

CHANDA PRESCOD-WEINSTEIN
UNIVERSITY OF NEW HAMPSHIRE

INTRODUCTION TO ASTROPHYSICS

ABOUT ME



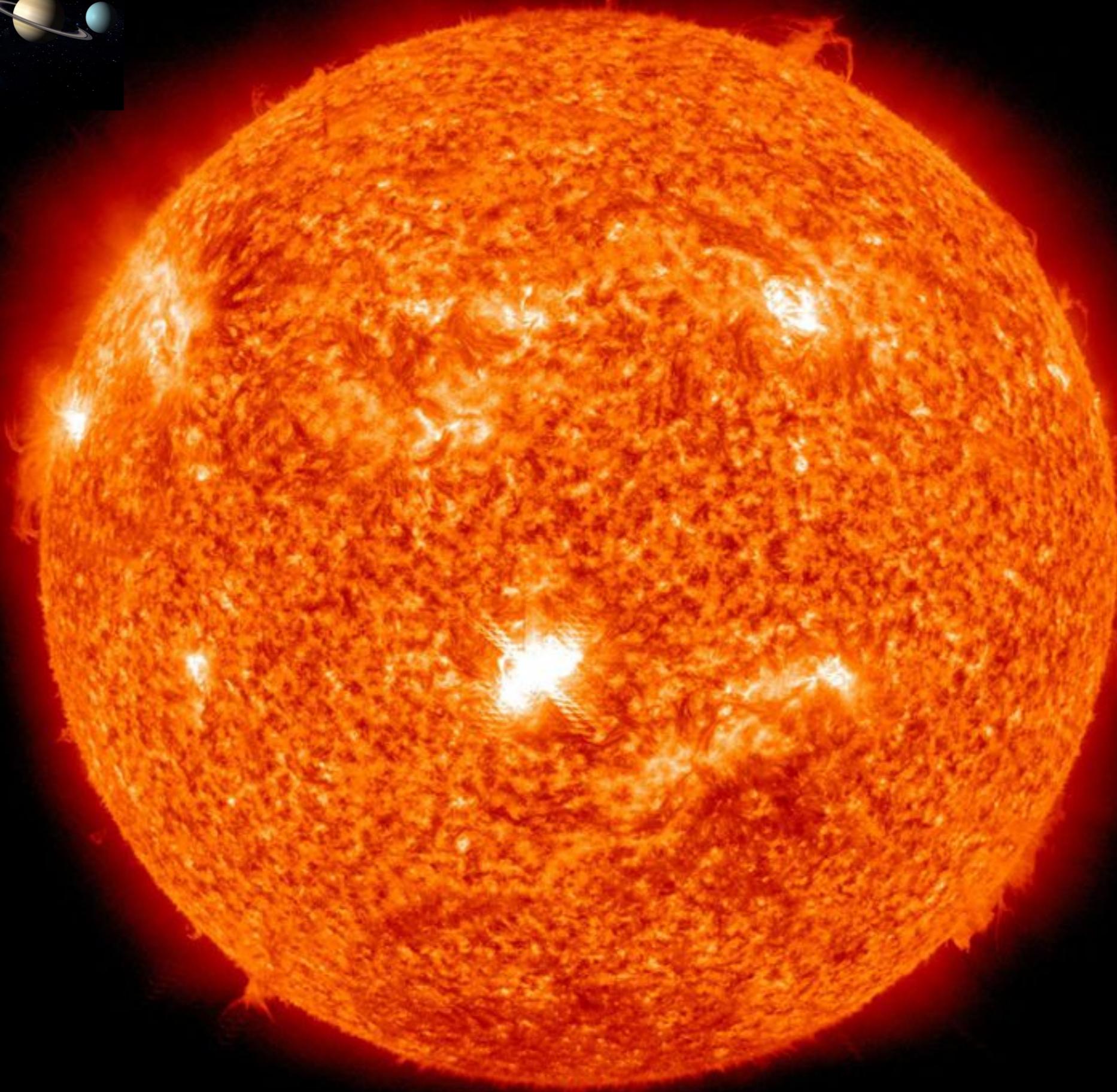
The Disordered Cosmos

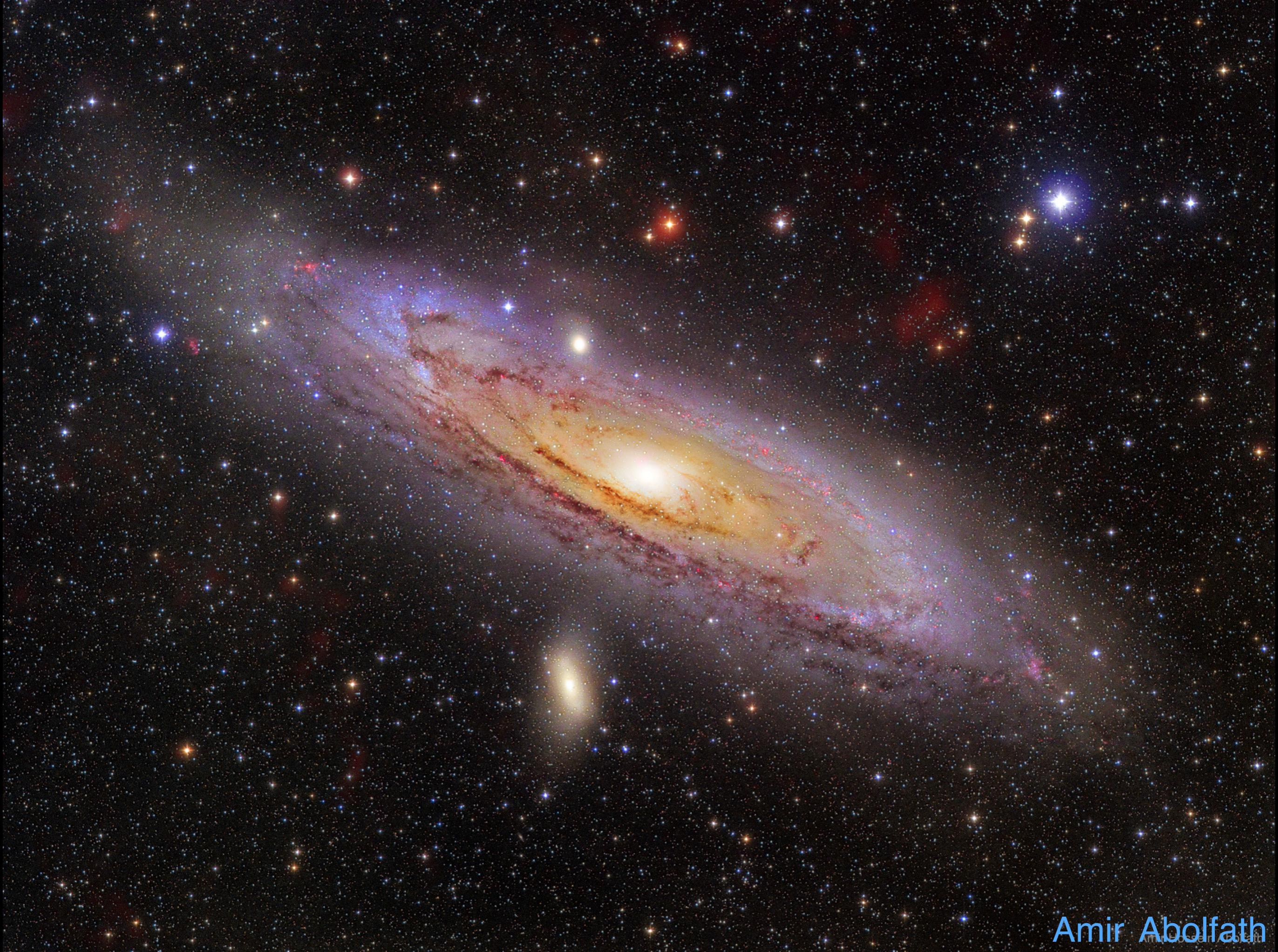
A Journey into
Dark Matter,
Spacetime, &
Dreams Deferred

Chanda Prescod-Weinstein

Outline as Questions

- What do we see when we look at the sky?
- How do we see the sky?
- What questions does this process raise?
- What techniques do we use to try and answer these questions?
- What areas of physics do we need to draw on?







What we see

- Our solar system: a star, planets, moons
- Stars
- Exoplanets
- Dying stars (supernovae)
- Stellar remnants (white dwarfs, **neutron stars**, black holes)
- Galaxies
- Galaxy clusters
- Gamma Ray Bursts . . . ???

Neutron Stars and African School of Physics

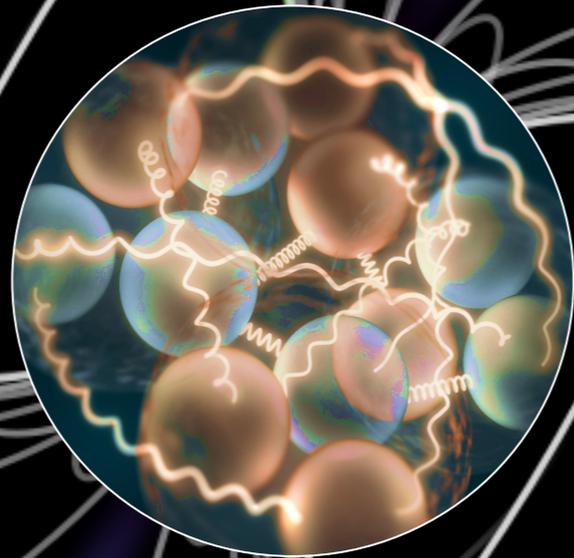


Mr. Yves Kini

ASP 2018

**Now: University of
Amsterdam!**

**Thermonuclear
burst oscillation of
accreting neutron
stars**



YOU?

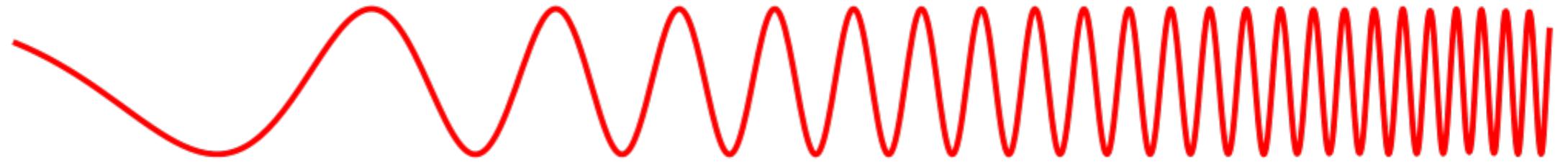


Outline as Questions

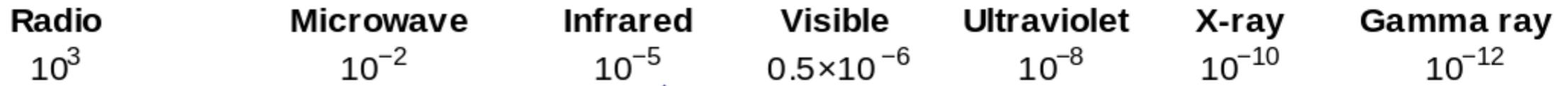
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Electromagnetic Spectrum

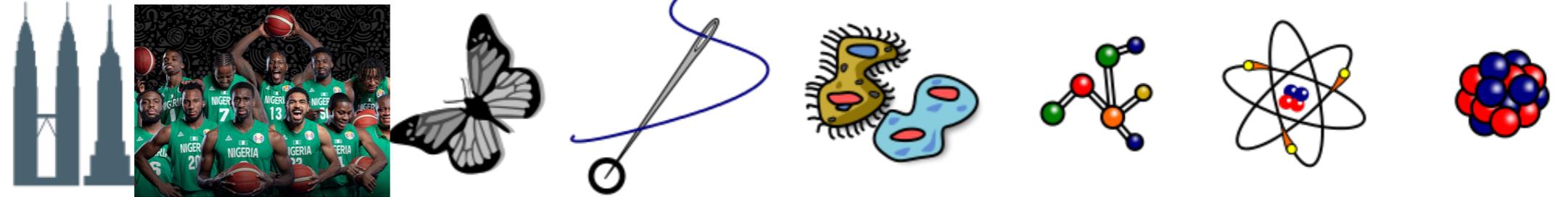
Penetrates Earth's Atmosphere?



Radiation Type
Wavelength (m)

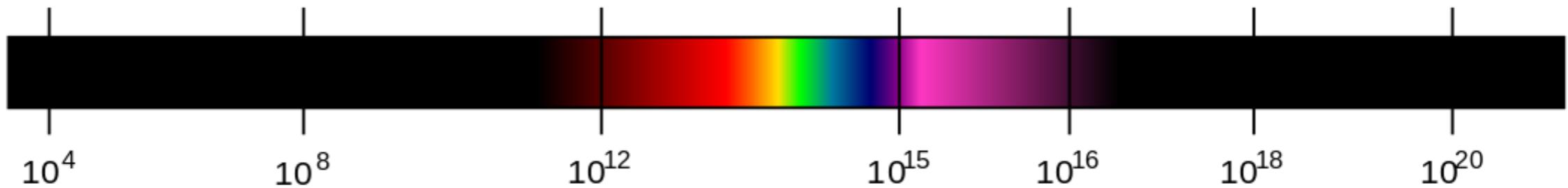


Approximate Scale
of Wavelength

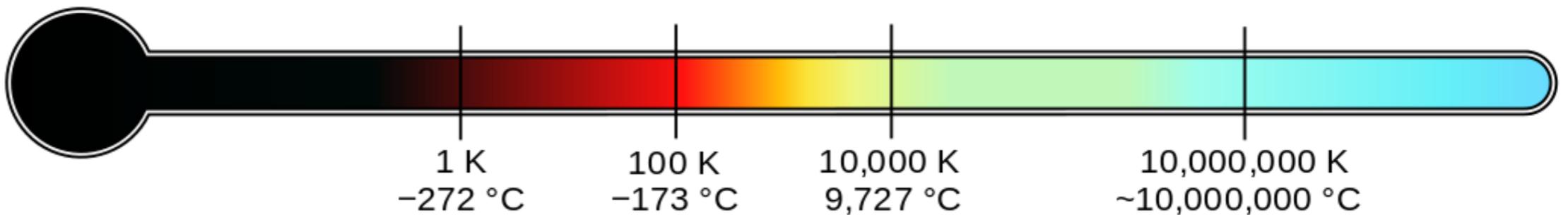


Buildings Humans Butterflies Needle Point Protozoans Molecules Atoms Atomic Nuclei

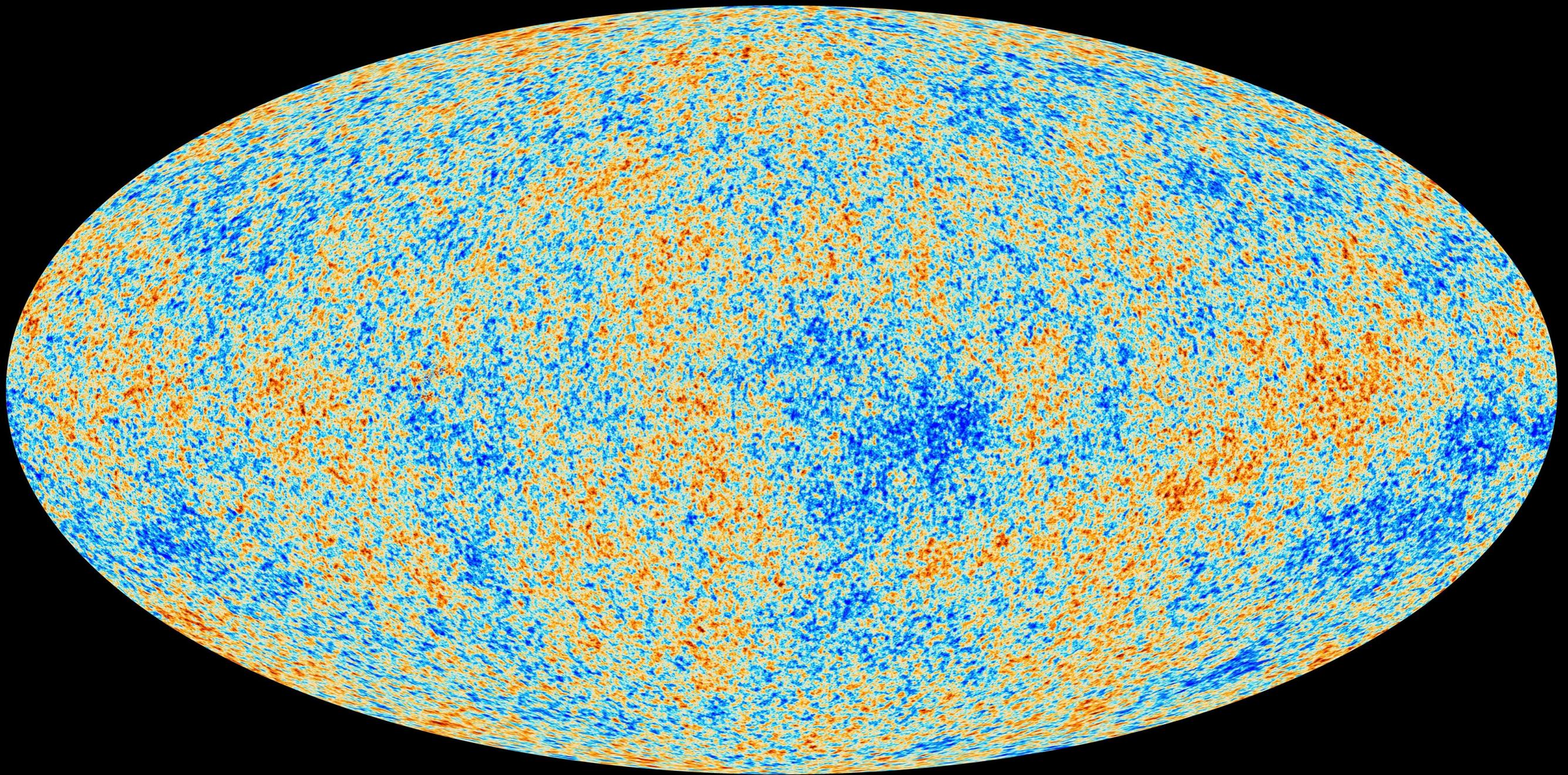
Frequency (Hz)

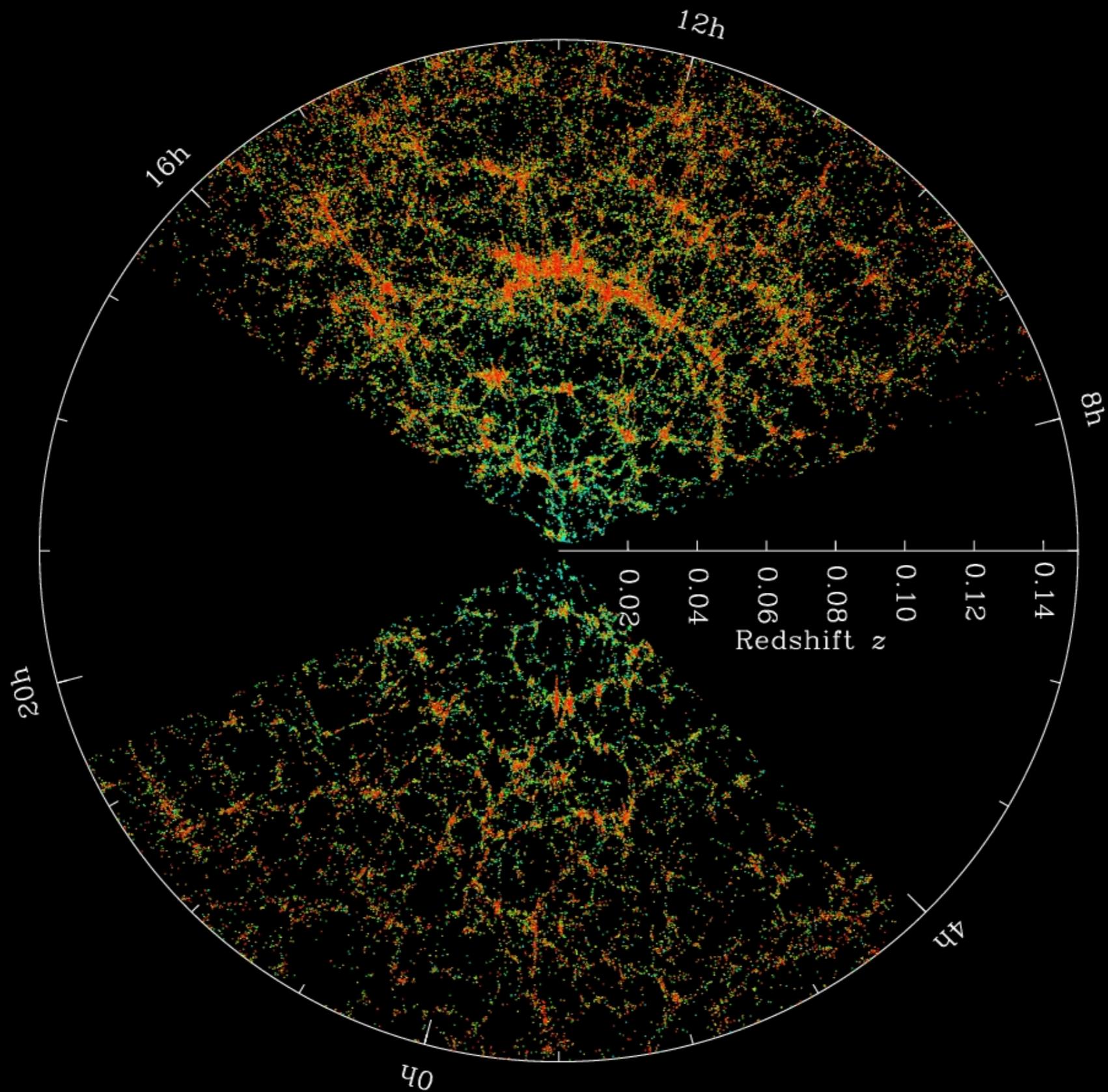


Temperature of
objects at which
this radiation is the
most intense
wavelength emitted

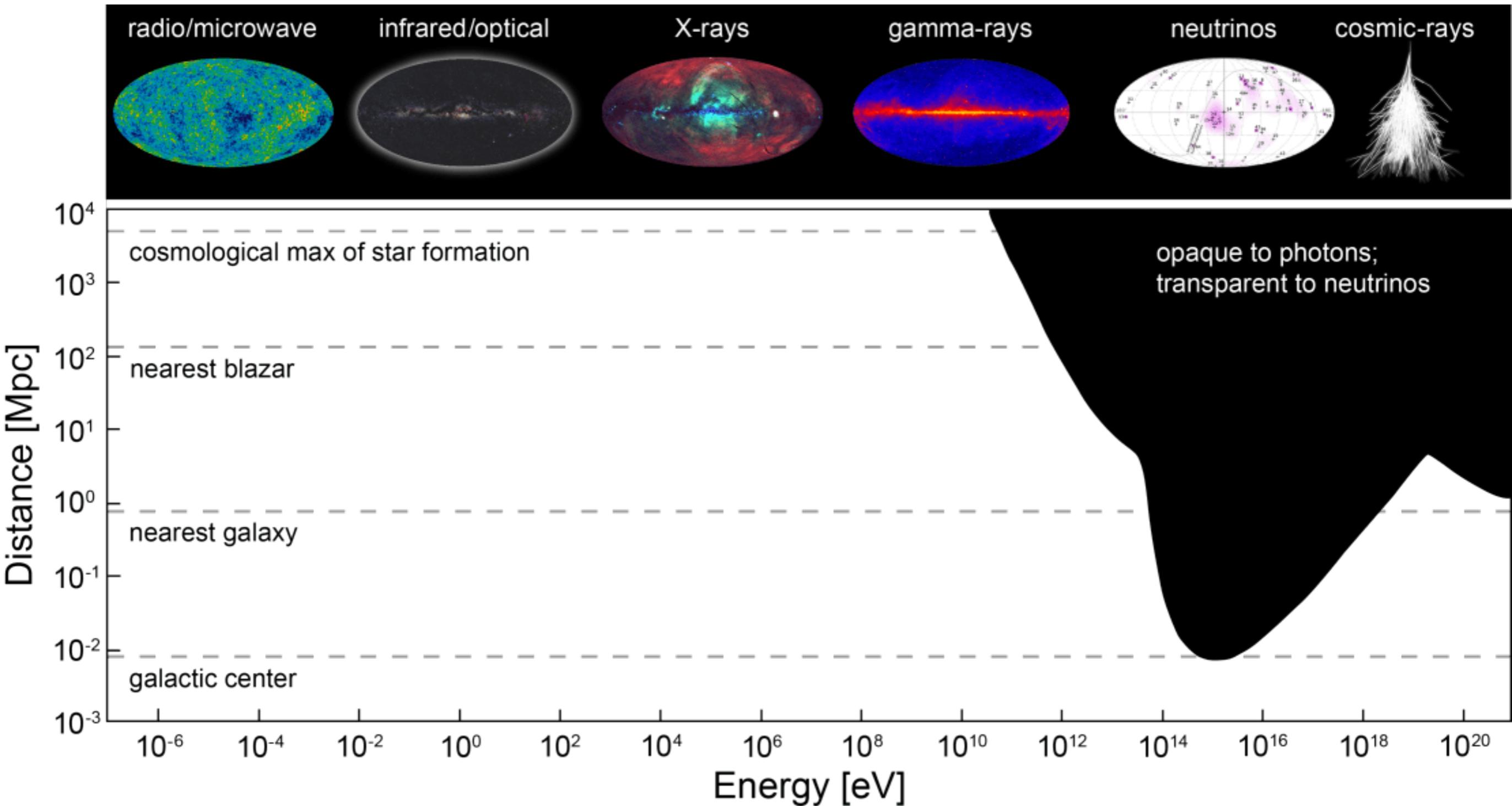


Cosmic Microwave Background Radiation

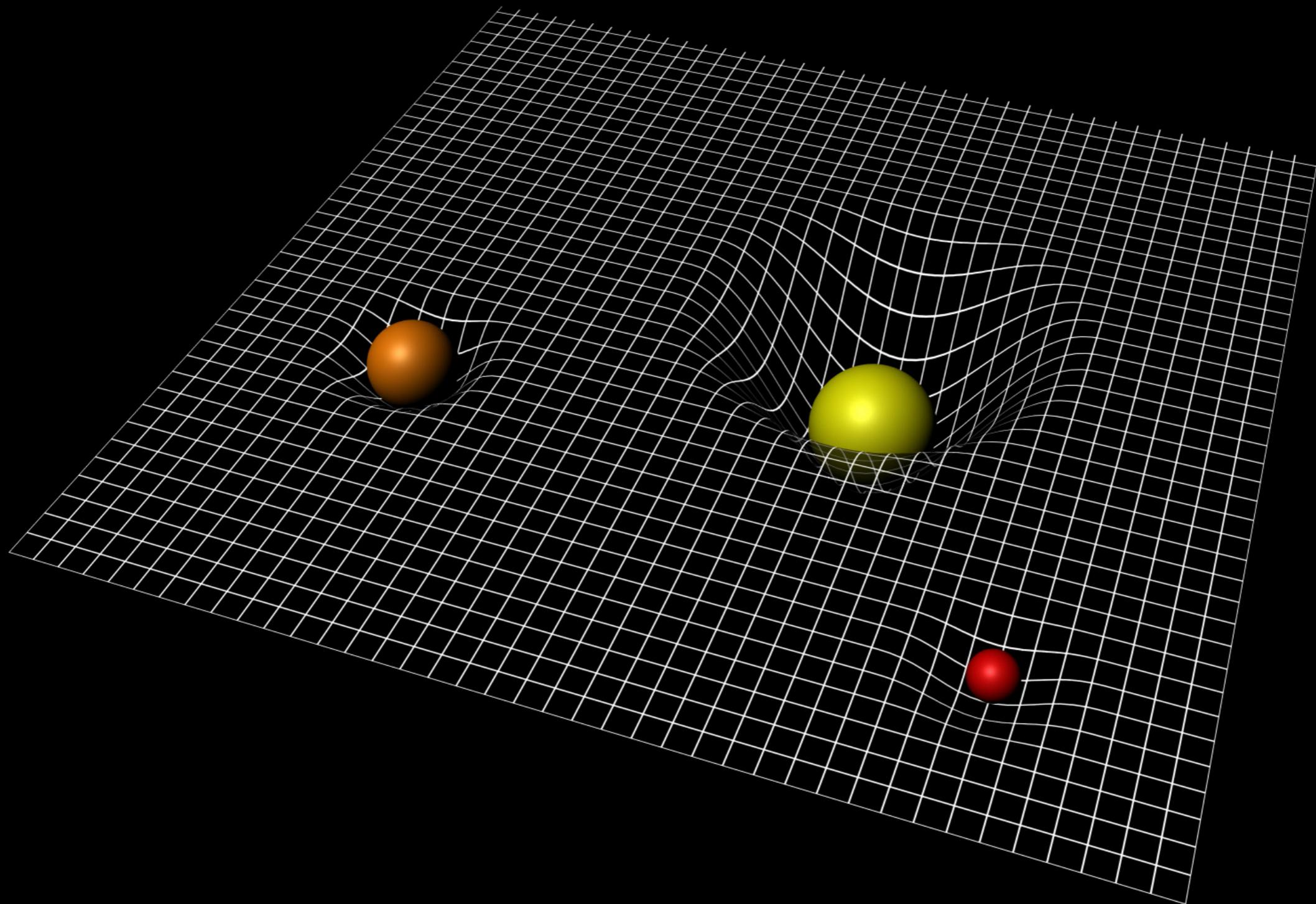




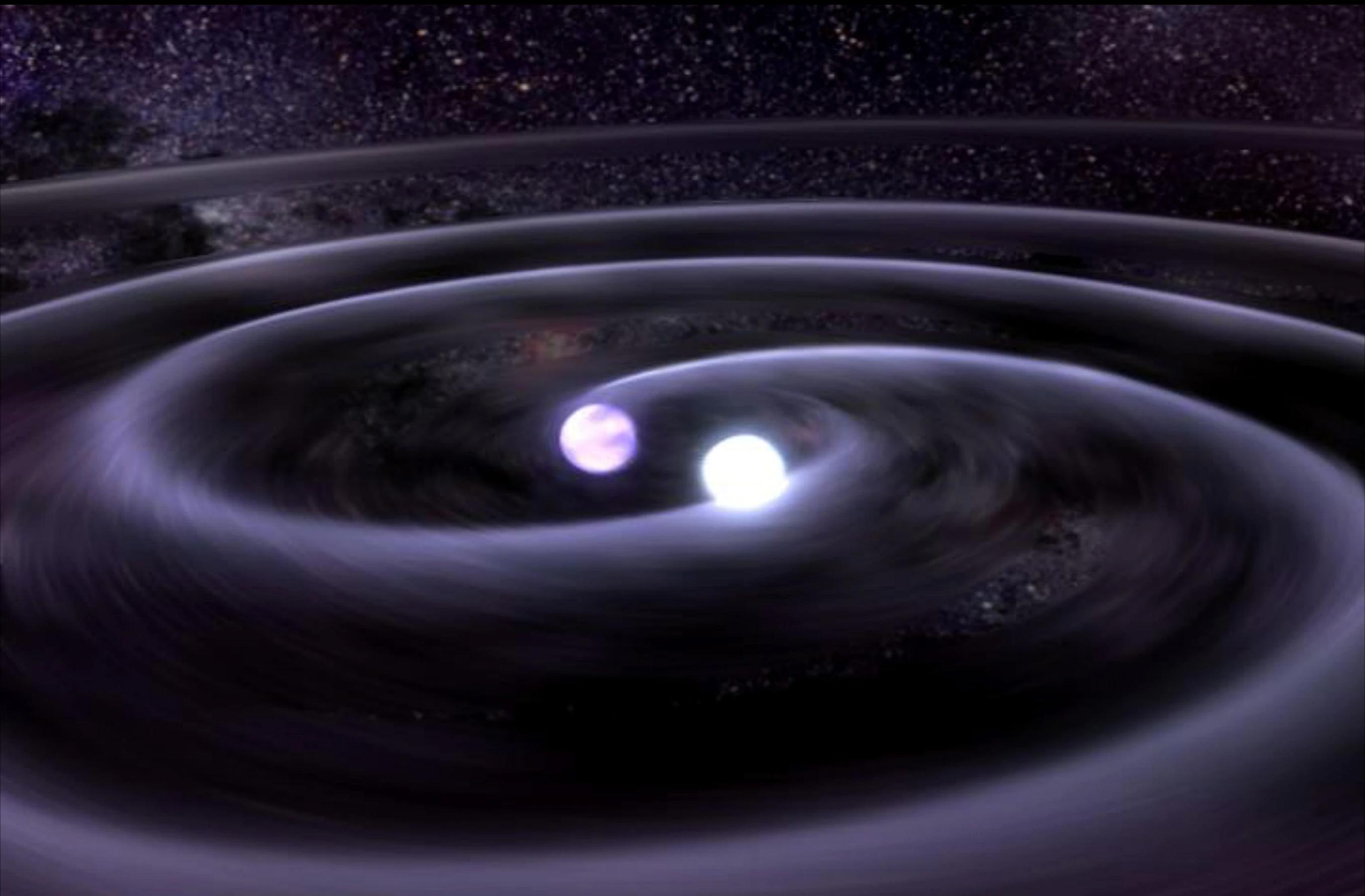
Electromagnetic Spectrum



Spacetime is Curved

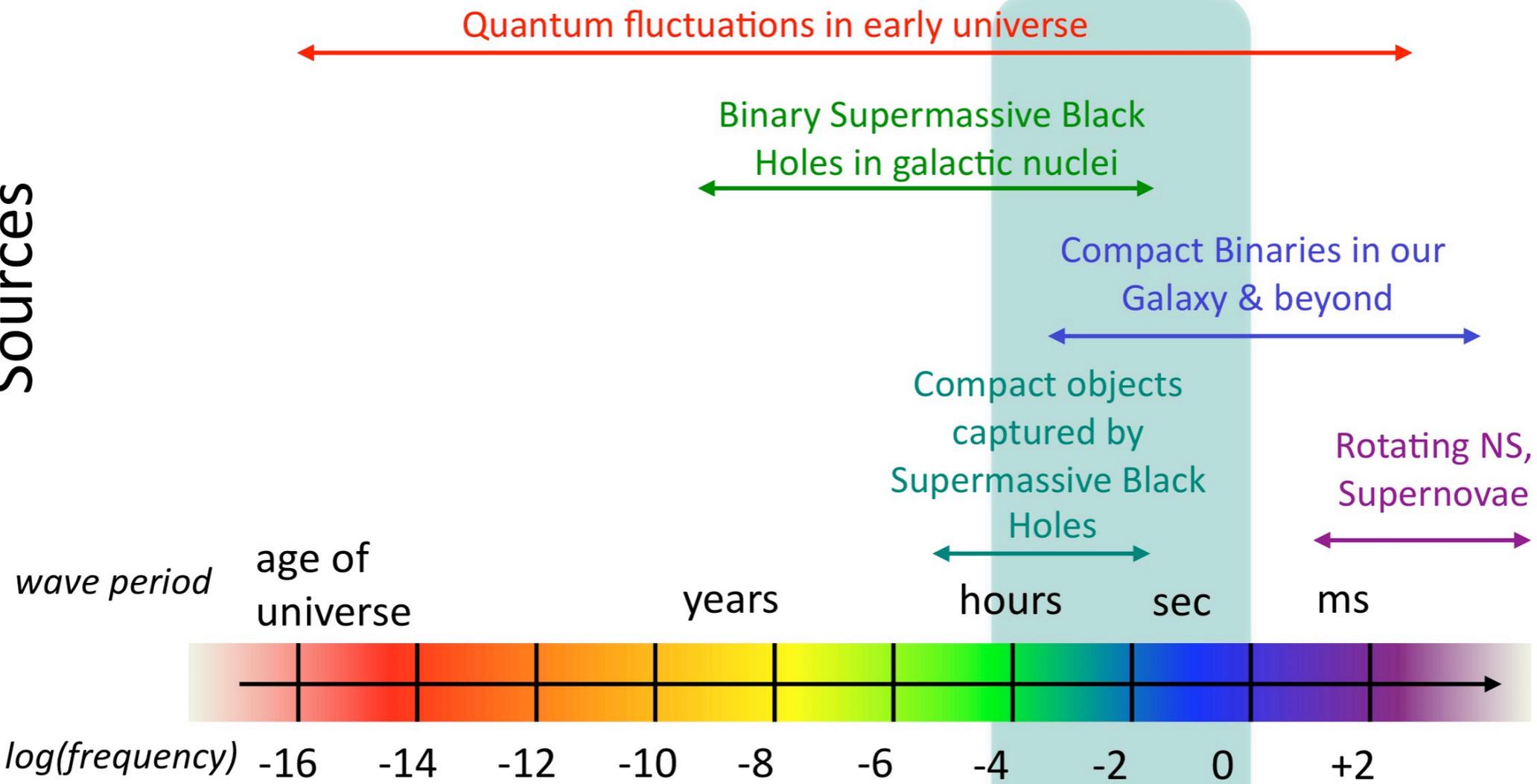


Gravitational Waves

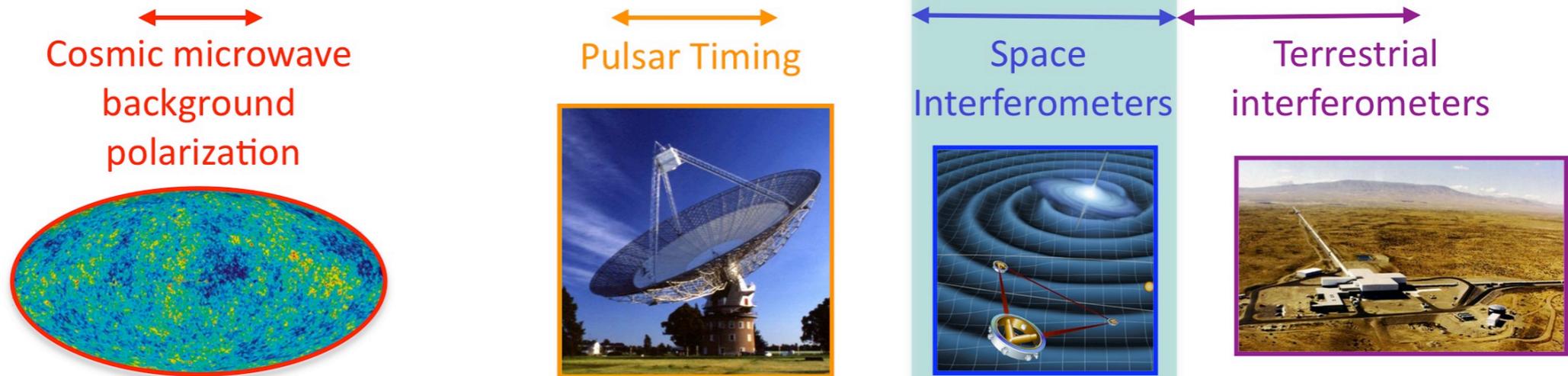


The Gravitational Wave Spectrum

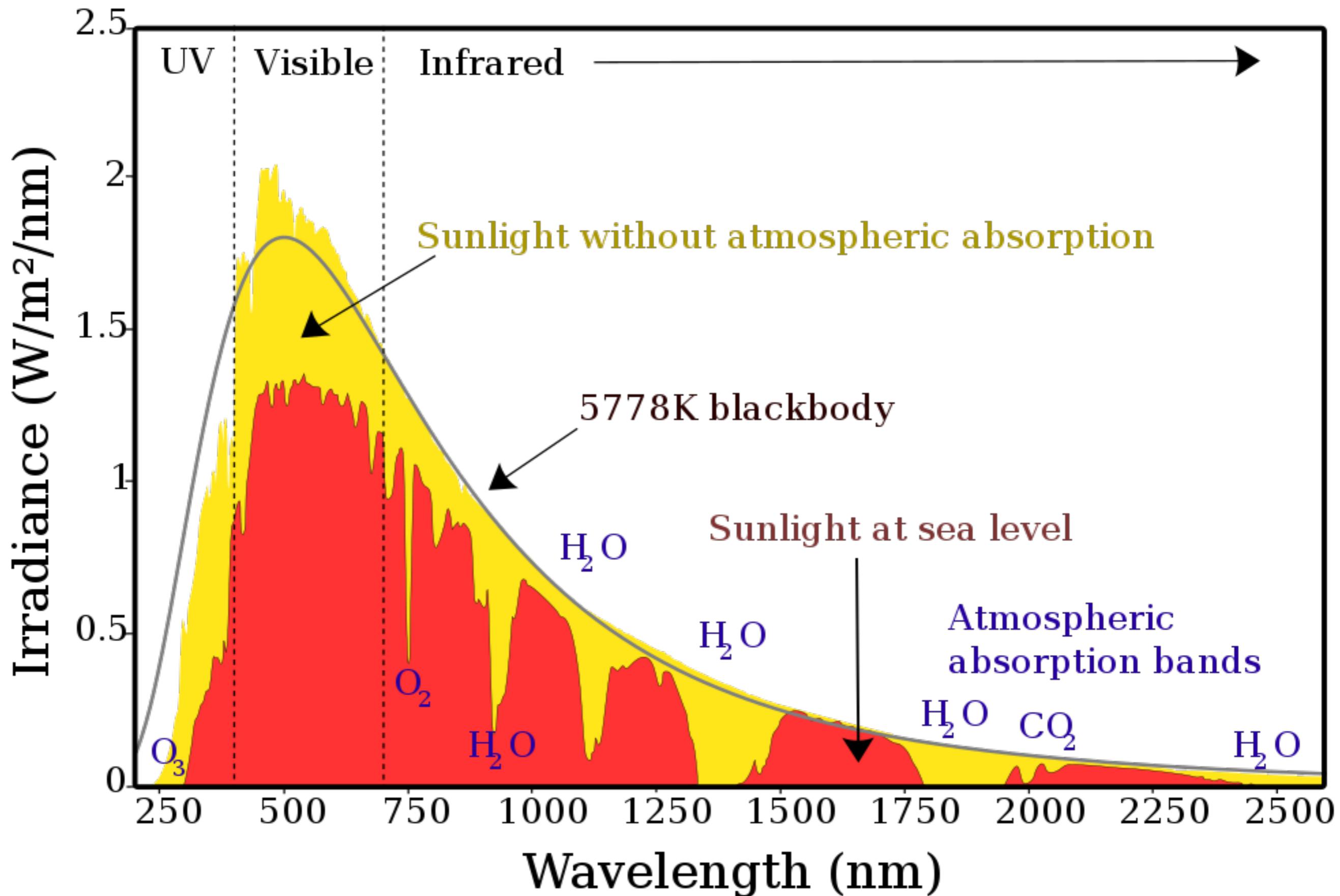
Sources

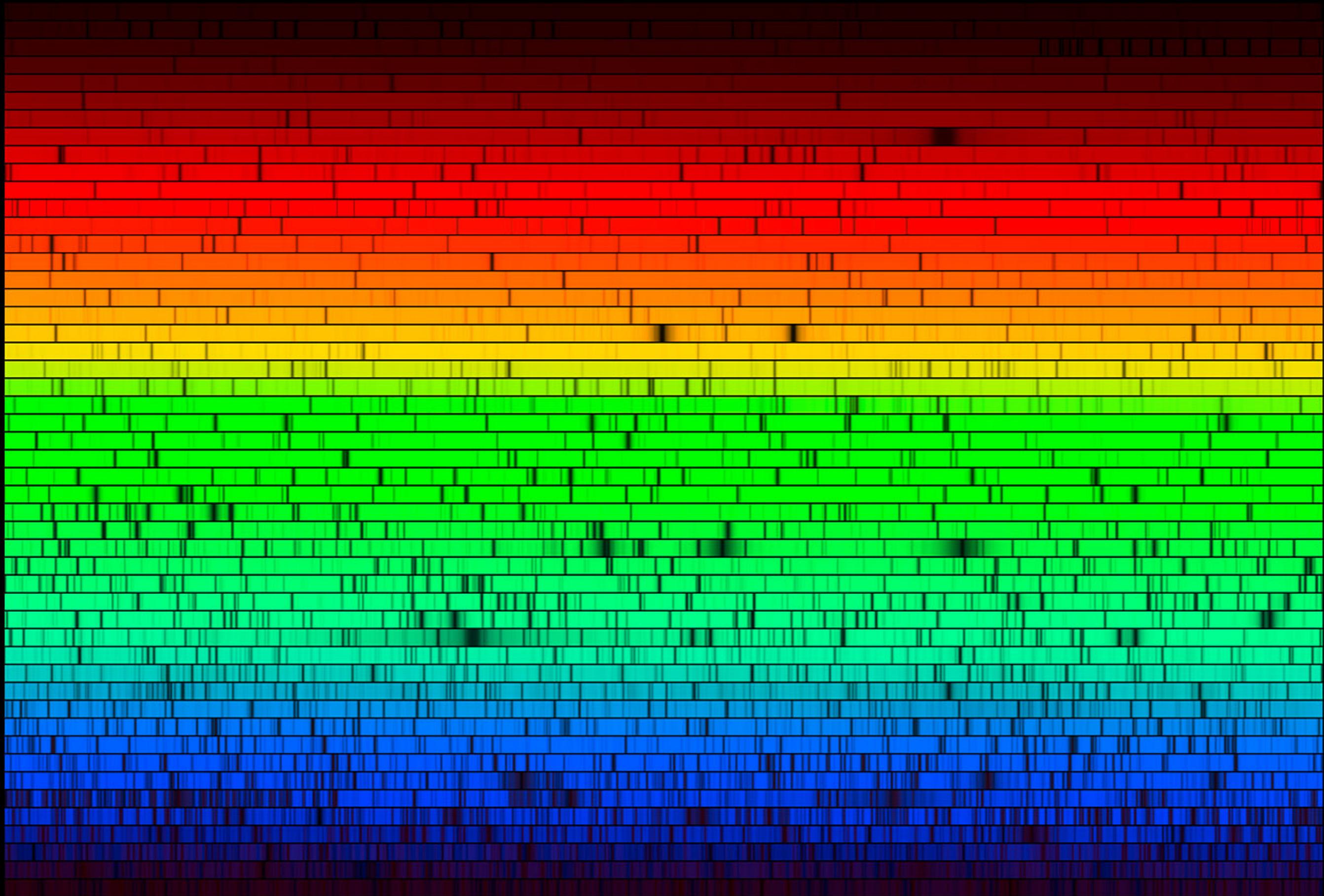


Detectors



Spectrum of Solar Radiation (Earth)





Hot Source
(Star)

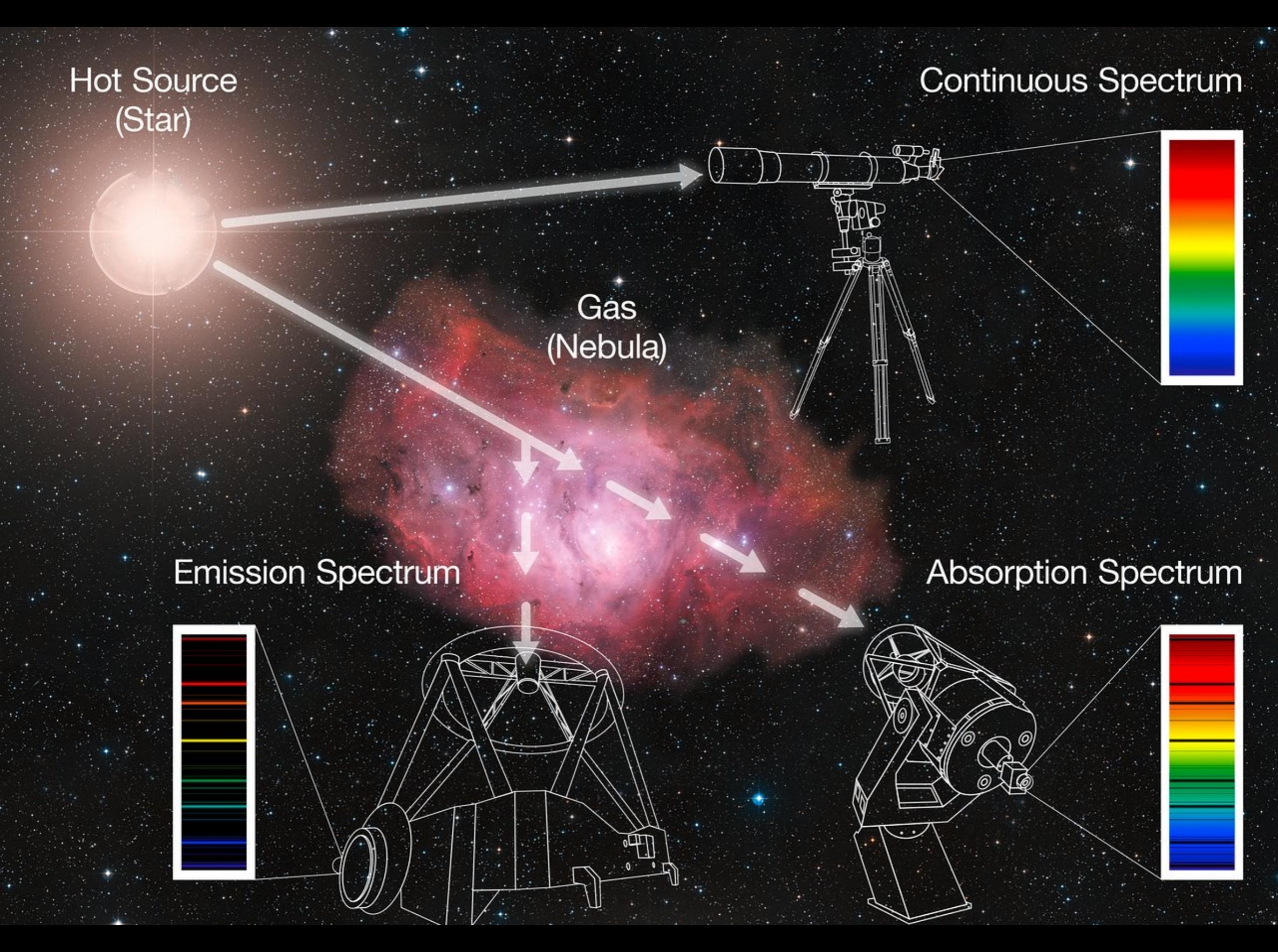
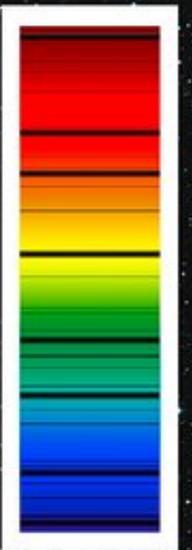
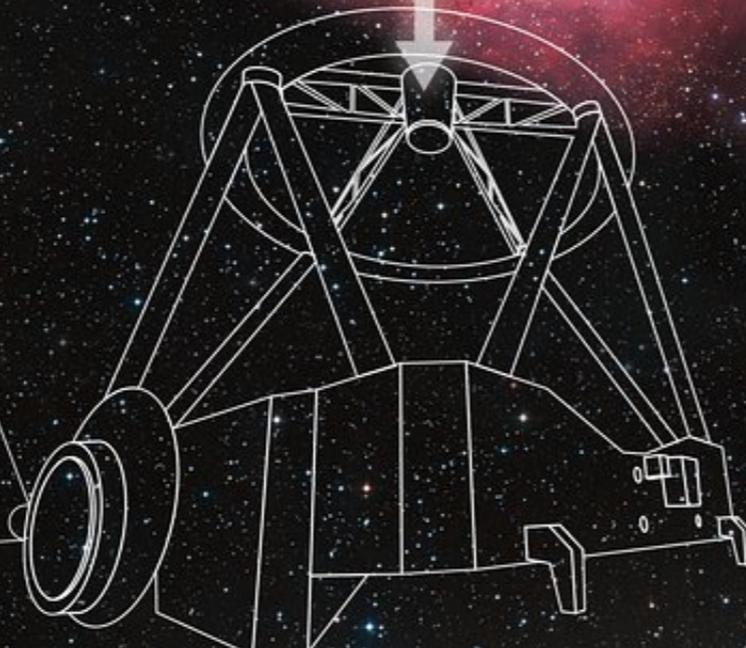
Continuous Spectrum

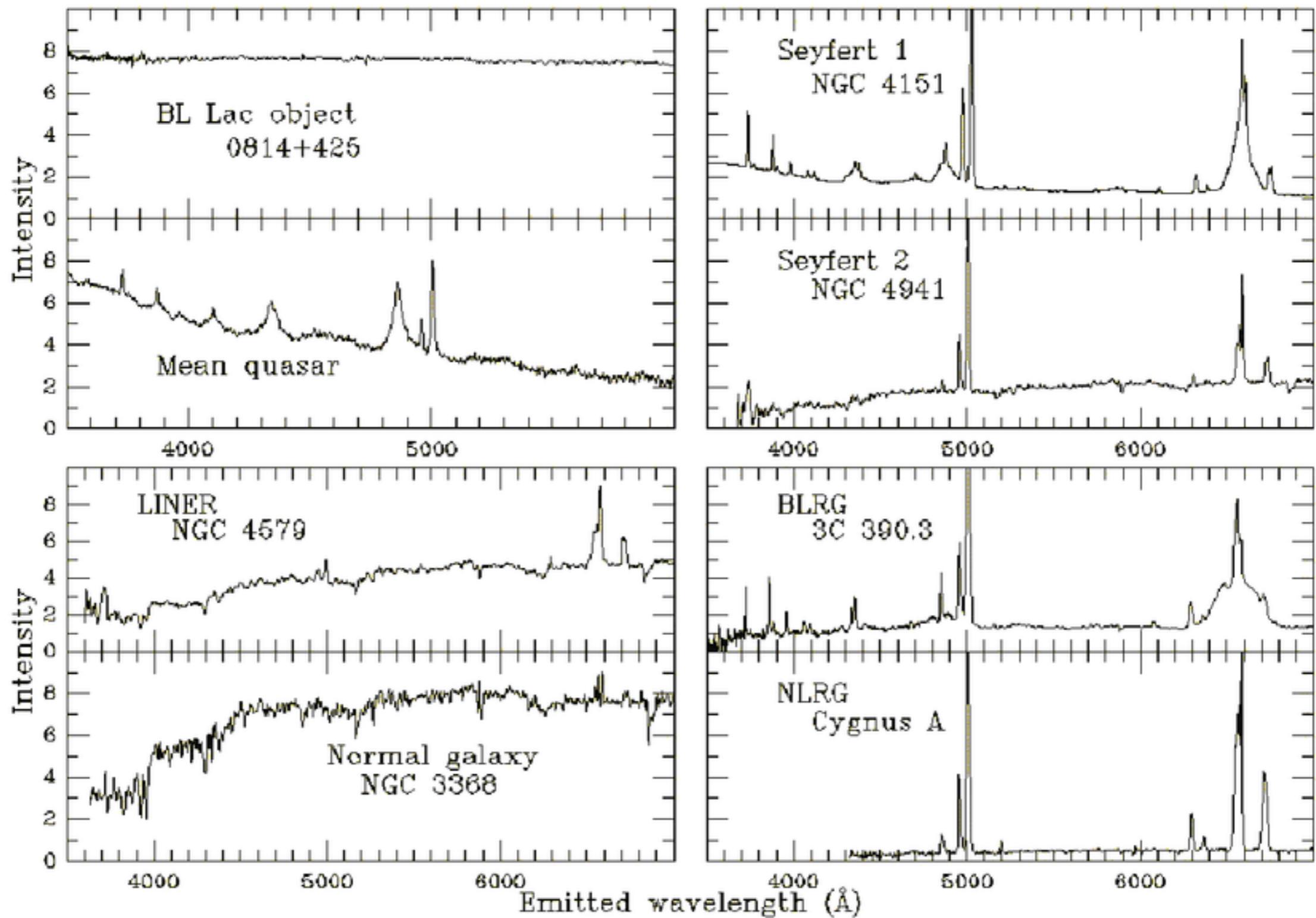


Gas
(Nebula)

Emission Spectrum

Absorption Spectrum





Characteristic spectra of different AGN types. Credit: W. C. Keel

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Distance Measurements

- **Light year:** distance of earth to sun, $1 \text{ ly} = 9.46 \times 10^{15} \text{ m}$
- **Parsecs:** $1 \text{ pc} = 3.08 \times 10^{16} \text{ m}$
- **Megaparsecs:** $1 \text{ Mpc} = 10^6 \text{ pc}$

Unit	Abbreviation	Conversion
Astronomical Unit	AU	$1 \text{ AU} = 1.5 \times 10^{11} \text{ m}$
Light Year	lyr	$1 \text{ ly} = 9.46 \times 10^{15} \text{ m}$
Parsec	pc	$1 \text{ pc} = 3.08 \times 10^{16} \text{ m}$
		$1 \text{ pc} = 3.26 \text{ ly}$ or $1 \text{ pc} = 206265 \text{ AU}$

Distance Measurements

Method used	Distances measured
Using radio waves a pulse reflection	Planets or asteroids in the solar system
Parallax	Up to distances of 300 light years
Cepheids	Up to 2.5 million light years
Brightness (inverse square law)	Up to 5 Billion light years
Red Shifts	Distances beyond 5 billion light years

Cosmic Distances

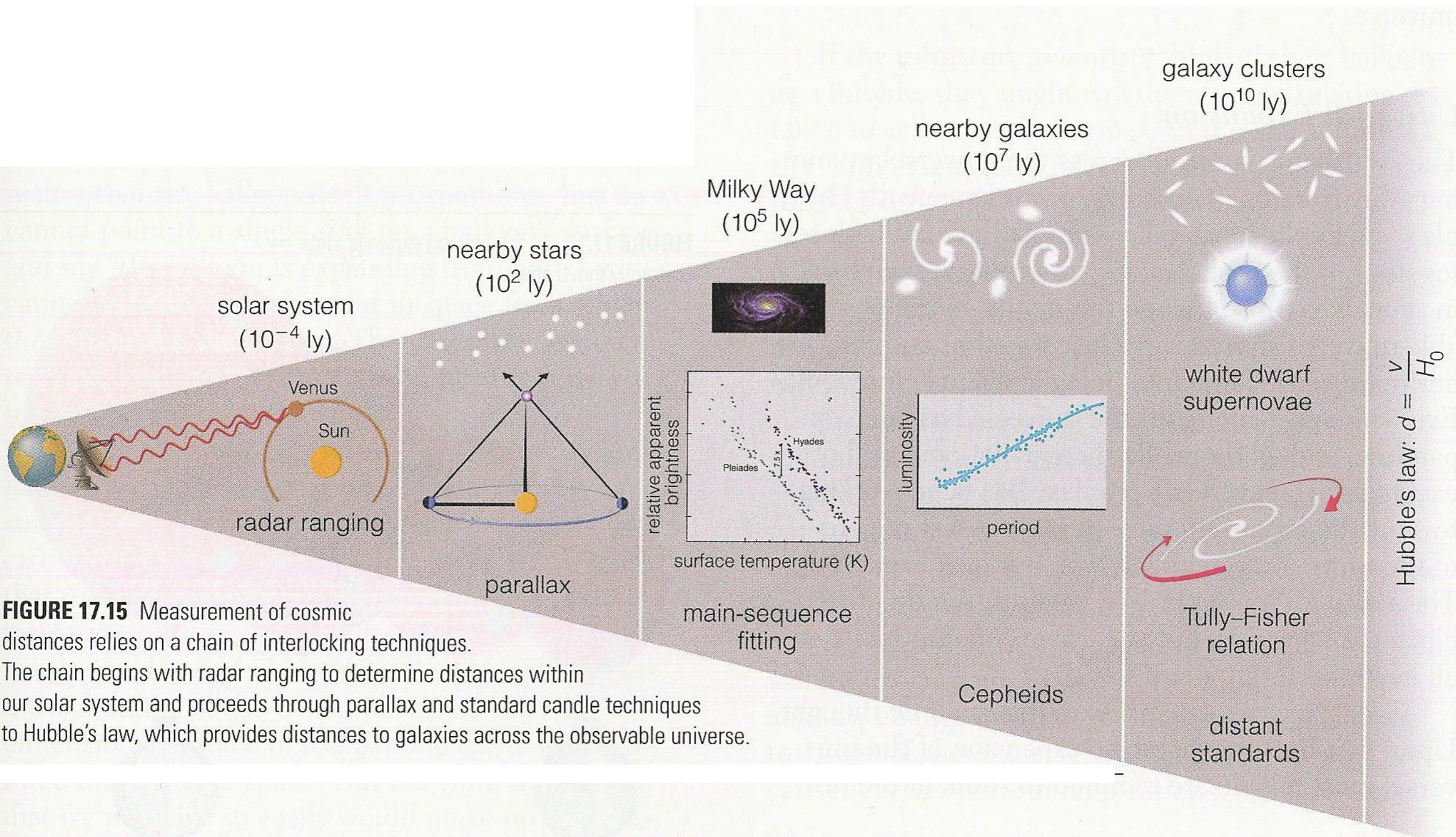
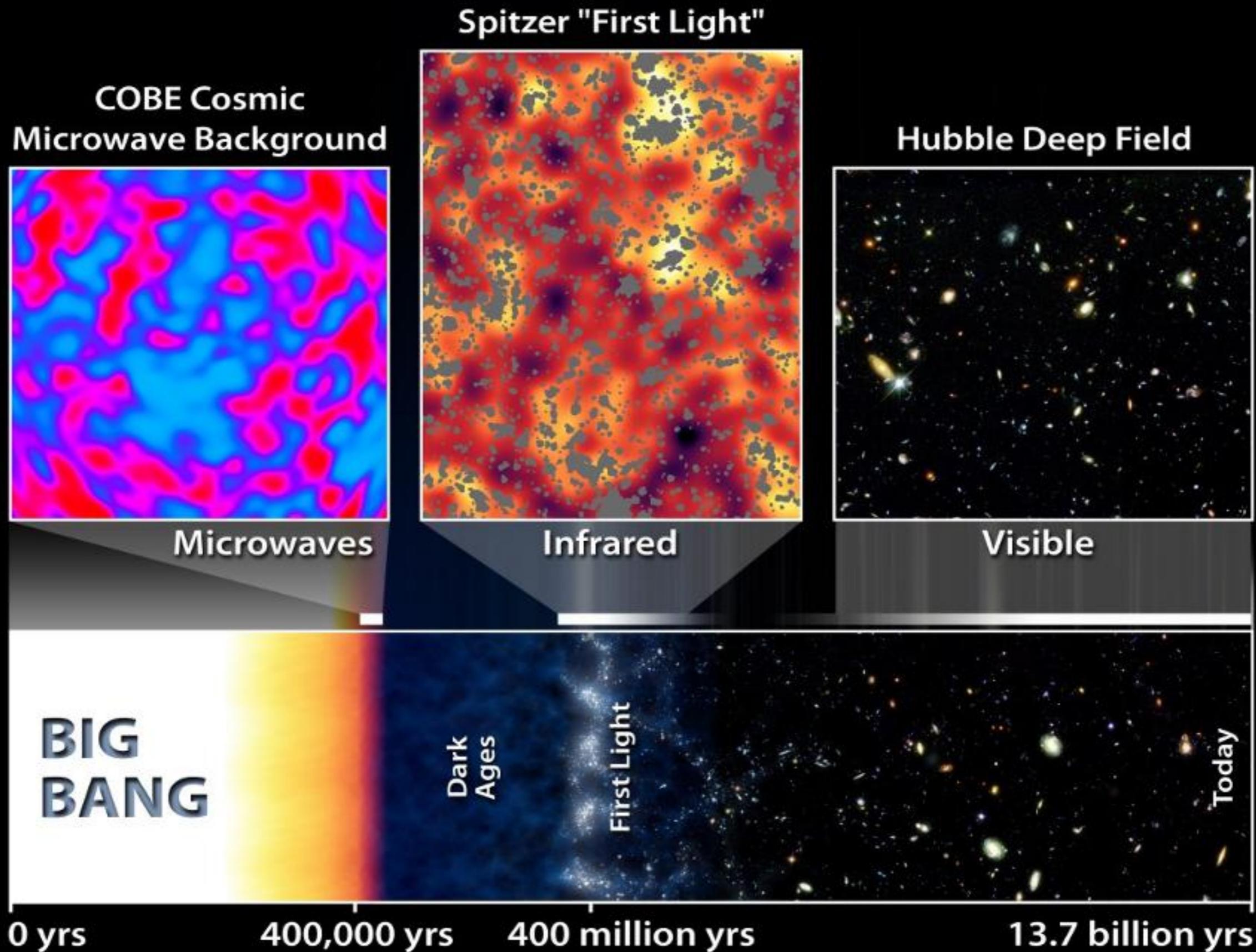


FIGURE 17.15 Measurement of cosmic distances relies on a chain of interlocking techniques. The chain begins with radar ranging to determine distances within our solar system and proceeds through parallax and standard candle techniques to Hubble's law, which provides distances to galaxies across the observable universe.

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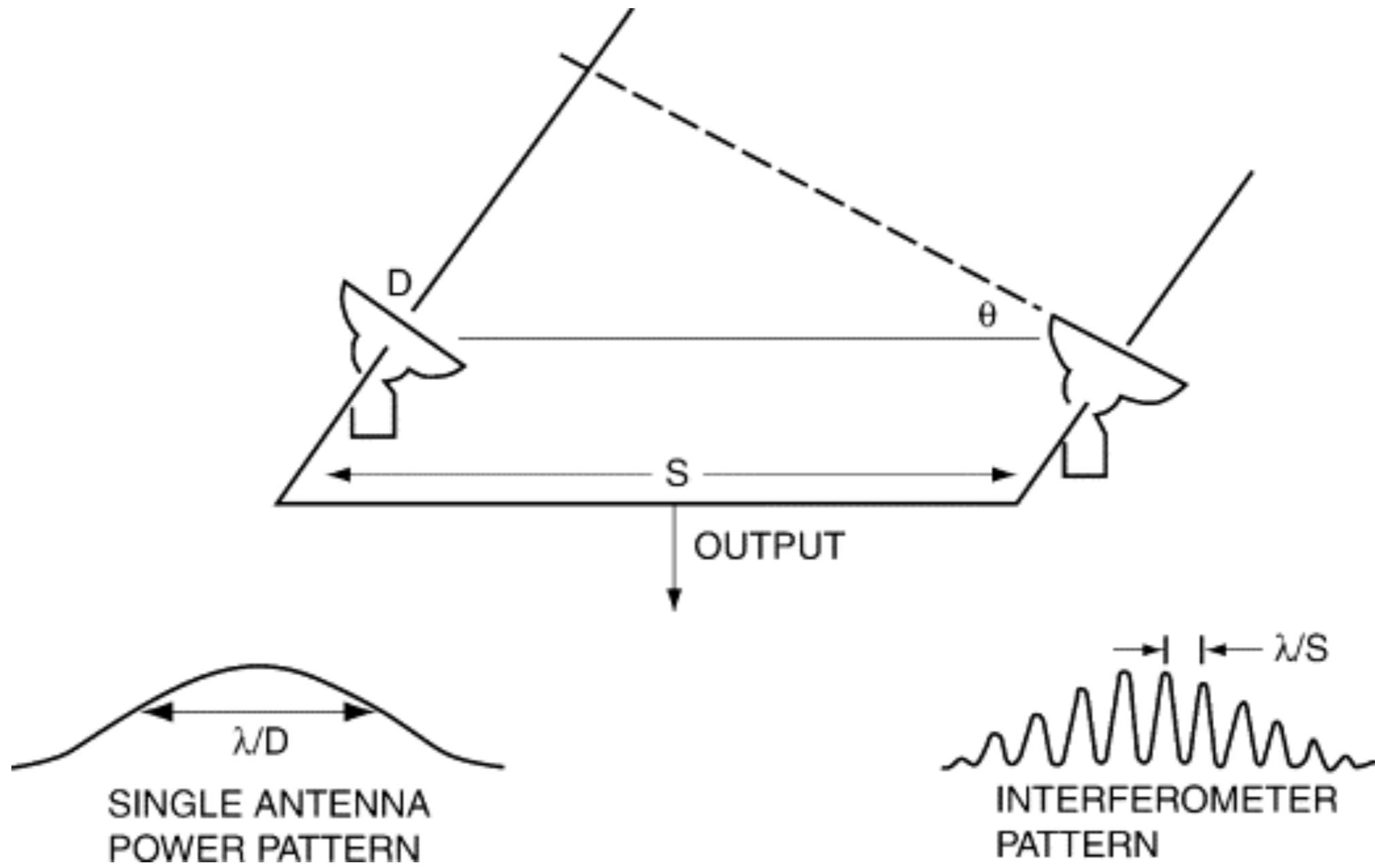
Timeline of the Universe

Spitzer Space Telescope • IRAC

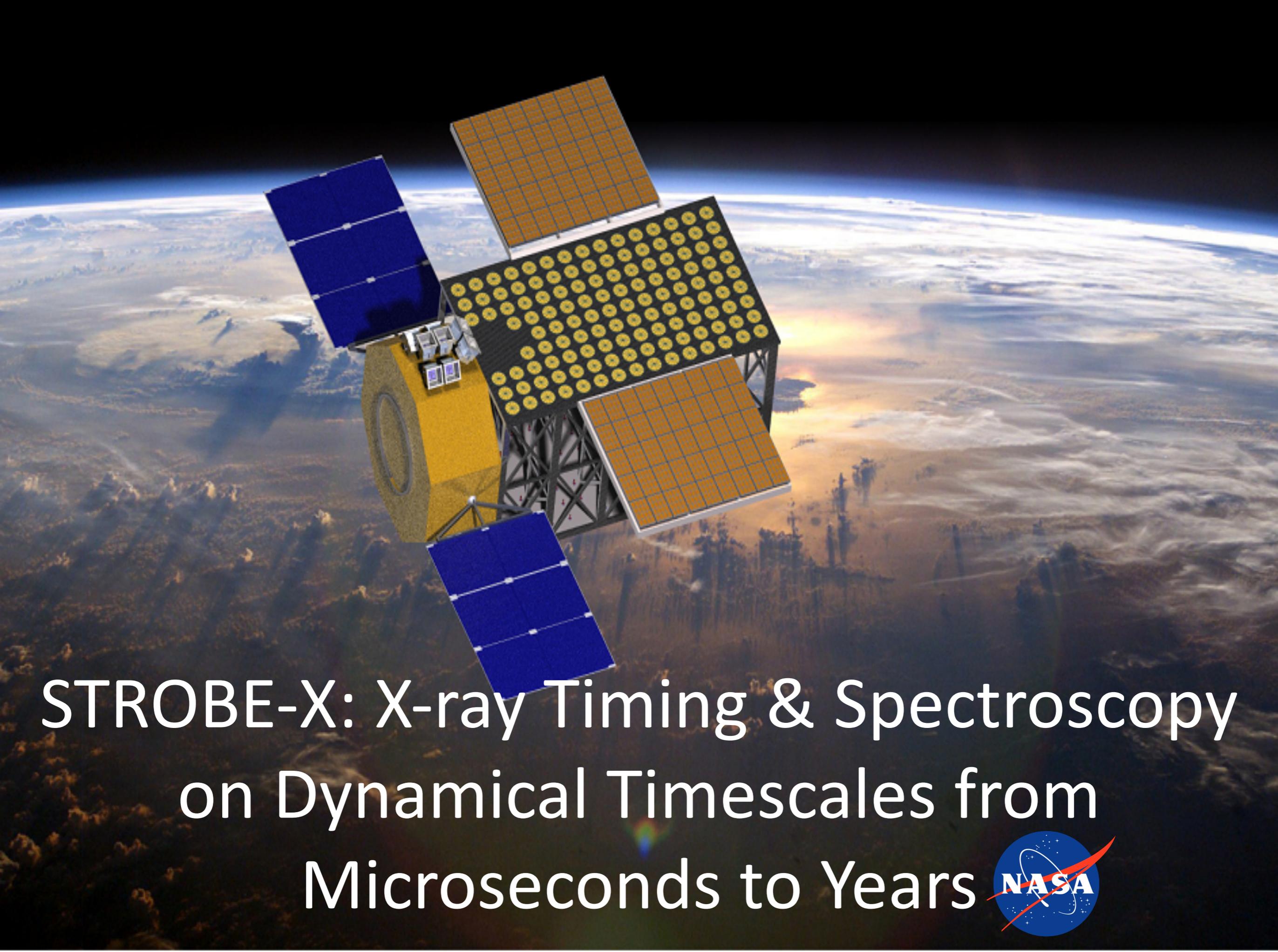
Square Kilometer Array



Radio Interferometers





A detailed 3D rendering of the STROBE-X satellite in orbit above Earth. The satellite features a central yellow cylindrical component, a large black panel with a grid of yellow circular detectors, and several blue and orange solar panel arrays. The background shows the Earth's surface with clouds and a bright sun on the horizon.

STROBE-X: X-ray Timing & Spectroscopy
on Dynamical Timescales from
Microseconds to Years



Areas of Physics Required

- Astronomy is a lot of **statistical mechanics**
- Relativity
- Radiative processes
- Quantum *and* classical mechanics
- Nuclear physics
- Electrical and mechanical engineering
- Particle physics
- Planetary science/geophysics/geology

Next Talk: The Expanding Universe

Expanding Balloon Analogy
Photons move and redshift
Galaxies spread apart but
stay the same size

