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UNIVERSITY OF NEW HAMPSHIRE

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# INTRODUCTION TO ASTROPHYSICS



# ABOUT ME



## The Disordered Cosmos

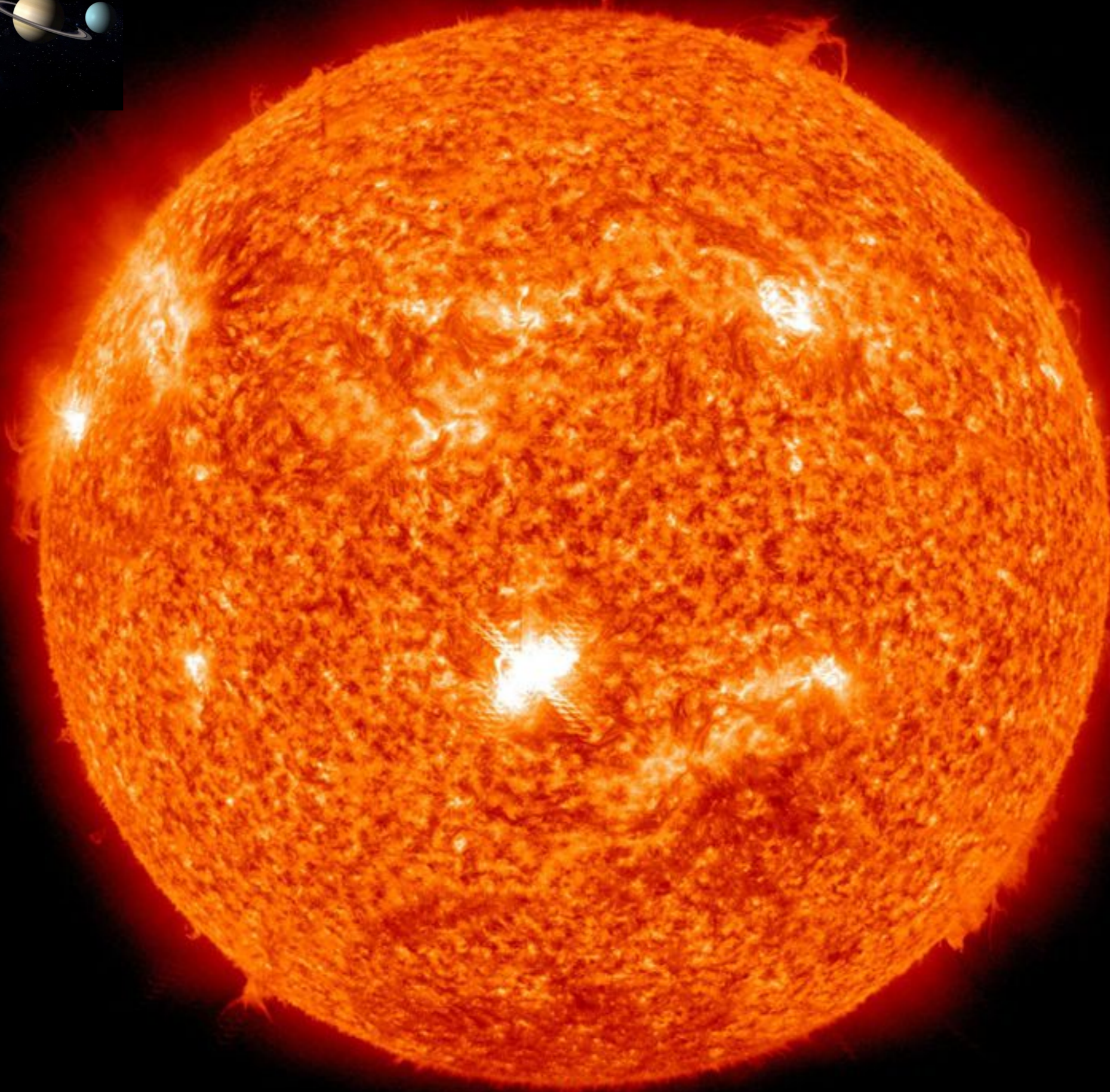
A Journey into  
Dark Matter,  
Spacetime, &  
*Dreams Deferred*

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

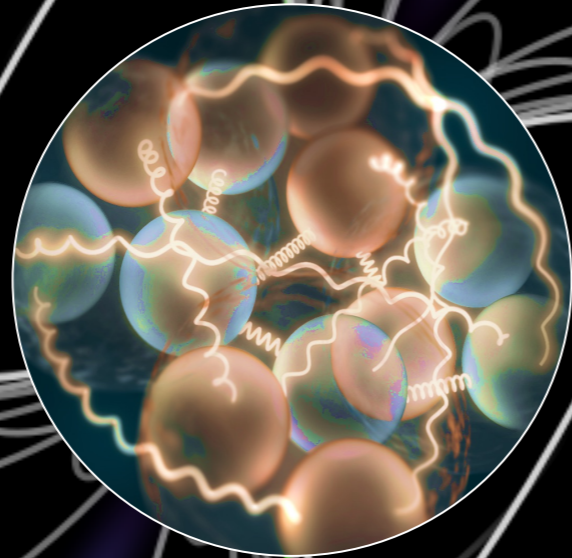


**Mr. Yves Kini**

**ASP 2018**

**Now: University of  
Amsterdam!**

**Thermonuclear  
burst oscillation of  
accreting neutron  
stars**





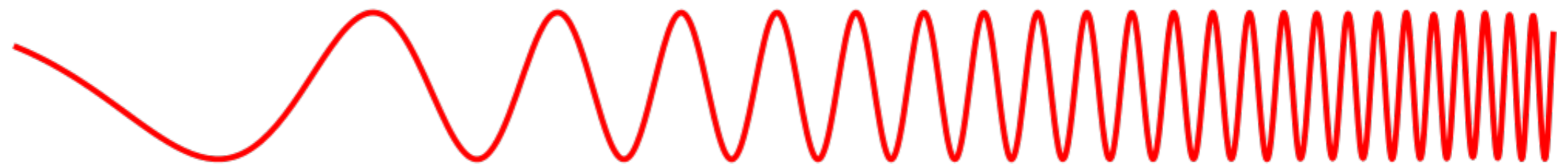
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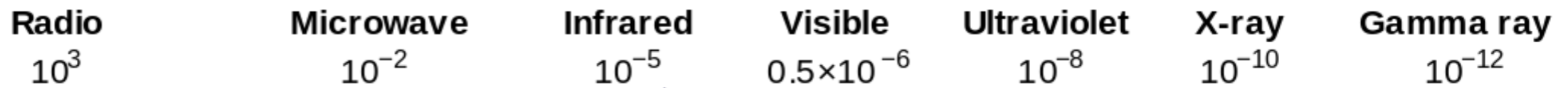


# Electromagnetic Spectrum

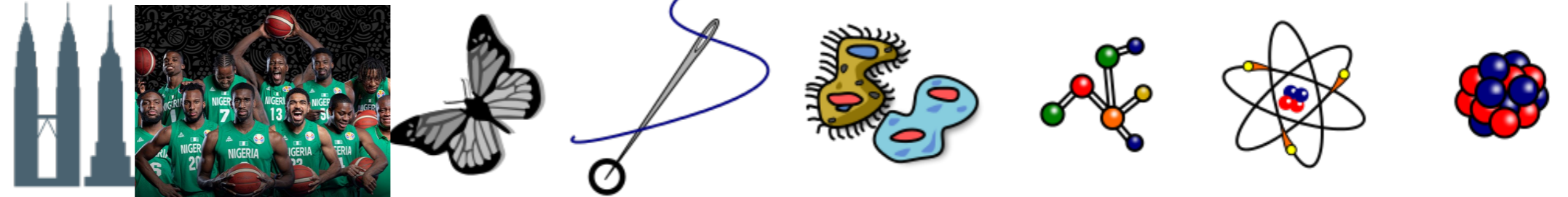
Penetrates Earth's Atmosphere?



Radiation Type  
Wavelength (m)

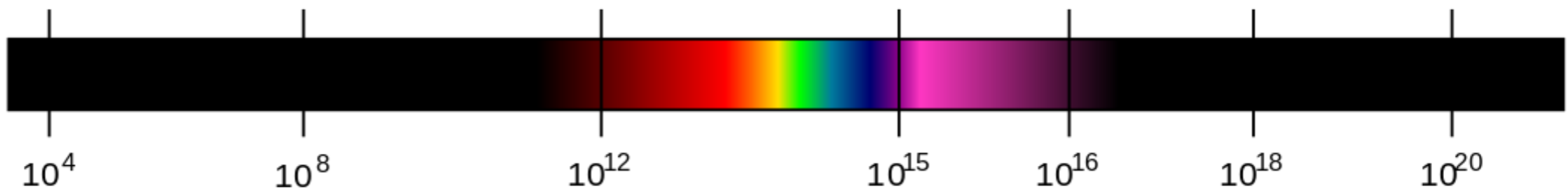


Approximate Scale  
of Wavelength

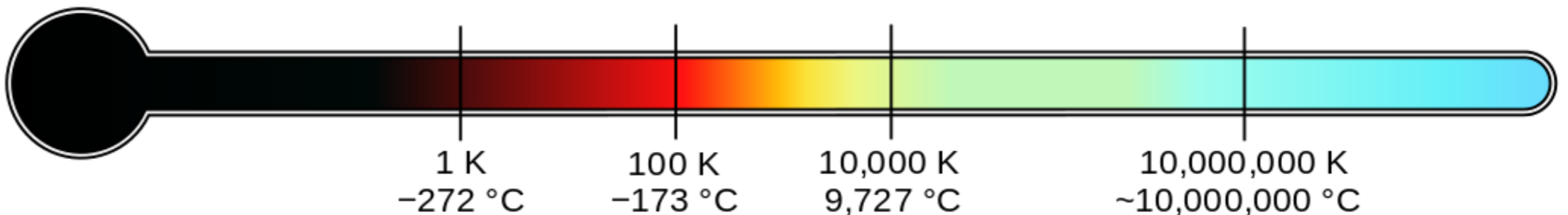


Buildings Humans Butterflies Needle Point Protozoans Molecules Atoms Atomic Nuclei

Frequency (Hz)

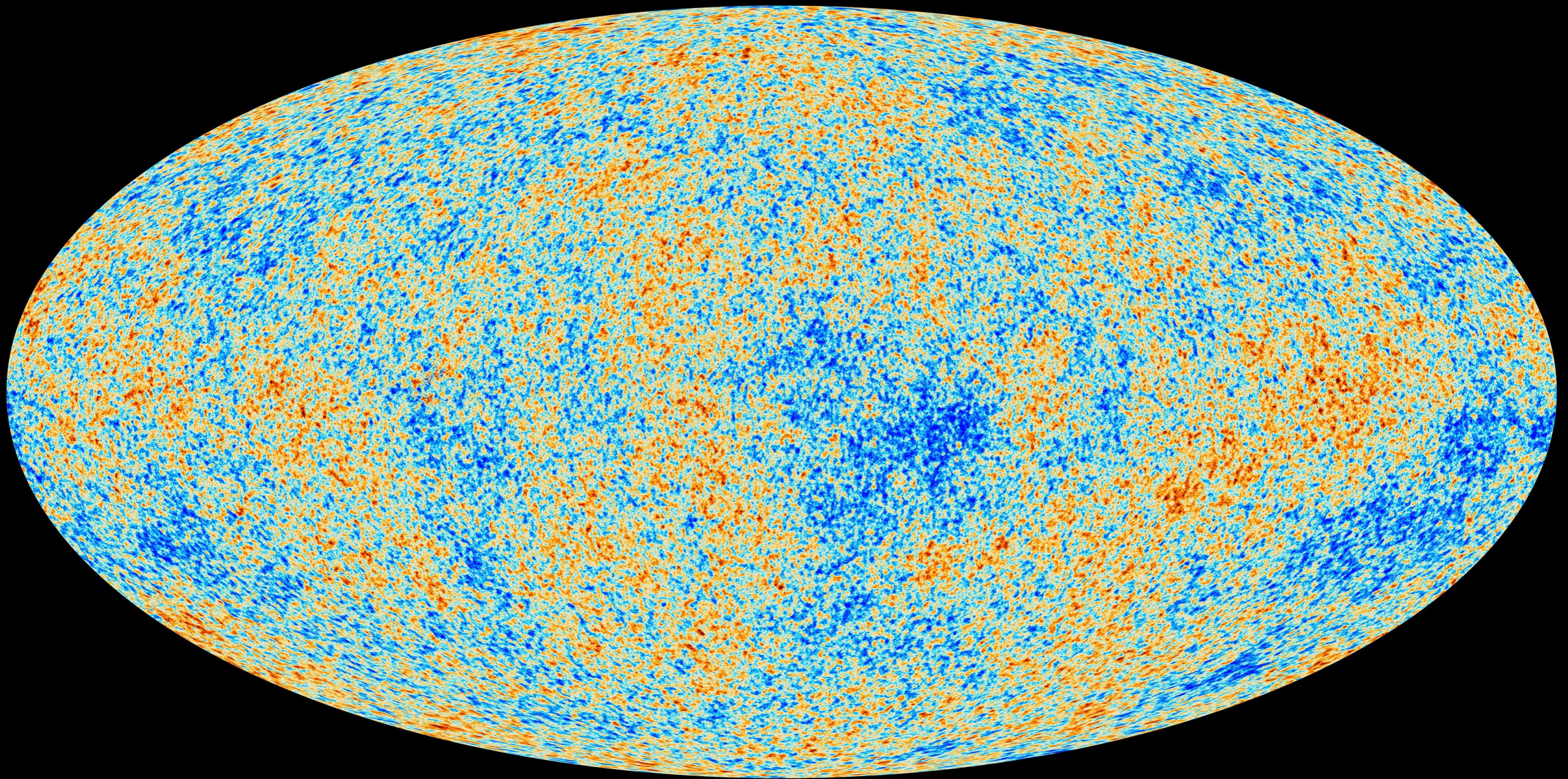


Temperature of  
objects at which  
this radiation is the  
most intense  
wavelength emitted

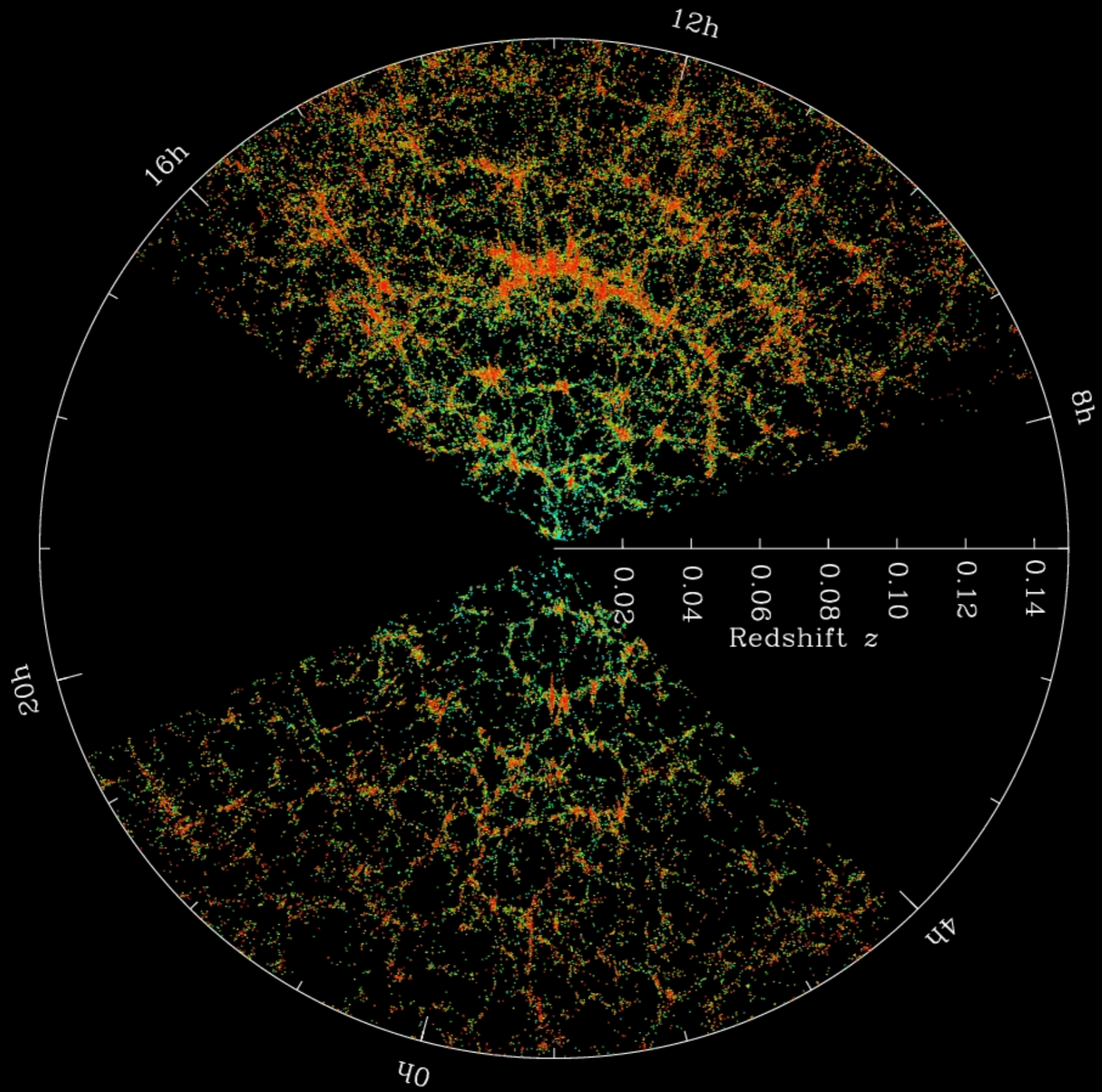




# Cosmic Microwave Background Radiation

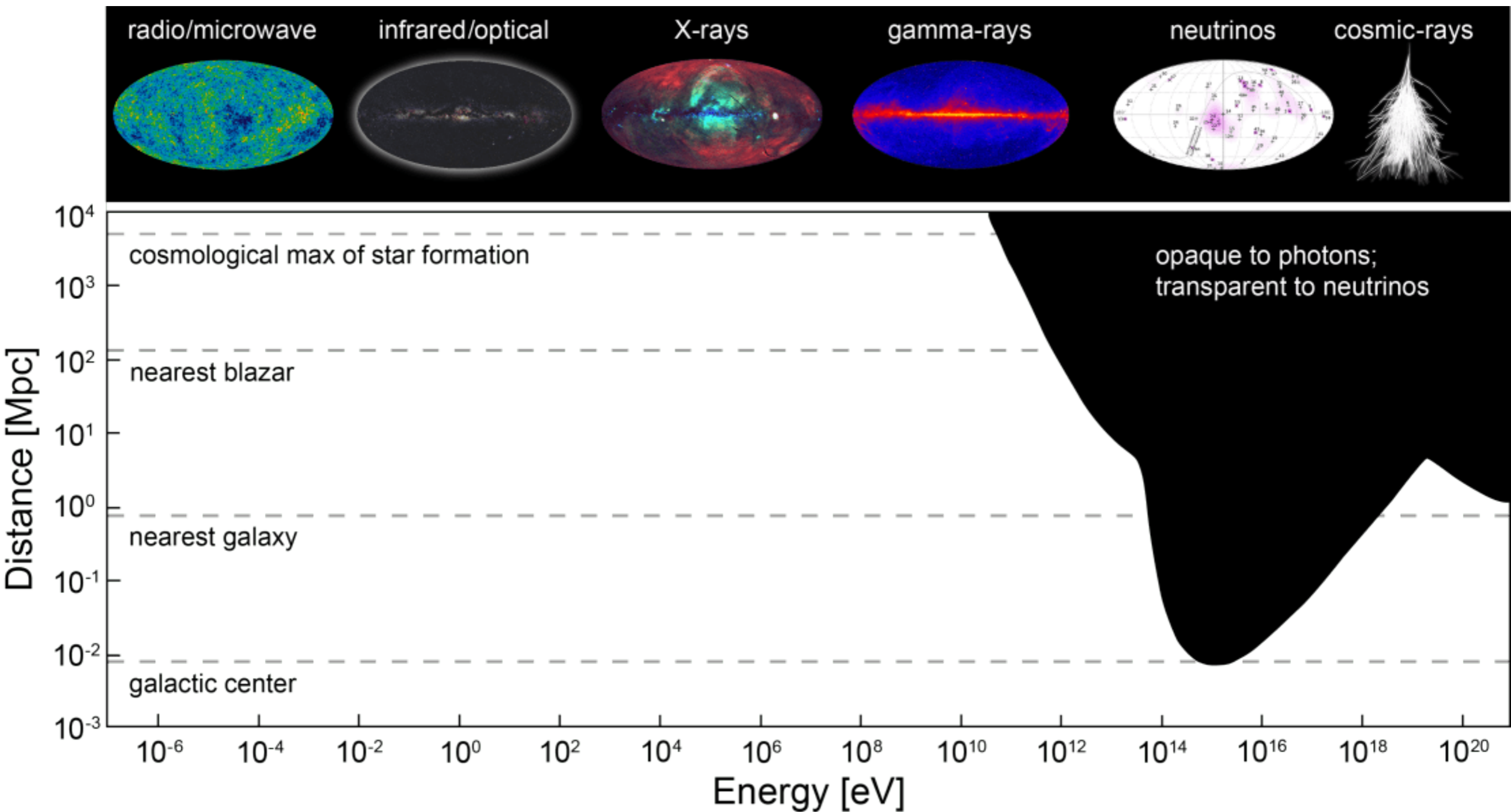






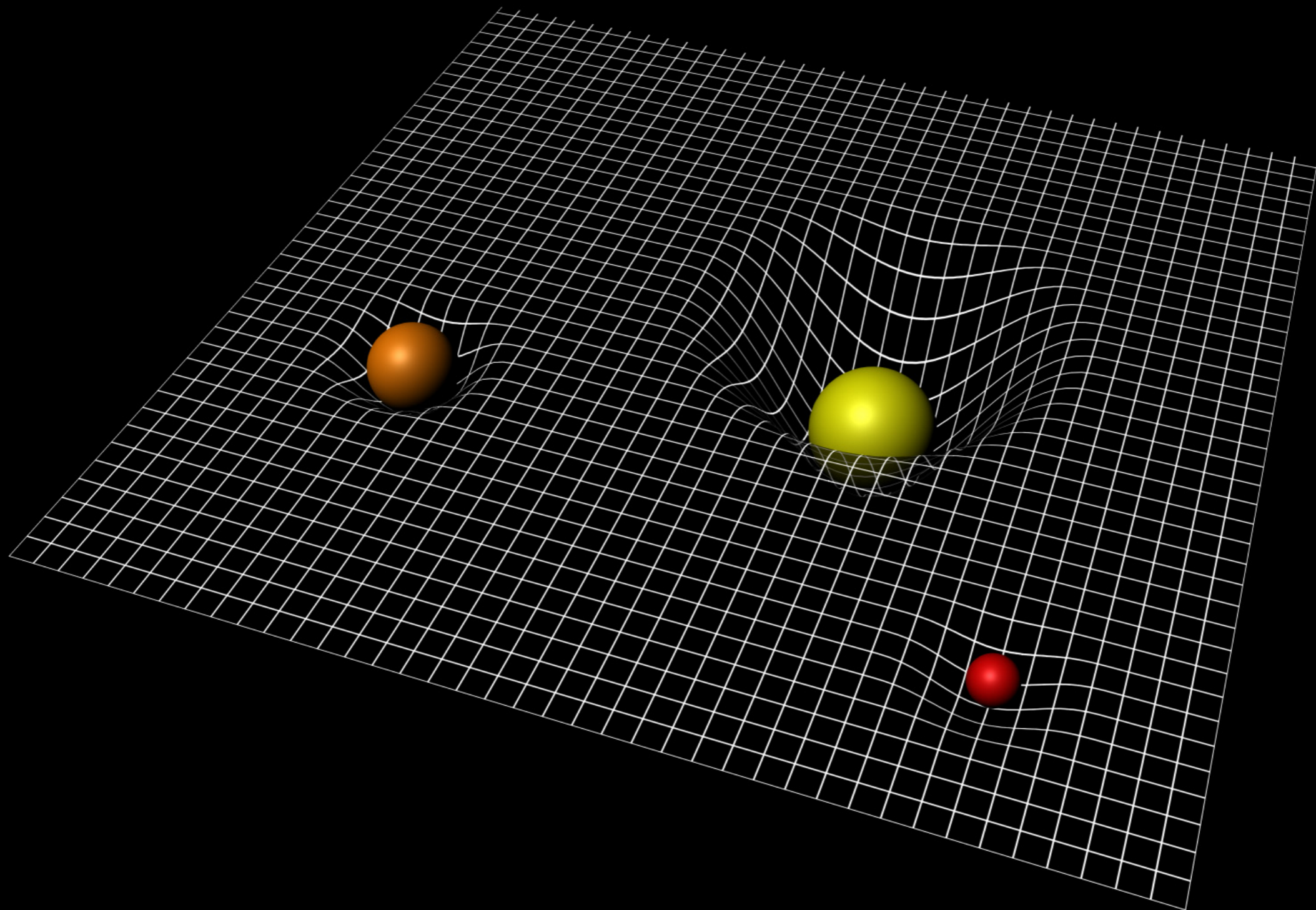


# Electromagnetic Spectrum



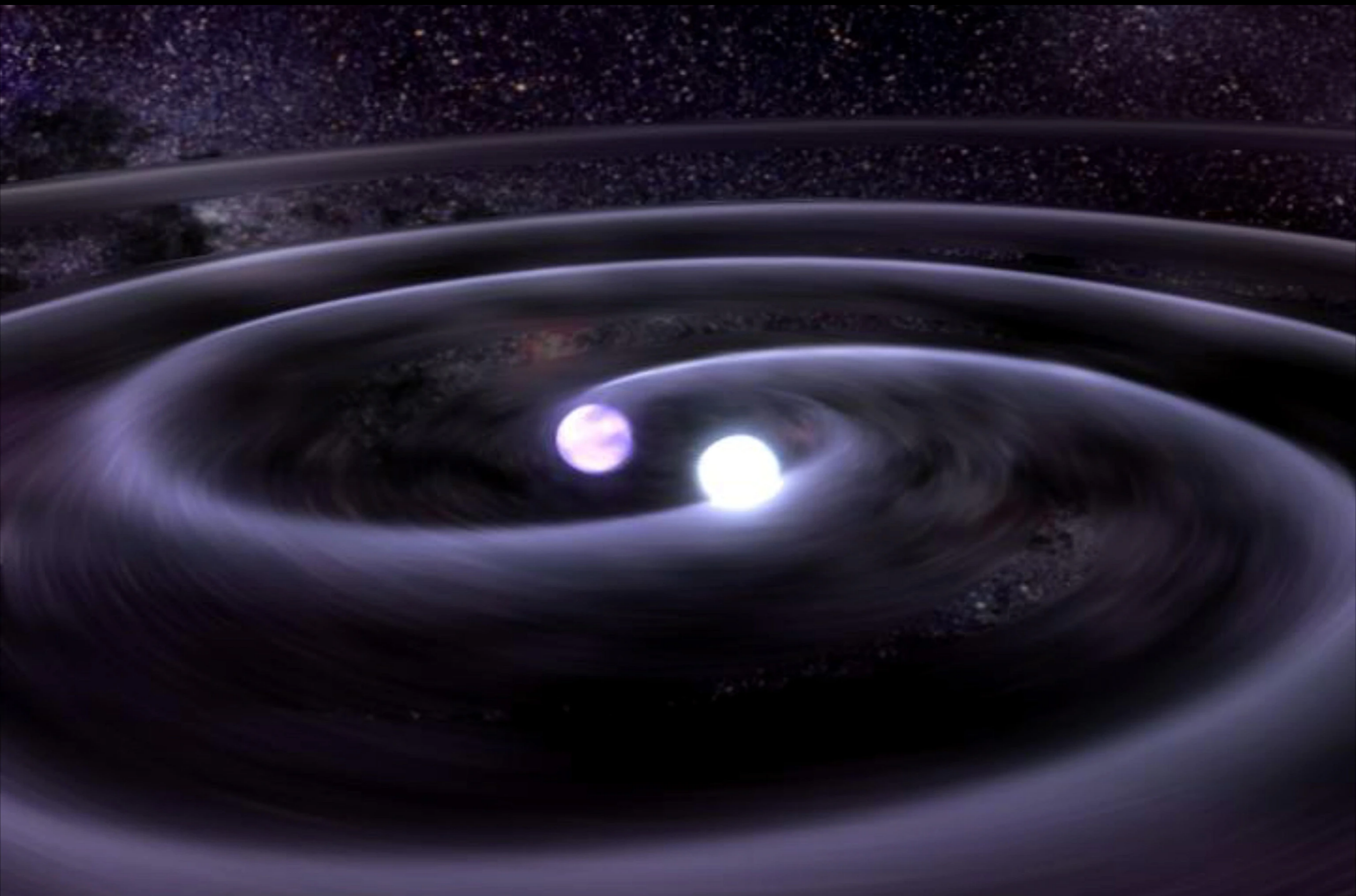


# Spacetime is Curved





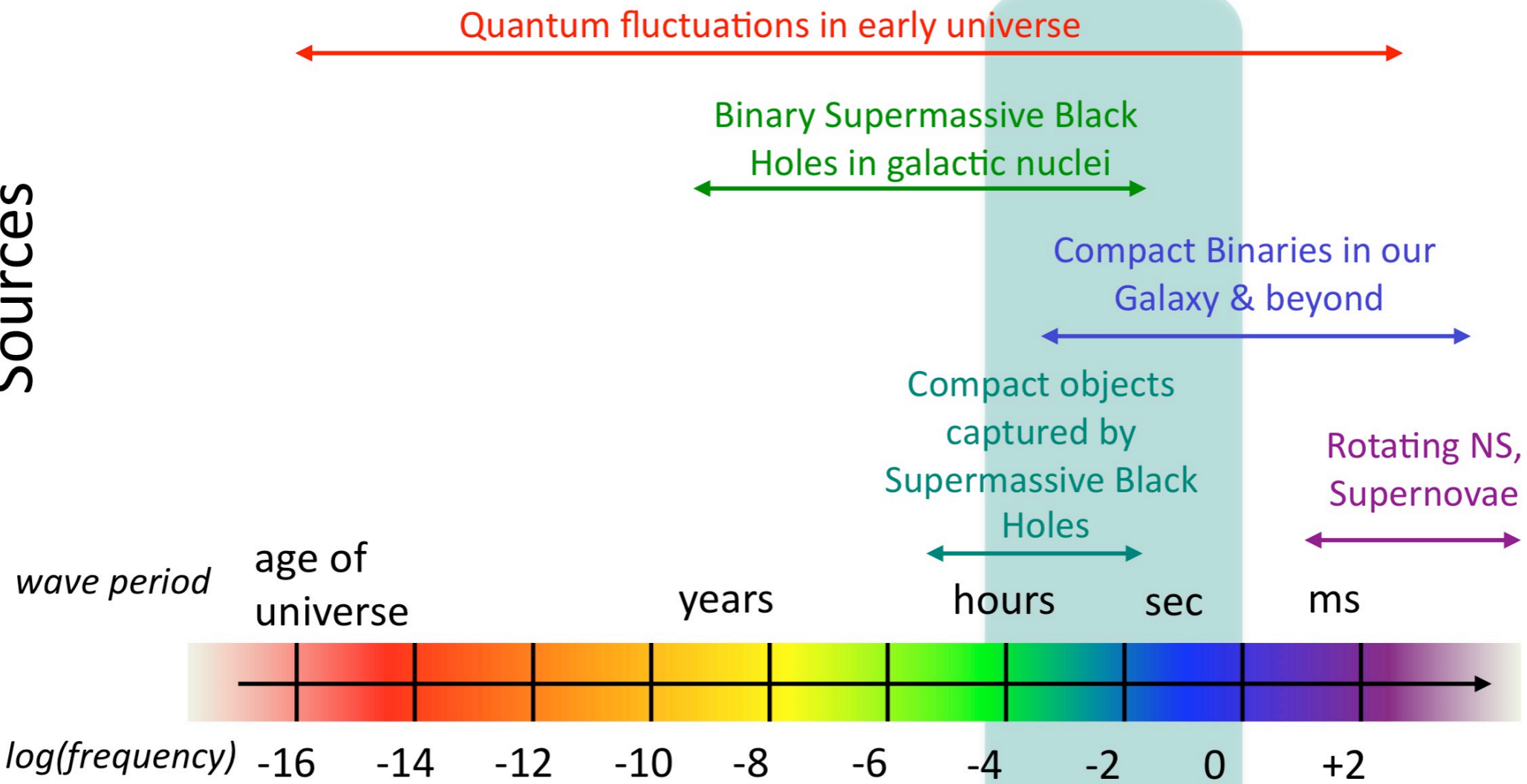
# Gravitational Waves



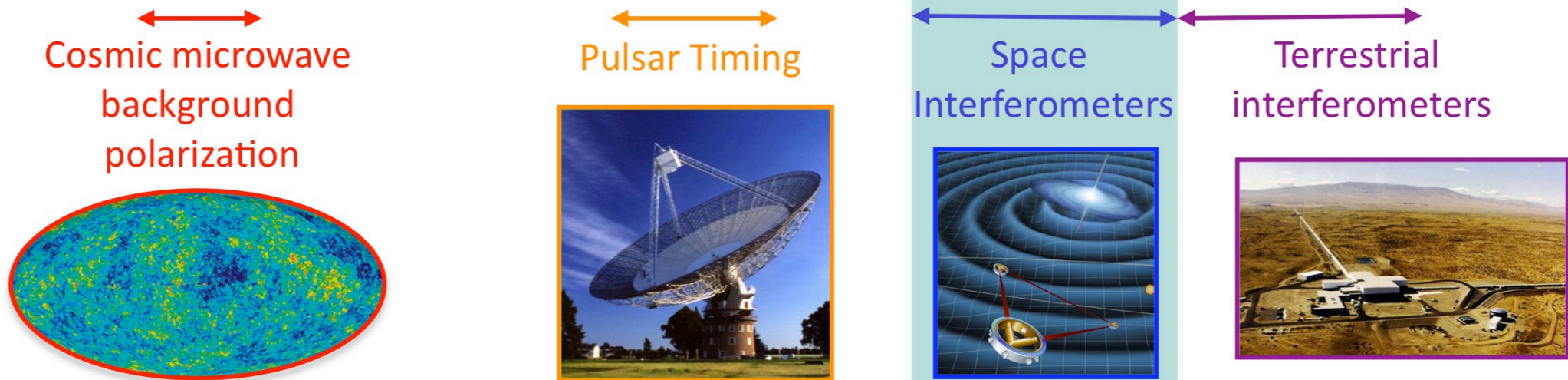


# The Gravitational Wave Spectrum

Sources

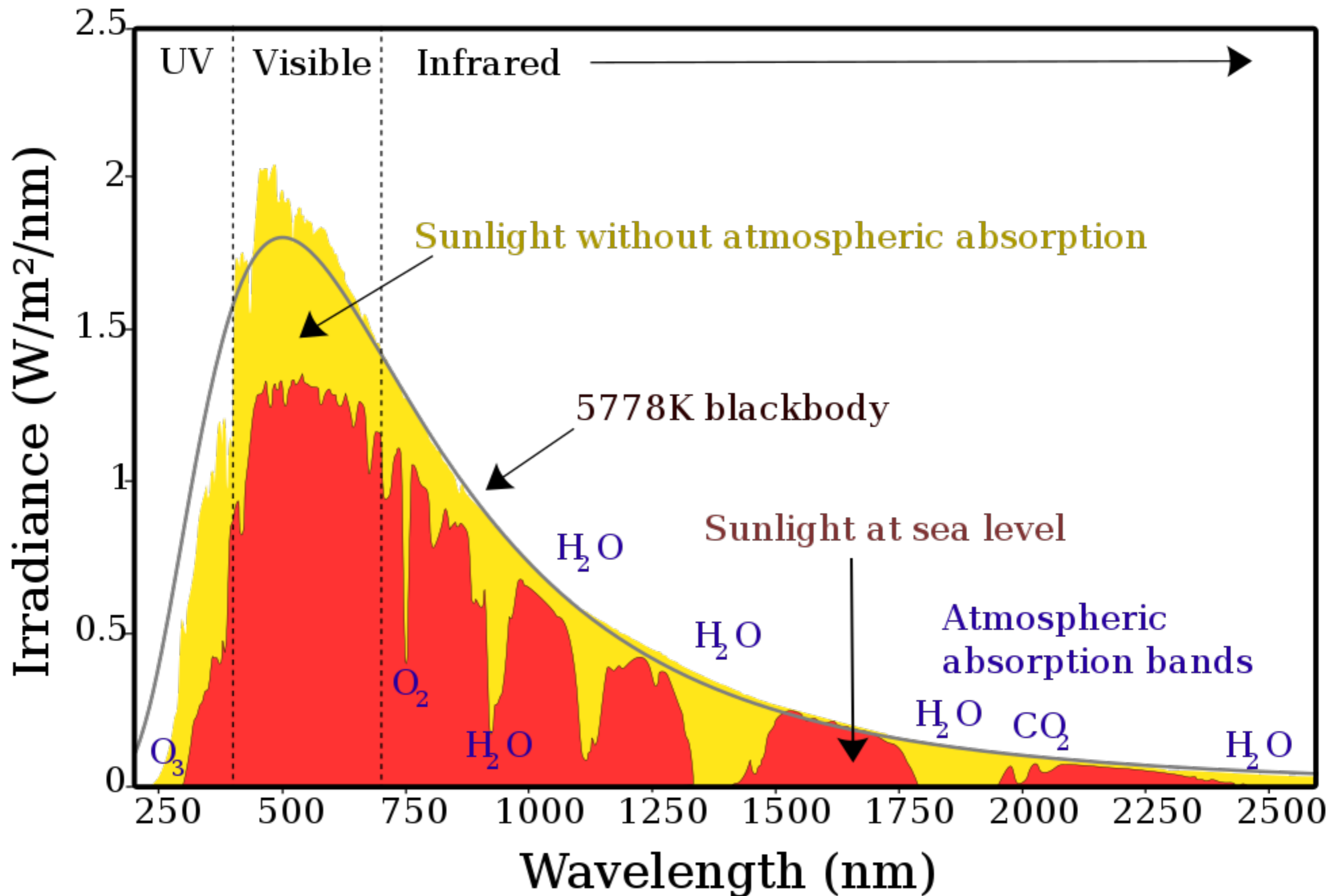


Detectors

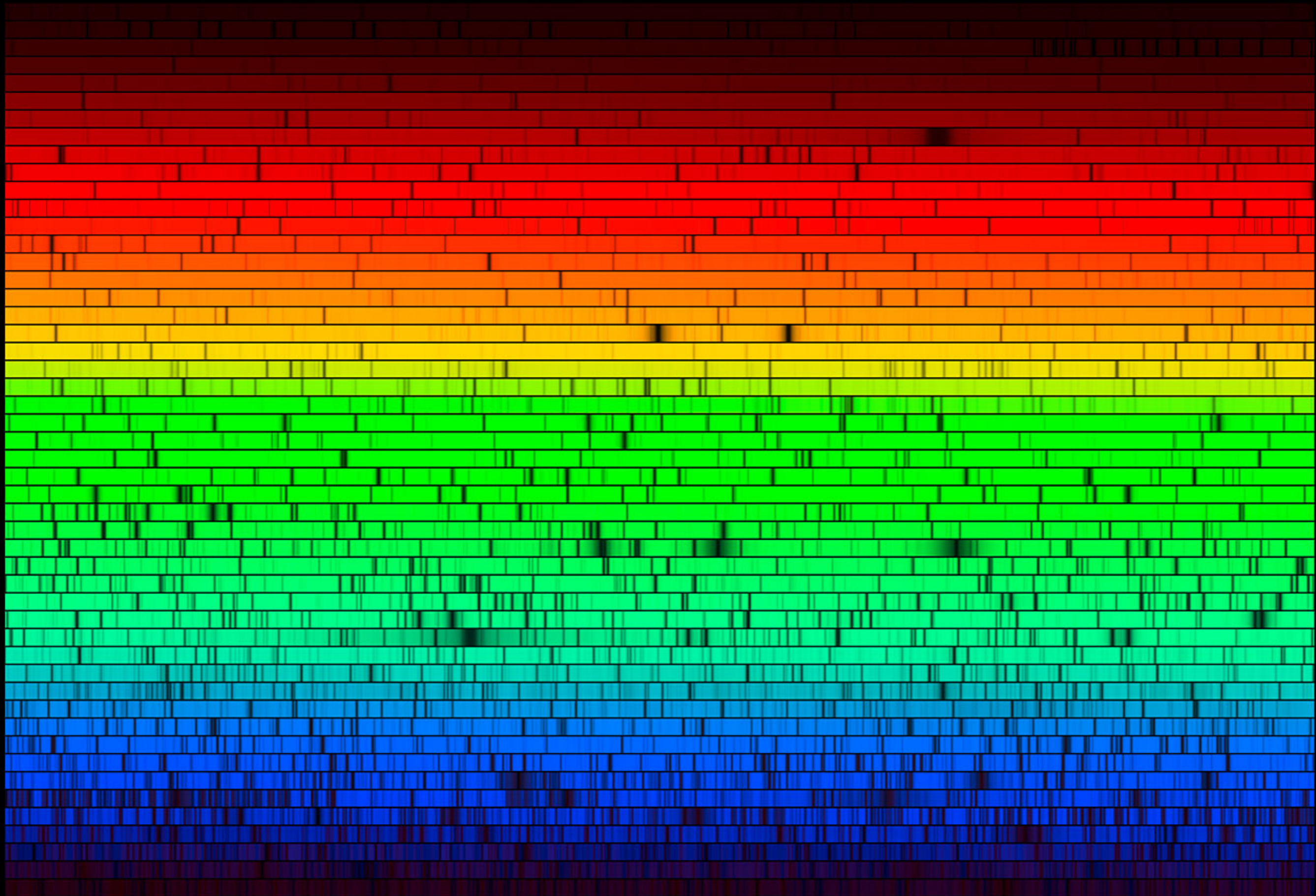




# Spectrum of Solar Radiation (Earth)









Hot Source  
(Star)

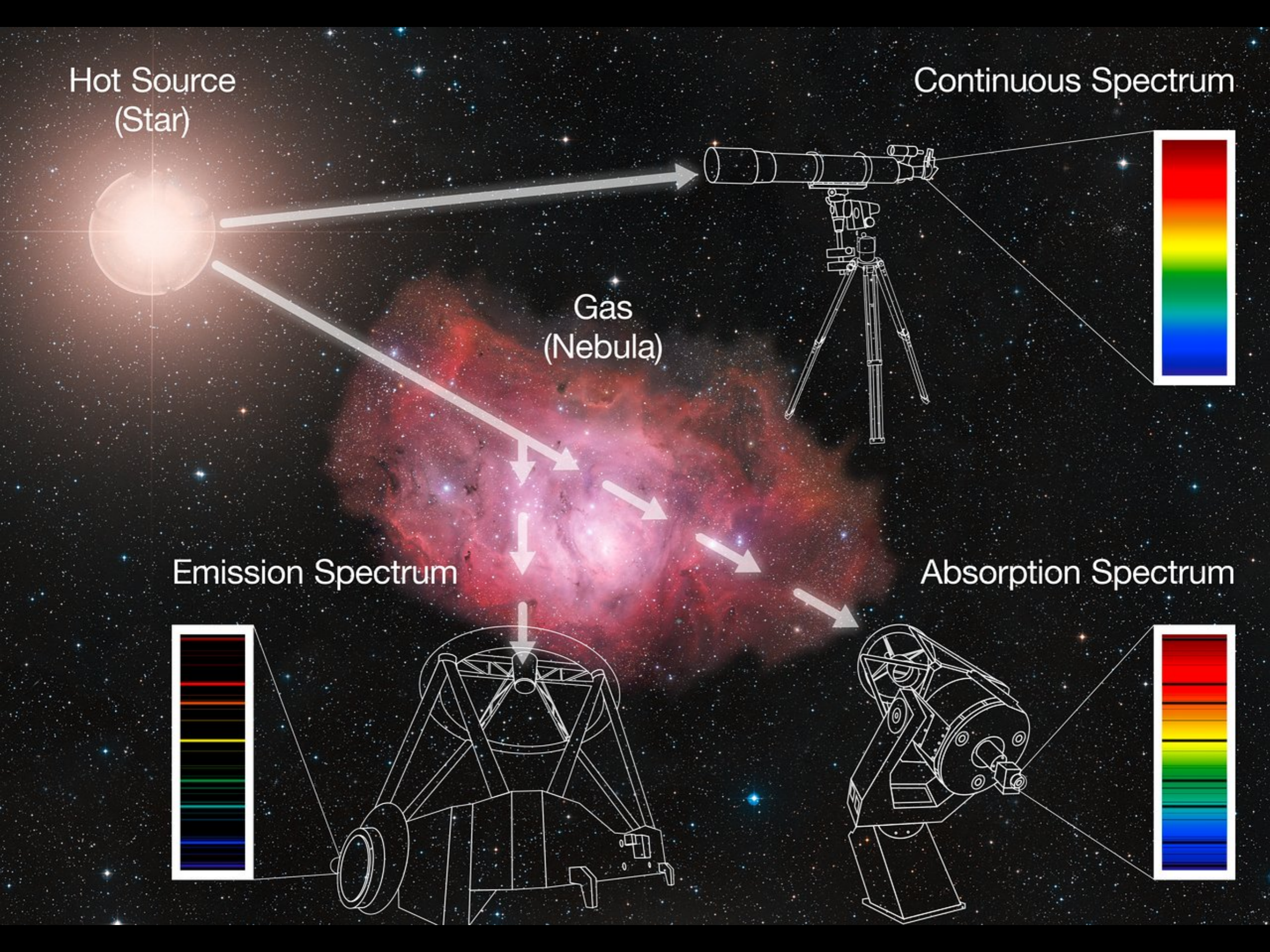
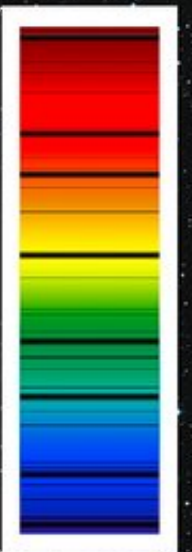
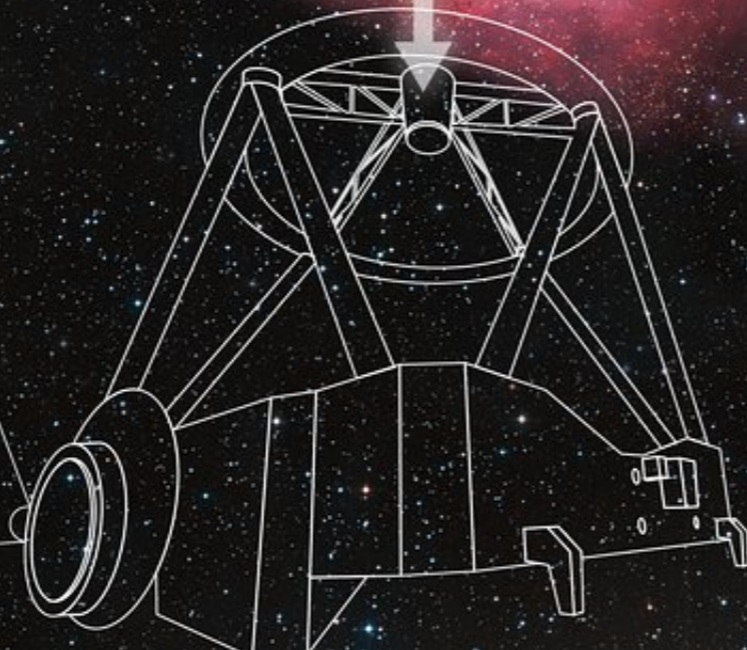
Continuous Spectrum



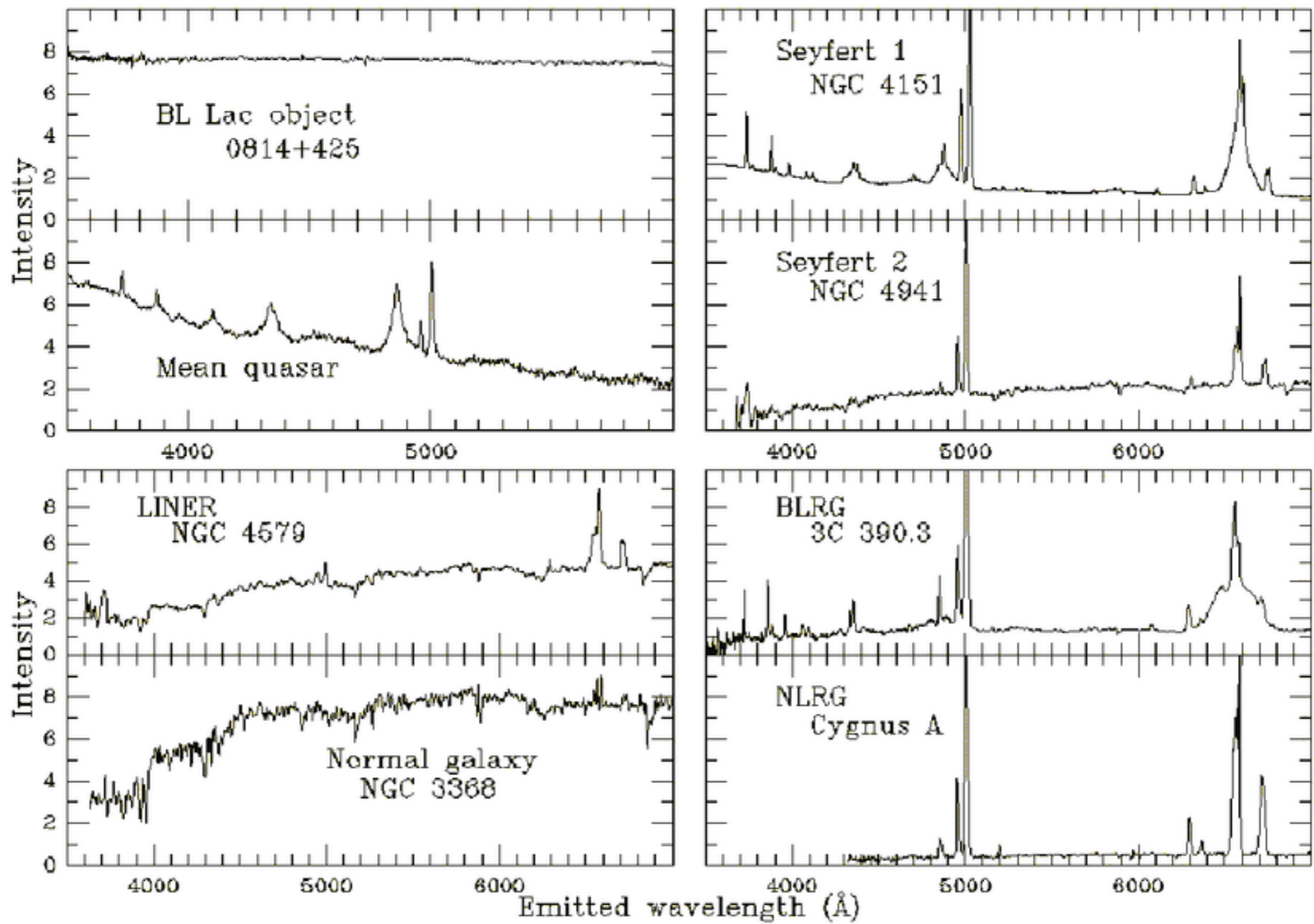
Gas  
(Nebula)

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 $1 \text{ pc} = 206265 \text{ AU}$

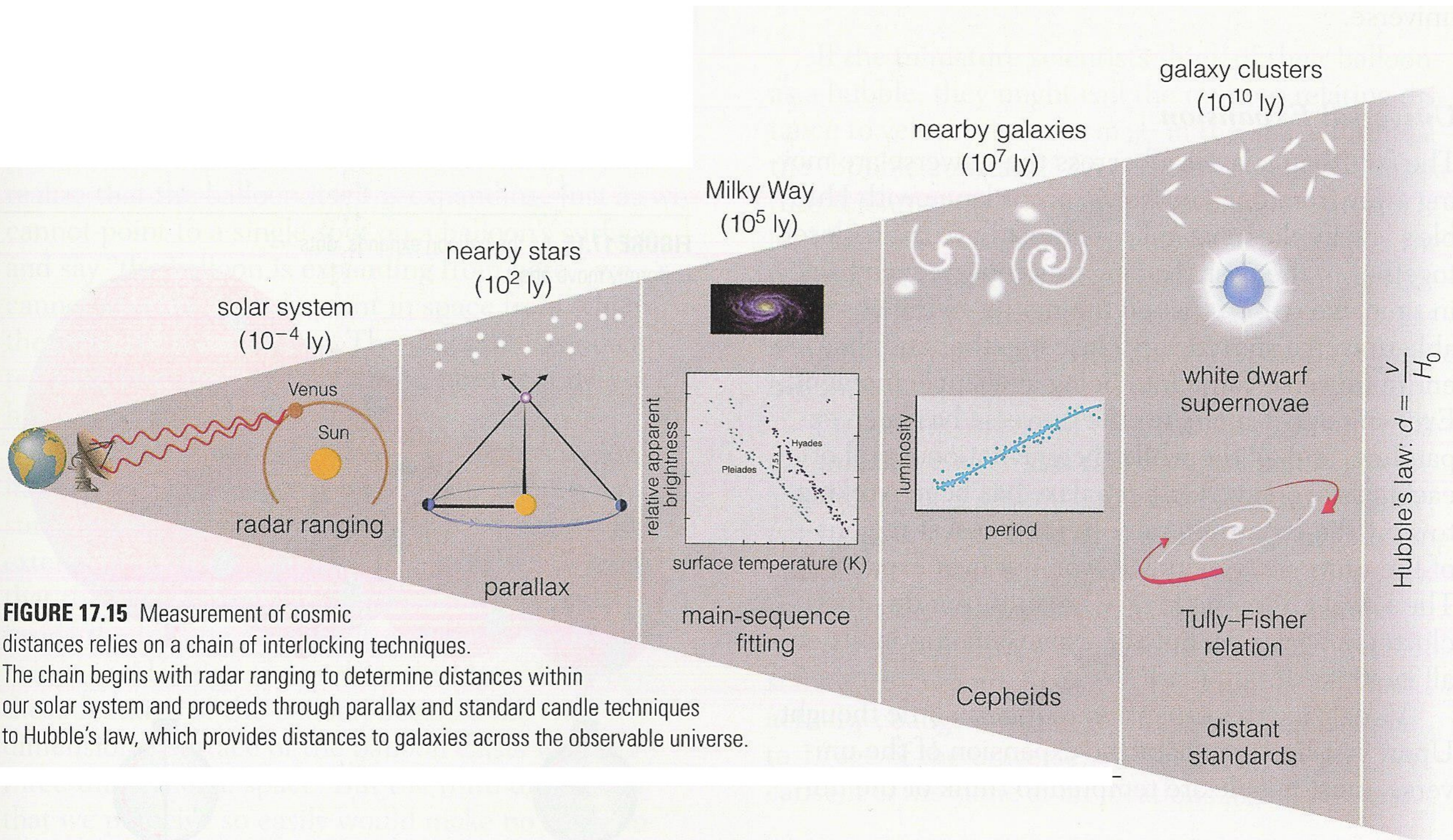


# Distance Measurements

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



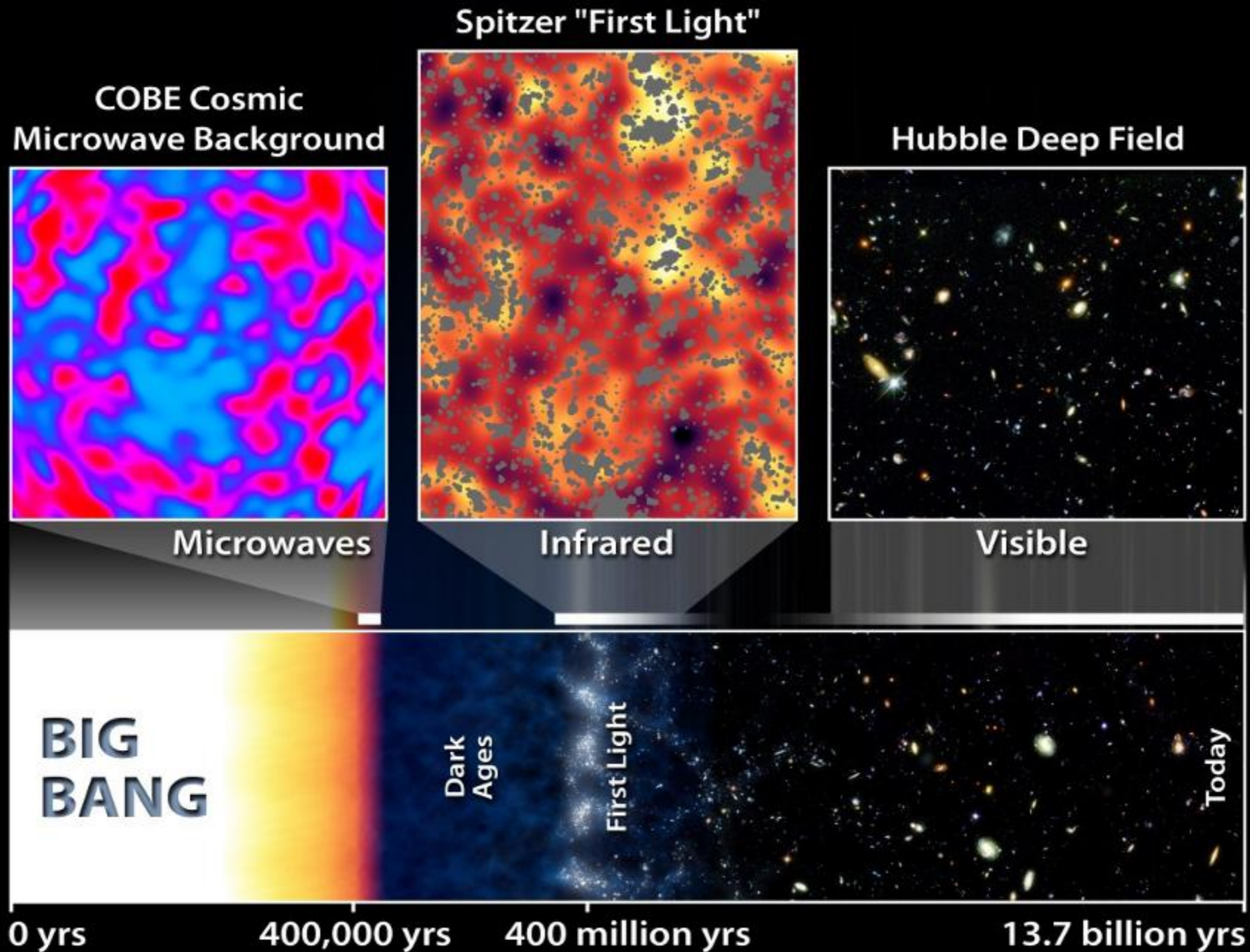
**FIGURE 17.15** Measurement of cosmic distances relies on a chain of interlocking techniques. The chain begins with radar ranging to determine distances within our solar system and proceeds through parallax and standard candle techniques to Hubble's law, which provides distances to galaxies across the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



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**Timeline of the Universe**

**Spitzer Space Telescope • IRAC**

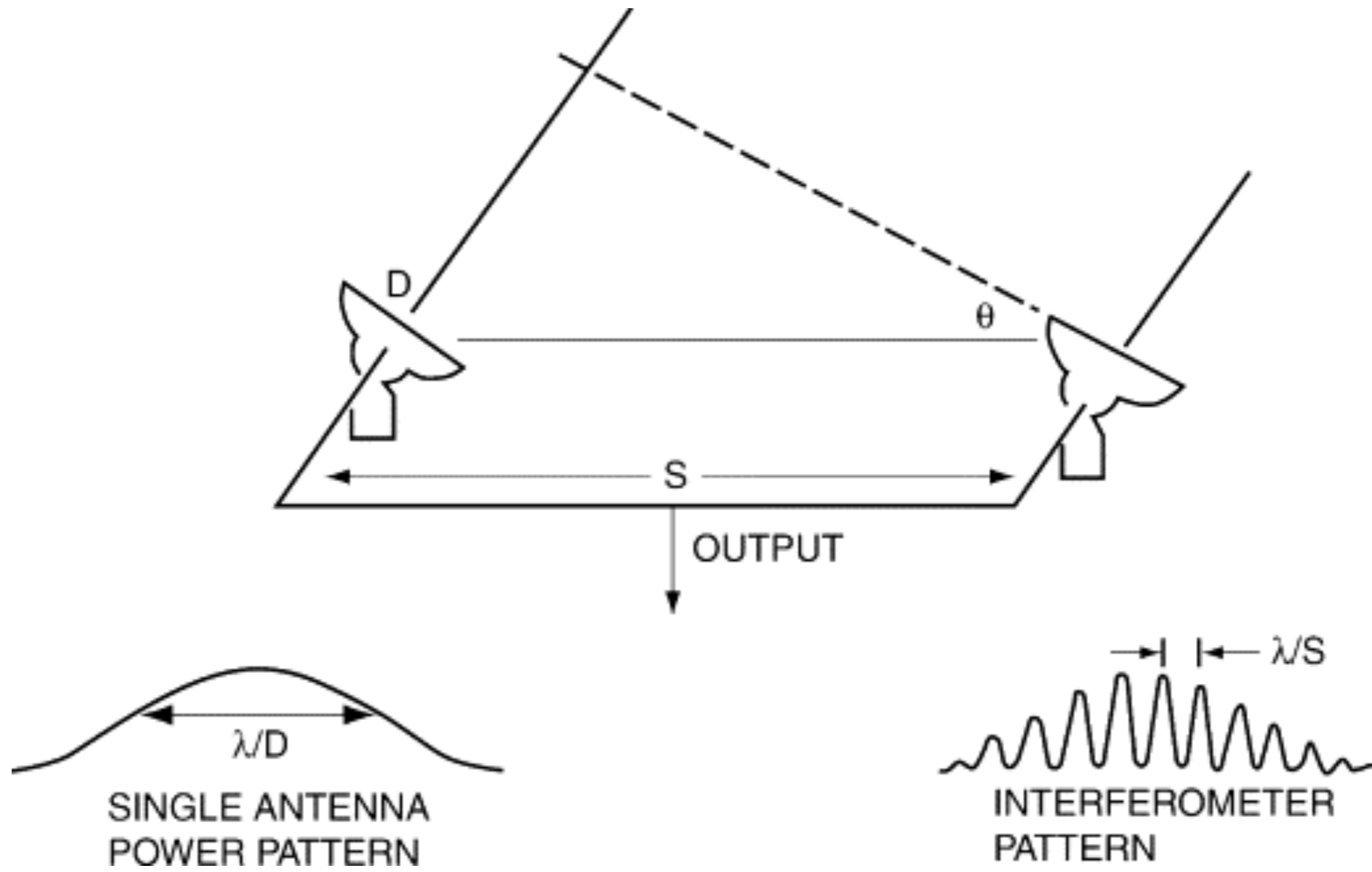


# Square Kilometer Array





# Radio Interferometers



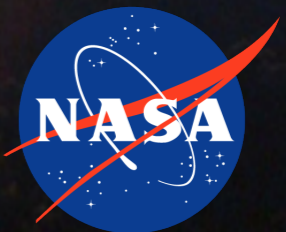








STROBE-X: X-ray Timing & Spectroscopy  
on Dynamical Timescales from  
Microseconds to Years





# 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**

