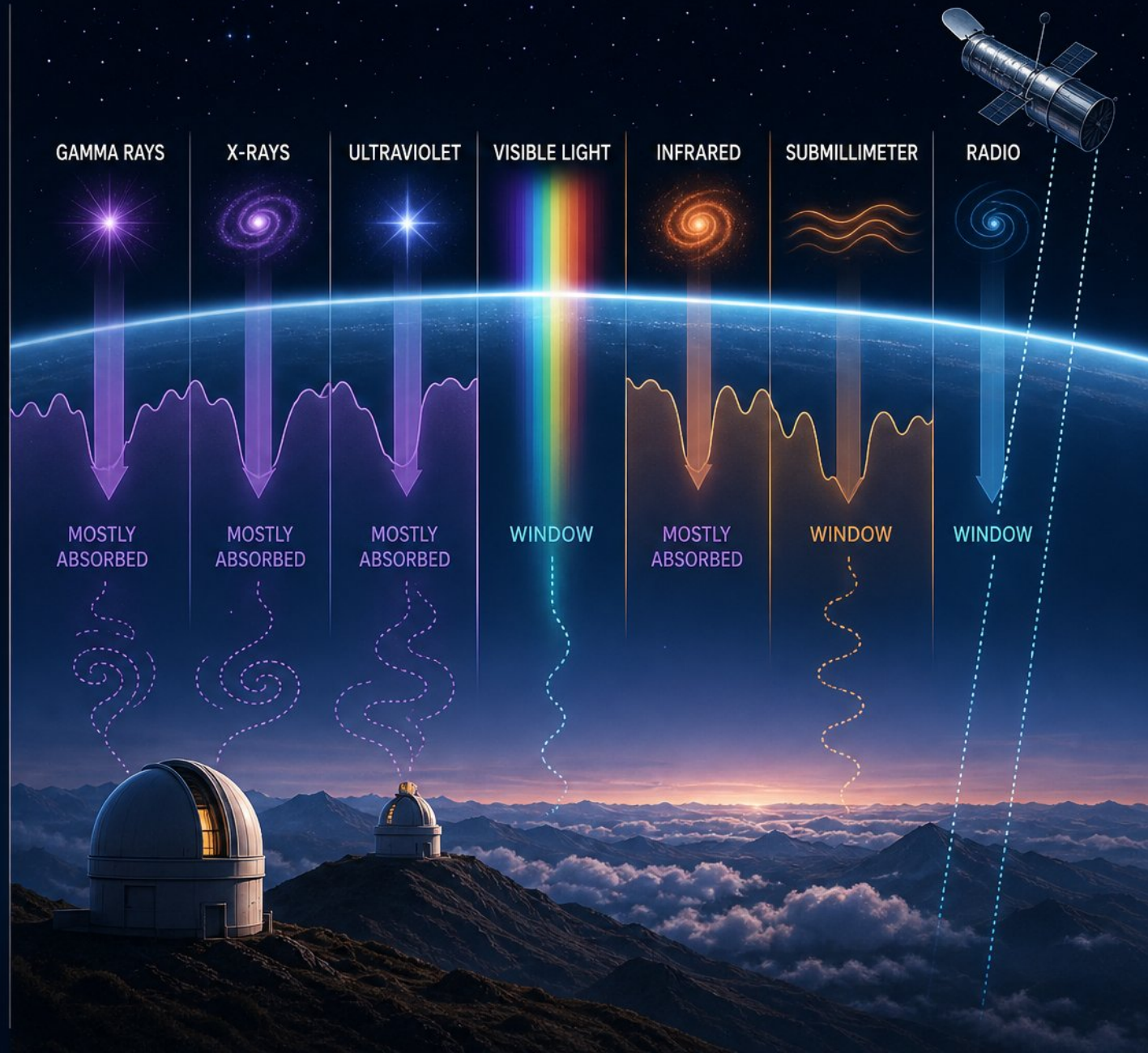
Why Wavelength Matters: How Light Carries Information

- Wavelength and frequency determine photon energy
- Temperature and physical processes set emitted wavelength
- Each waveband reveals specific physical conditions
- Cold gas glows in radio; dust in infrared; plasma in X-rays
- Multiwavelength astronomy combines all views of one object



Atmospheric Windows and the Ground vs. Space Decision

- - Optical and radio windows let radiation reach Earth's surface
- - Atmosphere absorbs most UV, infrared, X-ray, and gamma-ray light
- - Airglow and turbulence limit ground-based image quality and depth
- - High-altitude dry sites improve infrared and submillimeter access
- - Space telescopes offer darker skies, stable images, and wider wavebands



Radio Telescopes: Listening to the Cold Universe



- Large dishes and interferometer arrays act as one telescope



- Reveals neutral hydrogen, pulsars, cosmic microwave background, and cold gas



- Key observatories: VLA, ALMA, MWA, and SKA

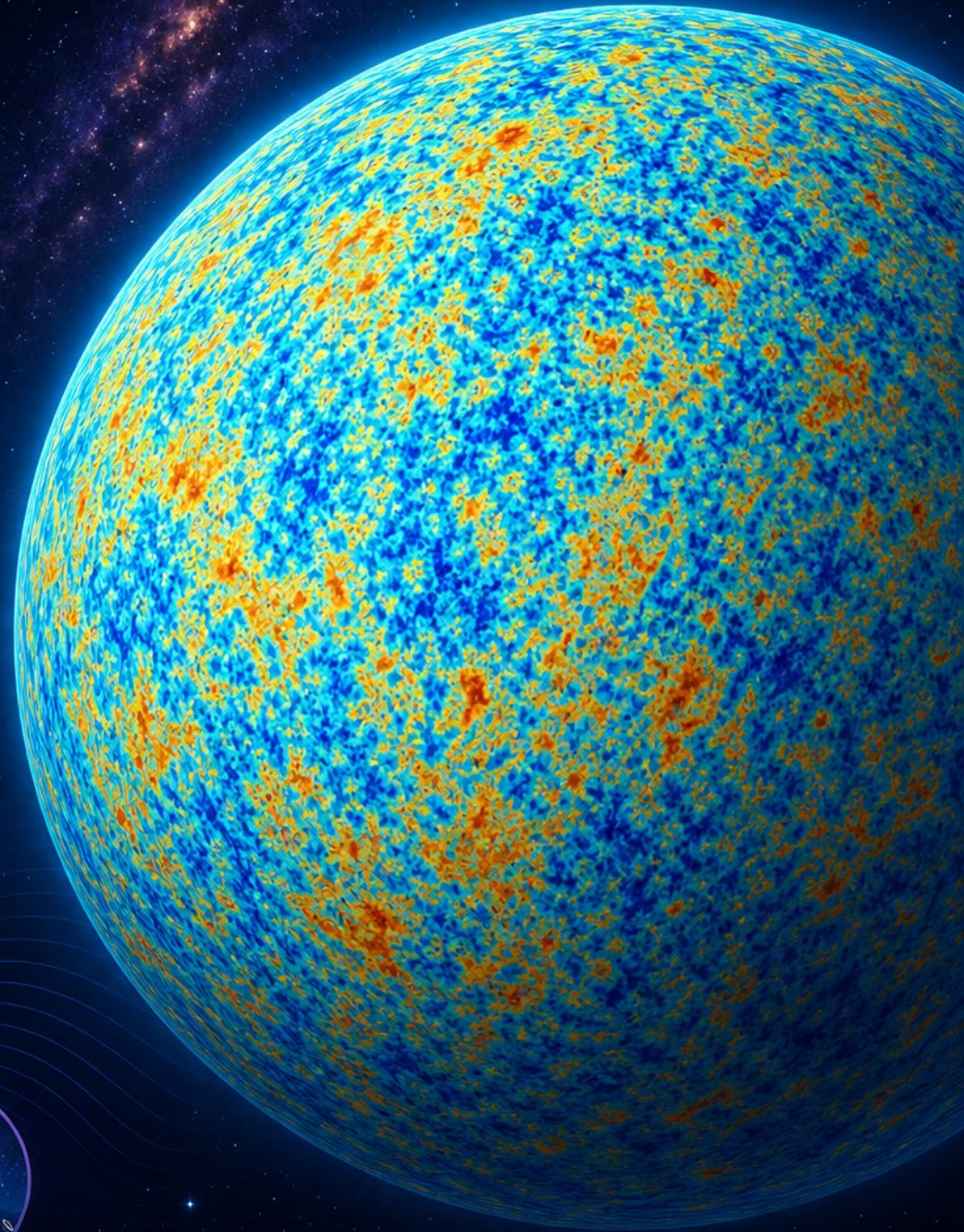


- Radio observations run day and night, even through cloud cover



Microwave and Submillimeter Astronomy: Echoes of the Early Universe

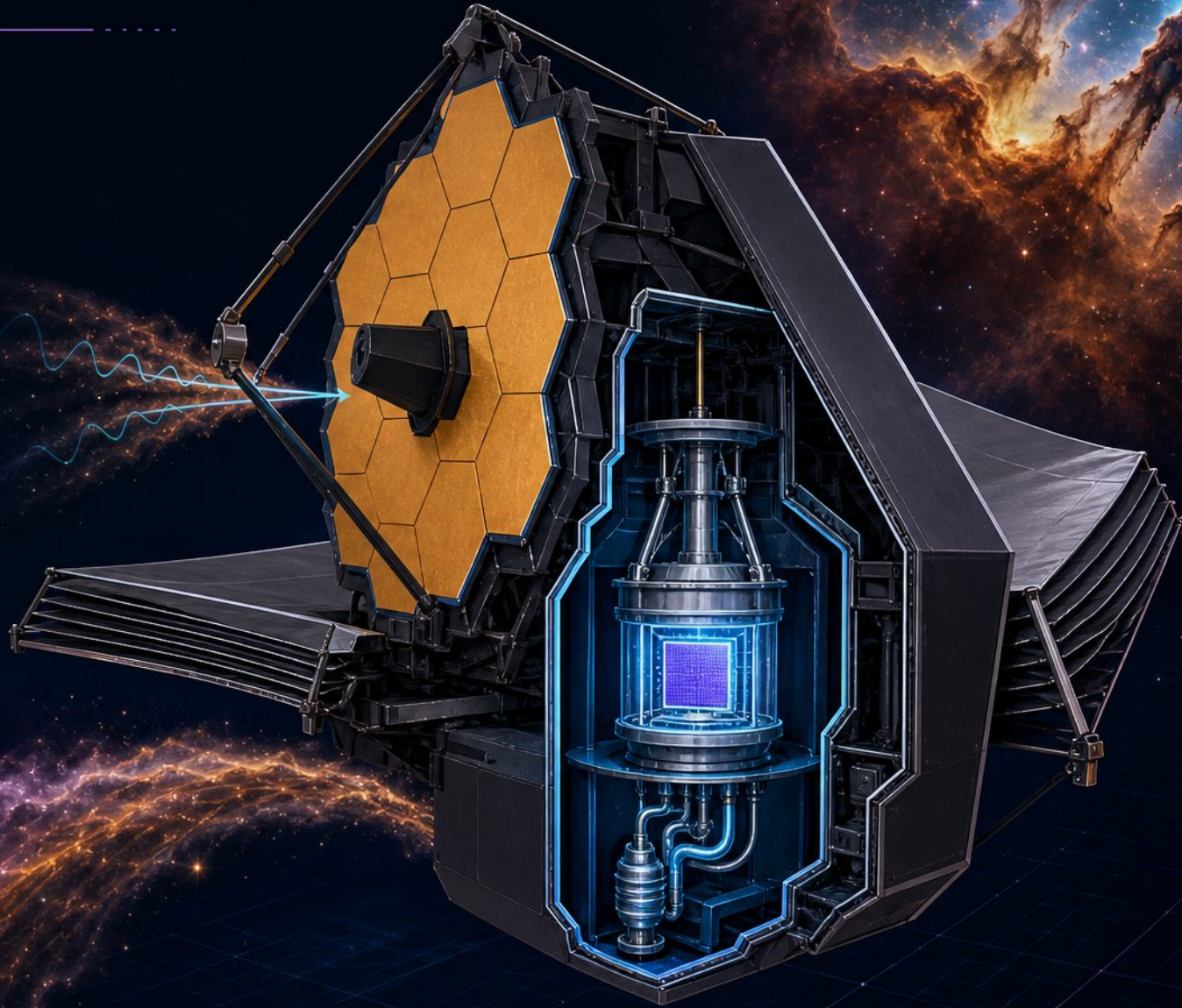
- Radio: longest wavelengths; microwave: CMB; submillimeter: cold dust
- CMB: relic Big Bang radiation, mapped by COBE, WMAP, Planck
- ALMA: 66 antennas study cold gas and star-forming regions
- High-redshift galaxies: warmer CMB suppresses detected flux
- Correcting for CMB prevents underestimating dust and gas mass



Infrared Telescopes:

Seeing Through Dust to Hidden Star Birth

- Infrared light penetrates interstellar dust that blocks visible light
- Reveals newborn stars, exoplanets, cool stars, and galactic centers
- Requires detector cooling and high-altitude or space-based placement
- JWST now leads; Spitzer and SOFIA paved the way



Visible and Ultraviolet Telescopes: From Hubble to the Hot Universe

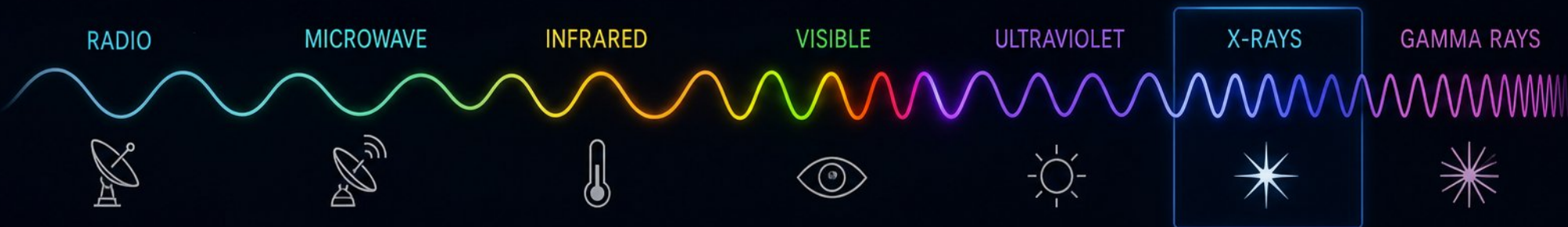
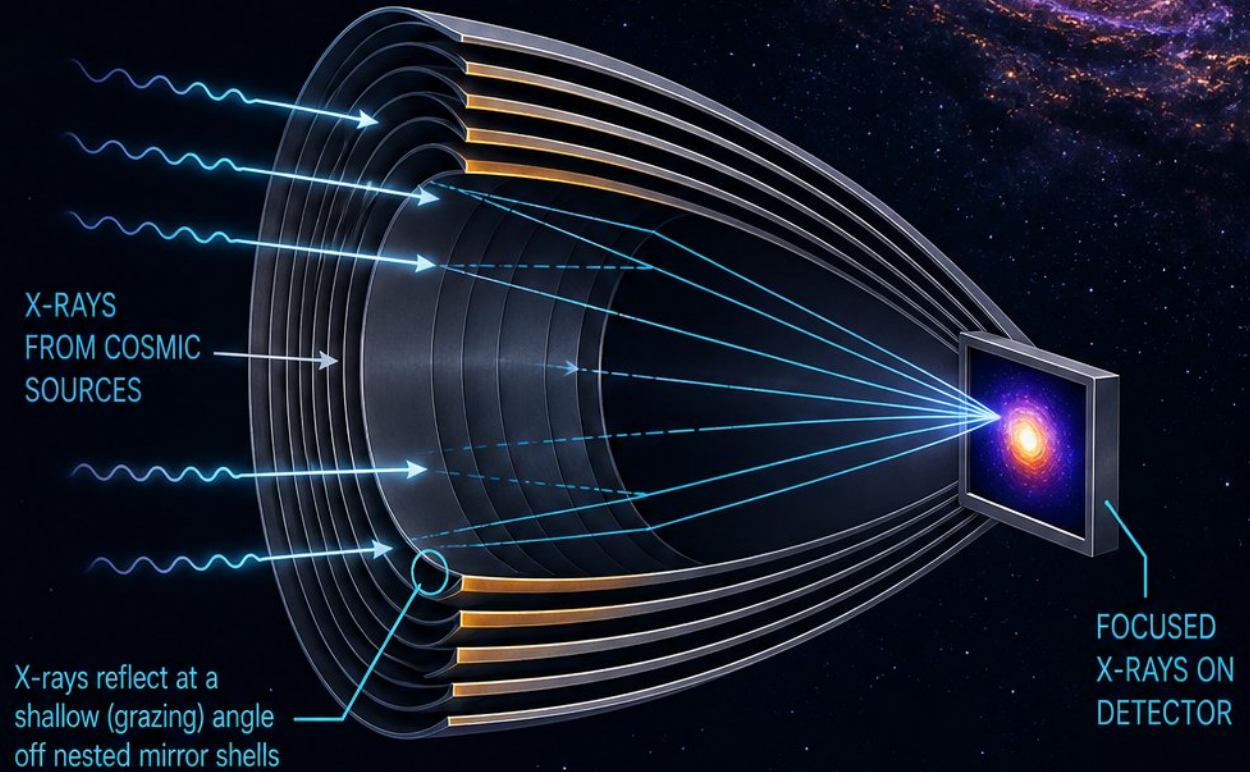
- Visible light is the historical foundation of telescope design.
- Ultraviolet reveals hot young stars, active galactic nuclei, and the interstellar medium.
- Hubble remains the workhorse for both visible and ultraviolet astronomy.
- A UV gap is coming before future missions arrive.
- UVEX, ULTRASAT, Spectr-UV, and Habitable Worlds Observatory will fill the gap.



X-ray Telescopes:

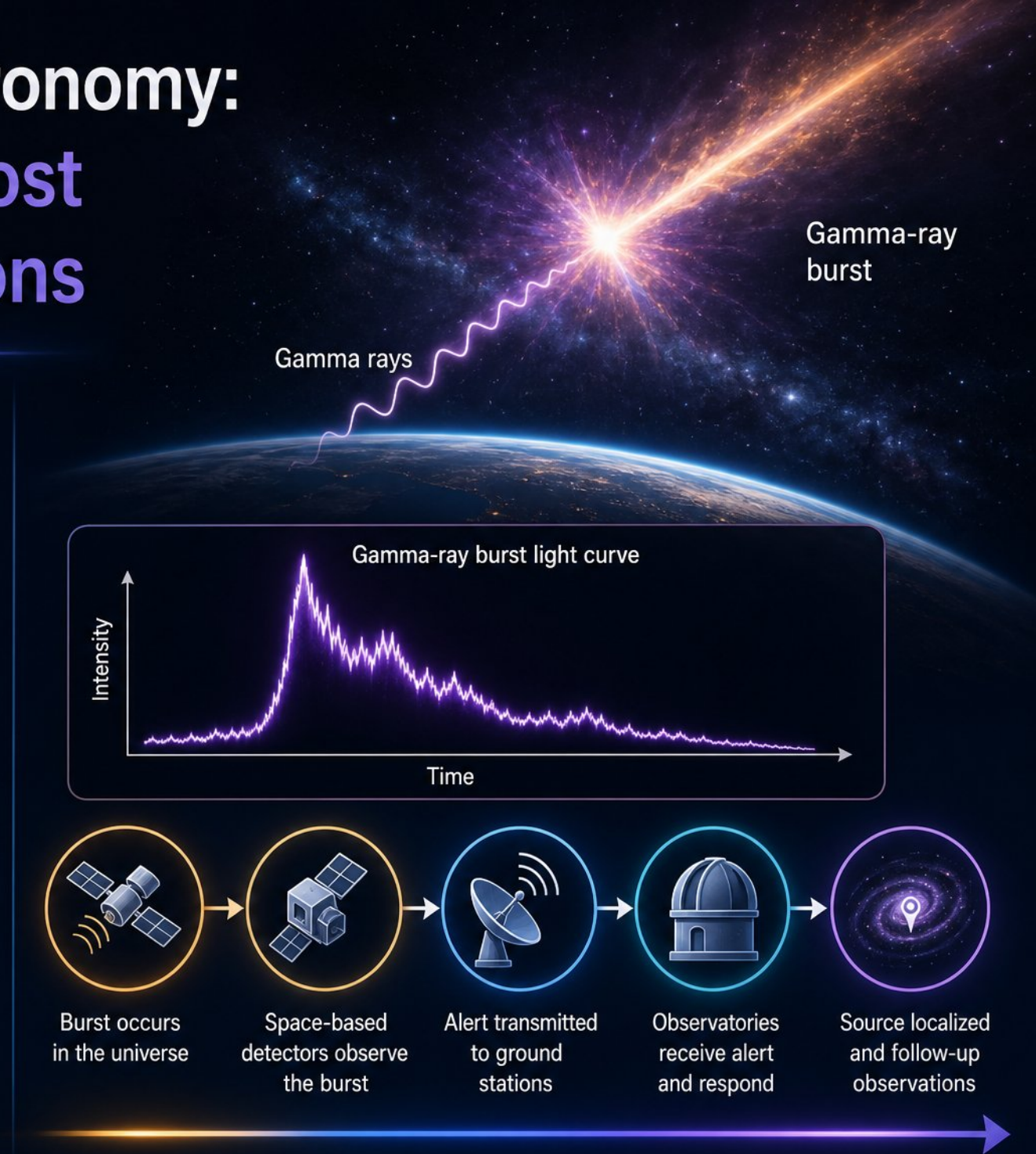
Probing Black Holes and Extreme Environments

- - X-rays need grazing-incidence mirrors and space-based platforms
- - Reveals black holes, neutron stars, supernova remnants, galaxy clusters
- - Chandra, XMM-Newton, NuSTAR remain the workhorses
- - Chandra found unexpected variable supernova remnants in M83
- - AXIS canceled, Lynx uncertain, ESA's NewAthena targets 2036-7



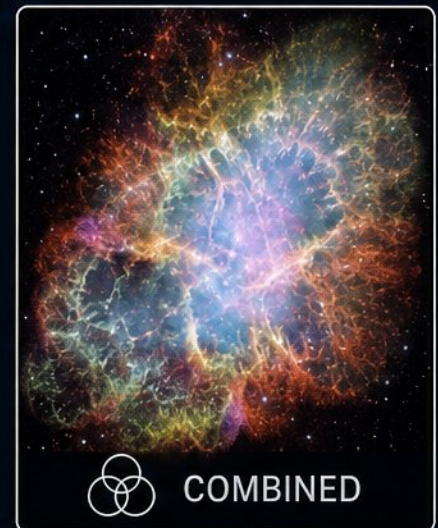
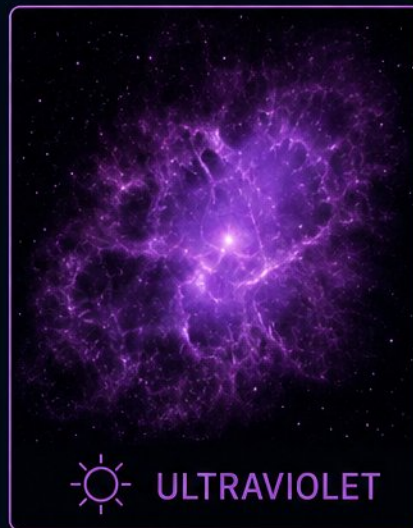
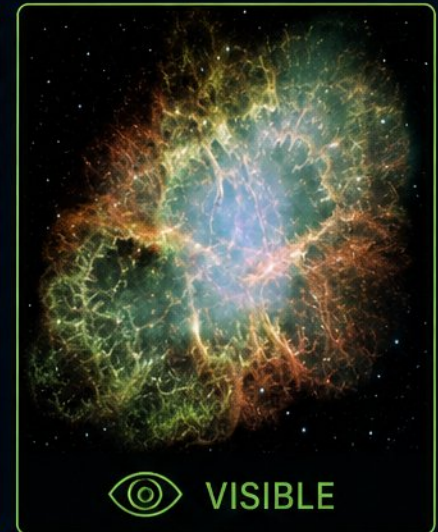
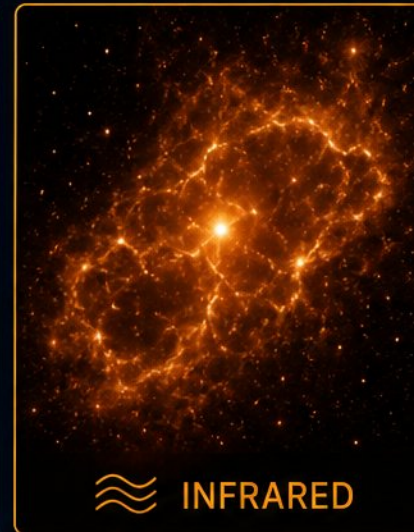
Gamma-ray Astronomy: Catching the Most Energetic Photons

- Gamma rays cannot be focused with conventional mirrors; they pass through or are absorbed.
- Cherenkov telescopes detect particle showers from gamma rays hitting Earth's atmosphere.
- Fermi's GBM and LAT detect bursts across 8 keV to 300 GeV.
- Gamma rays reveal gamma-ray bursts, pulsars, active galactic nuclei, and particle acceleration.
- New pipelines boost short GRB detections by about 50% and improve localization.



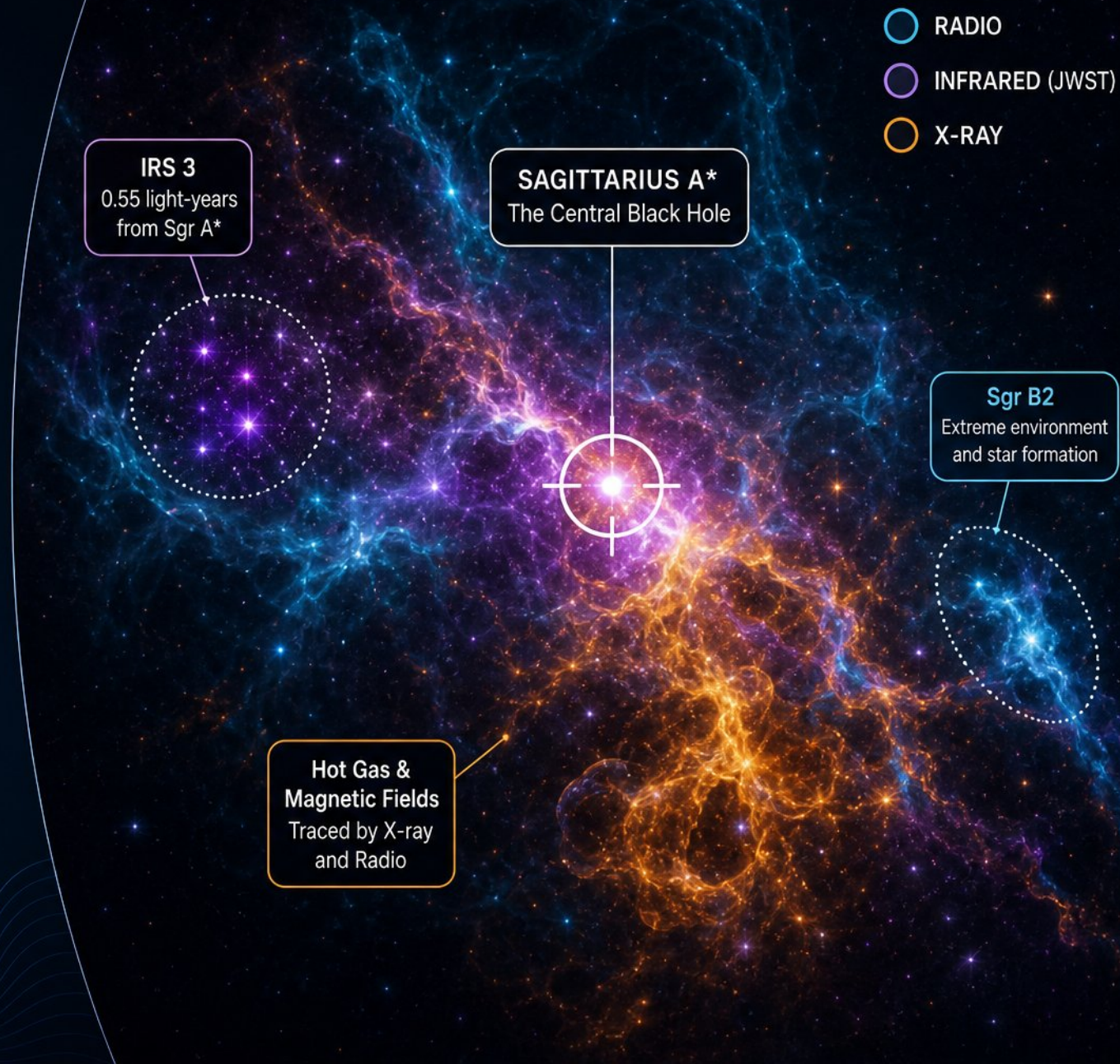
Multiwavelength Case Study: The Crab Nebula

- **Radio:** pulsar and electrons spiraling in magnetic fields
- **Infrared:** glowing dust and energetic electrons around the pulsar
- **Visible:** hydrogen filaments from the exploded star's outer layers
- **Ultraviolet and X-ray:** compact, high-energy emission near the neutron star
- Combined views map both remnant structure and the central pulsar



Multiwavelength Case Study: The Galactic Center

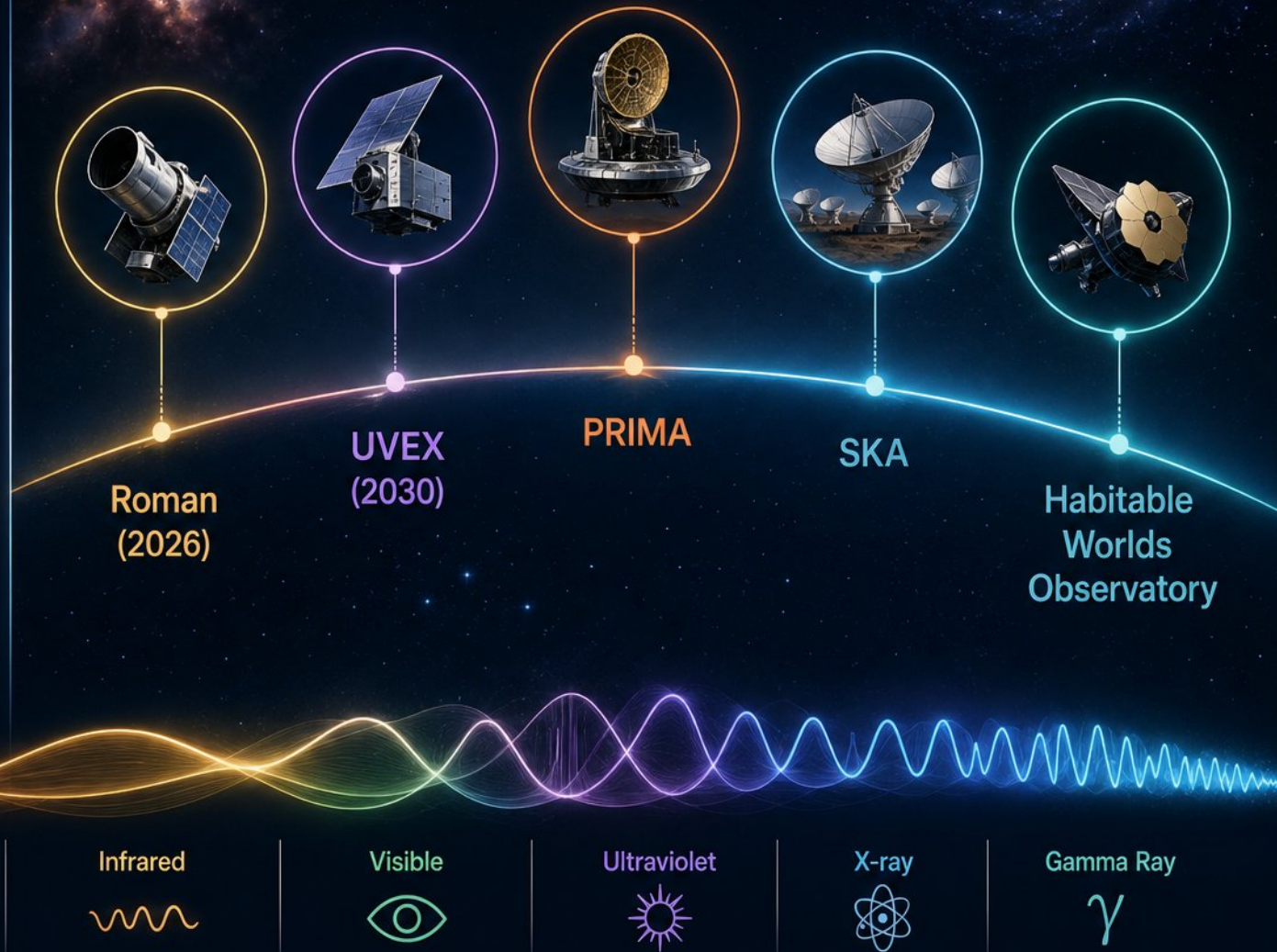
- Sagittarius A* appears differently across radio, infrared, and X-ray wavebands
- JWST infrared reveals stars and dust like IRS 3, 0.55 light-years from Sgr A*
- X-ray and radio data show hot gas, magnetic fields, and the central black hole
- Multiwavelength views explain star formation in extreme environments like Sgr B2



Future Telescopes:

The Next Decade of Multiwavelength Astronomy

- - Roman (2026): wide-field infrared surveys, dark energy, exoplanet census
- - UVEX (2030): all-sky ultraviolet imaging to fill the UV gap
- - PRIMA: far-infrared spectrometer for early-universe dust and galaxy evolution
- - SKA: next-generation radio array for cosmic magnetism and reionization
- - Habitable Worlds Observatory: UV-optical-IR flagship for exoplanet direct imaging



Teaching and Communicating Multiwavelength Astronomy



- Use NASA, ESA, NAOJ, and ESO multiwavelength galleries and interactives



- Present false-color and composite images with clear interpretation



- Explain wavelength bands through familiar examples and simple analogies



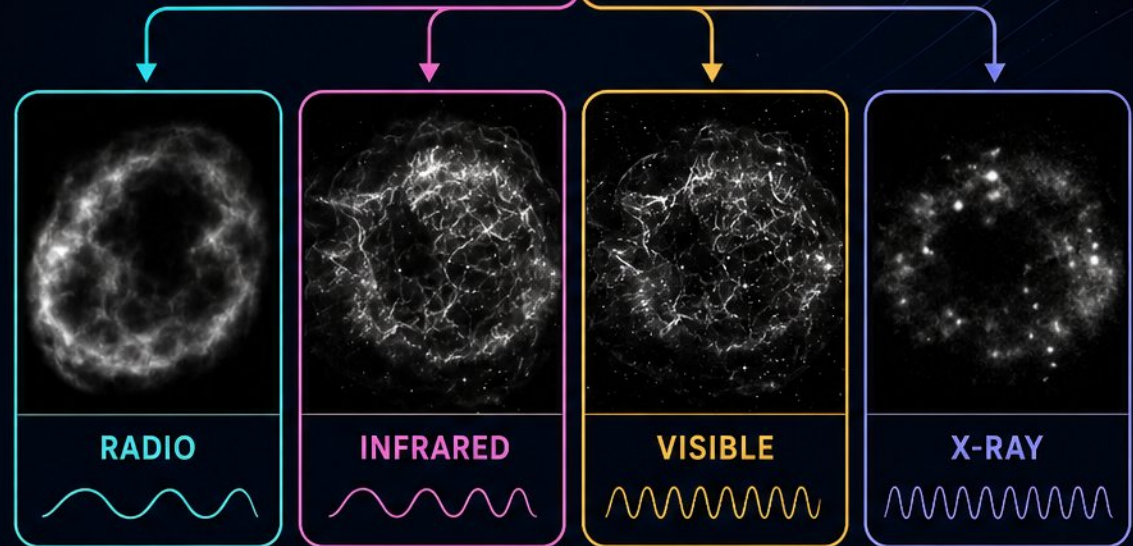
- Compare one object across radio, infrared, visible, and X-ray views



- Design activities that let students match wavebands to physical processes



FALSE-COLOR COMPOSITE



Summary and Action Plan

RADIO

INFRARED

VISIBLE / UV

X-RAY / GAMMA



- Radio: cold gas, pulsars, cosmic microwave background



- Infrared: dust-penetrating views of star formation



- Visible/UV: stars, hot young stars, interstellar medium



- X-ray/Gamma: black holes, neutron stars, extreme acceleration



- Multiwavelength views are essential for complete cosmic understanding



- Action: choose one resource, create one lesson piece, use Crab Nebula case



PersonWise.

PersonWise • AI digital-human course platform



Scan the code or click anywhere to watch this course live, with voice Q&A

personwise.ai/t/f591a880/public