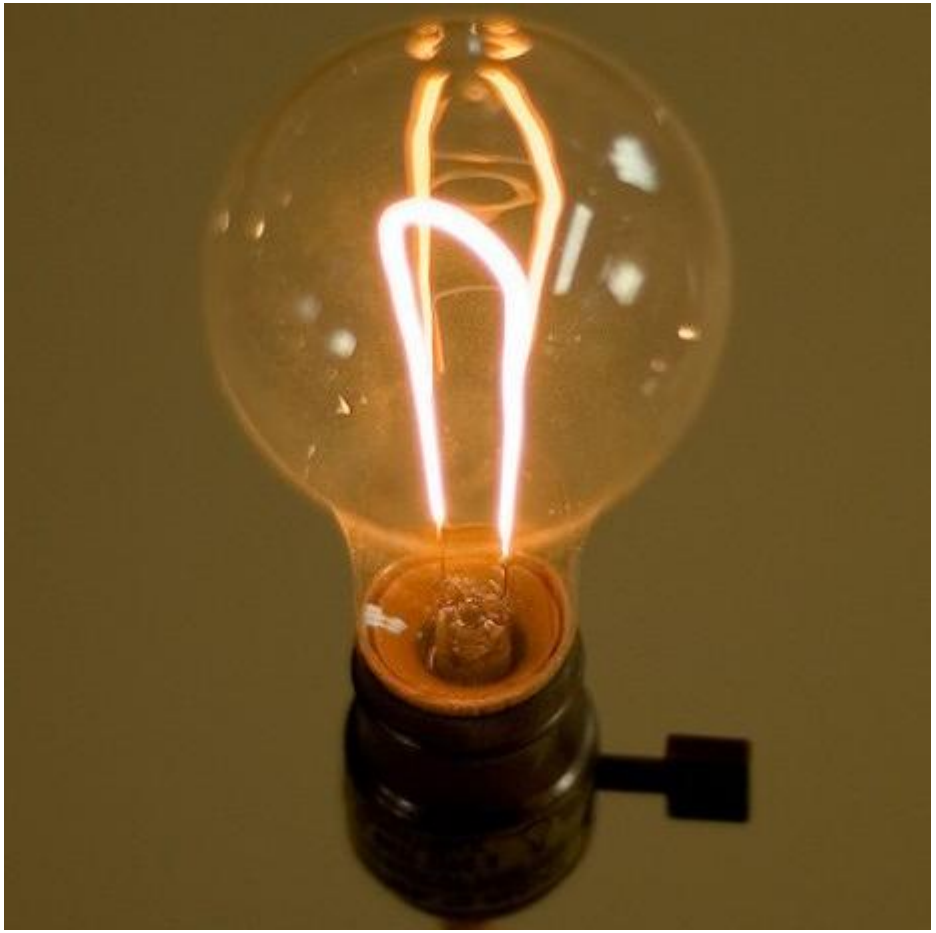
What causes light?

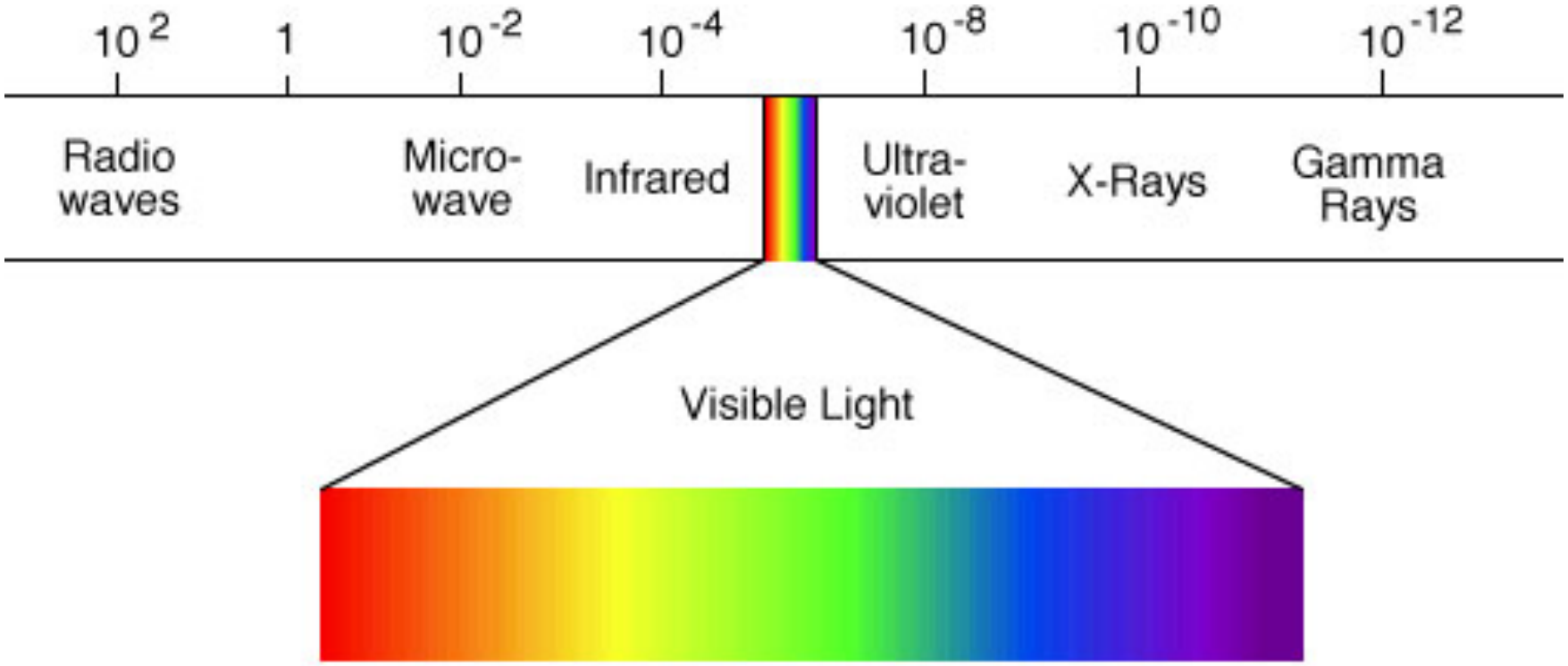
https://youtu.be/oCEKMEeZXug



Learning Target

I can construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

Approximate wavelength in meters:



LONG Wavelength

LOW Frequency

SHORT Wavelength

HIGH Frequency

Frequency-Energy Relationship

The energy of the radiation is related to the frequency of the light wave:

$$E = hf \quad \text{or} \quad E = \frac{hc}{\lambda}$$

The constant ***h*** is known as the Planck constant, and it is equal to:

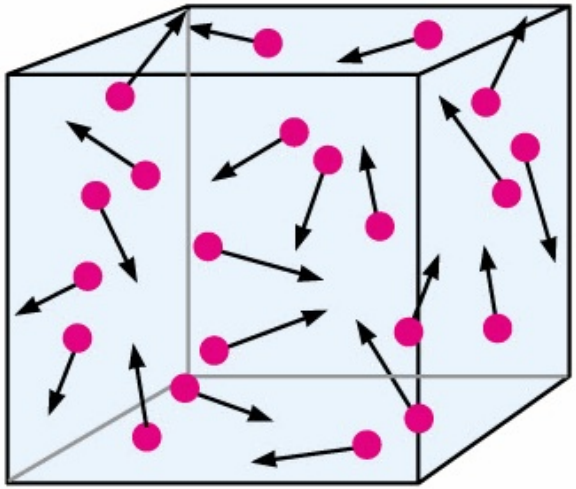
$$h = 4.14 \times 10^{-15}\ eV\text{-}s$$

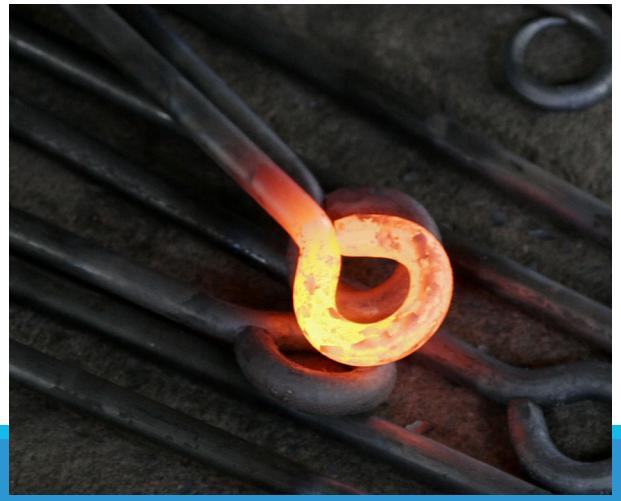
Thermal Radiation

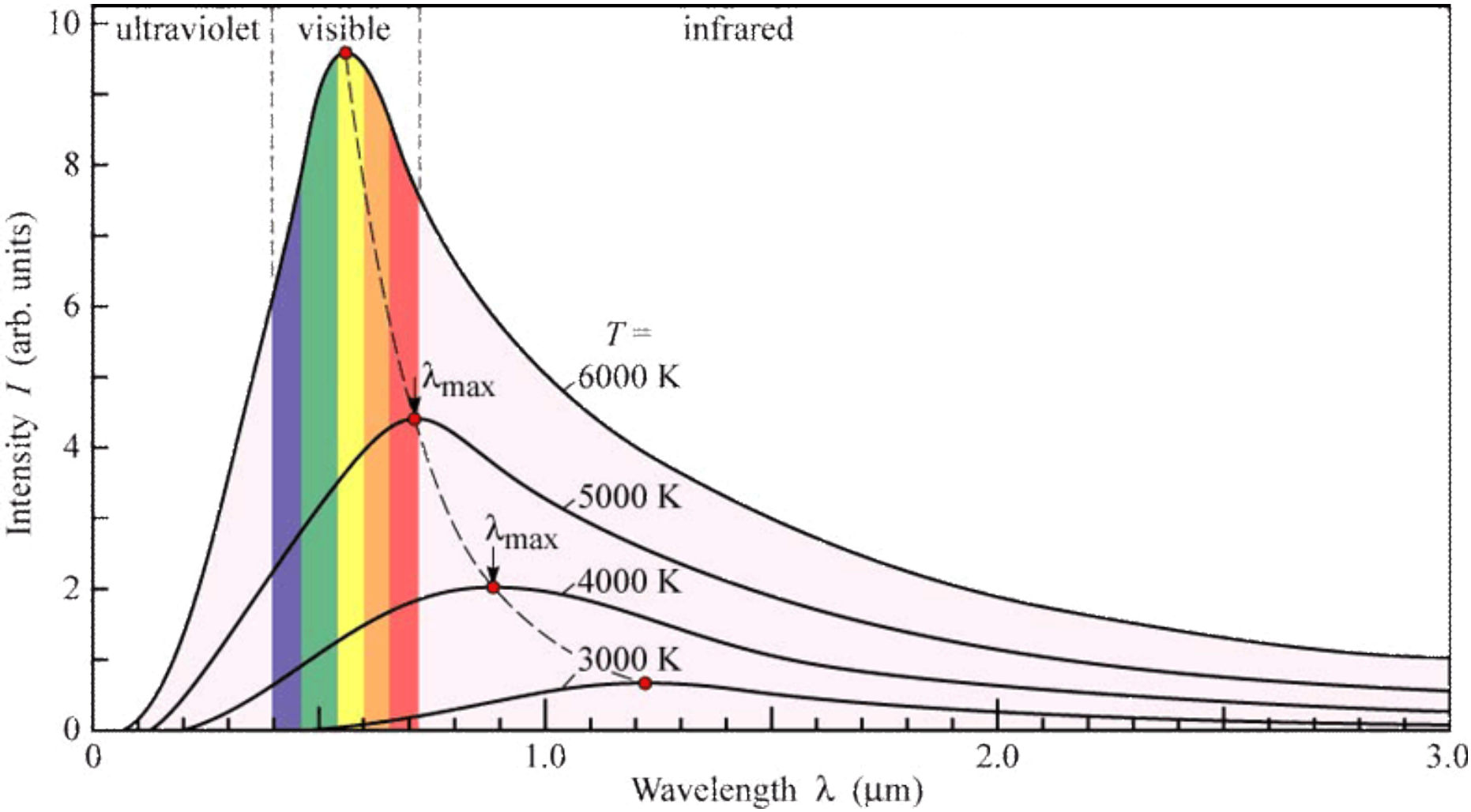
Electromagnetic radiation that is generated by the motion of charged particles in matter is known as **thermal radiation**.

Thermal radiation consists of a wide range of wavelengths—due to a wide spectrum of energies even at a single temperature.

- A few atoms move very fast—short wavelength radiation.
- A few atoms move very slow—long wavelength radiation.
- The majority of atoms move at a speed that depends on the temperature of the object.



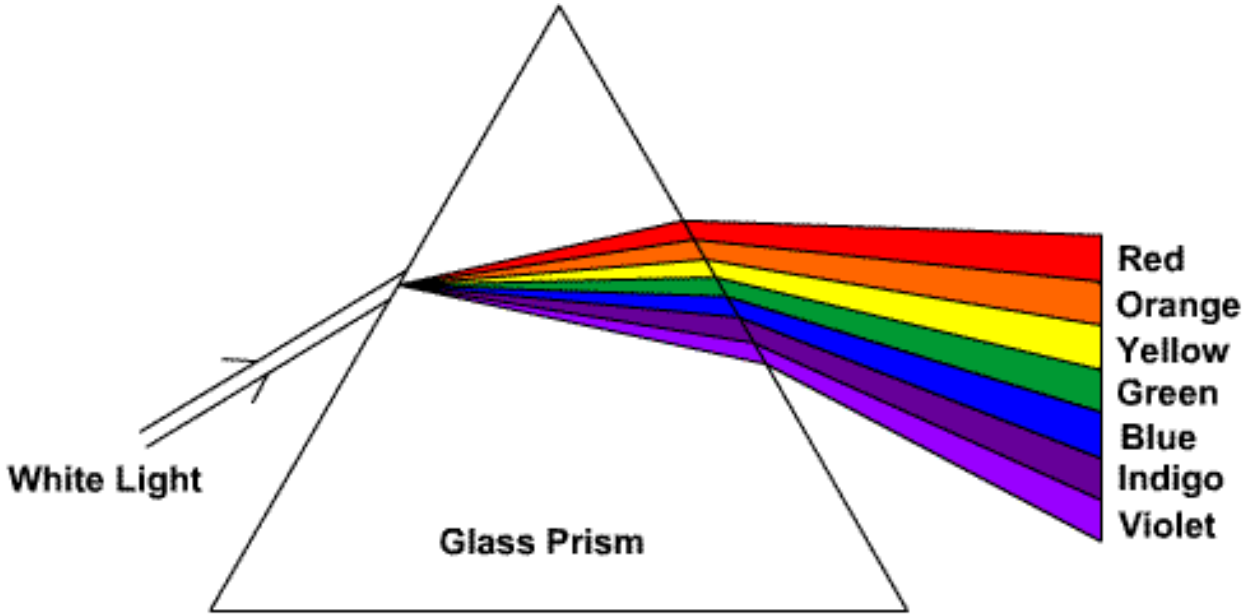



ultraviolet
visible
infrared
10
8
6
4
2
0
Intensity I (arb. units)
T =
6000 K
5000 K
4000 K
3000 K
λmax
λmax
0
1.0
2.0
3.0
Wavelength λ (μm)

Wavelength of Maximum Intensity

The wavelength of maximum intensity is inversely proportional to the temperature of the object measured in Kelvins (K):

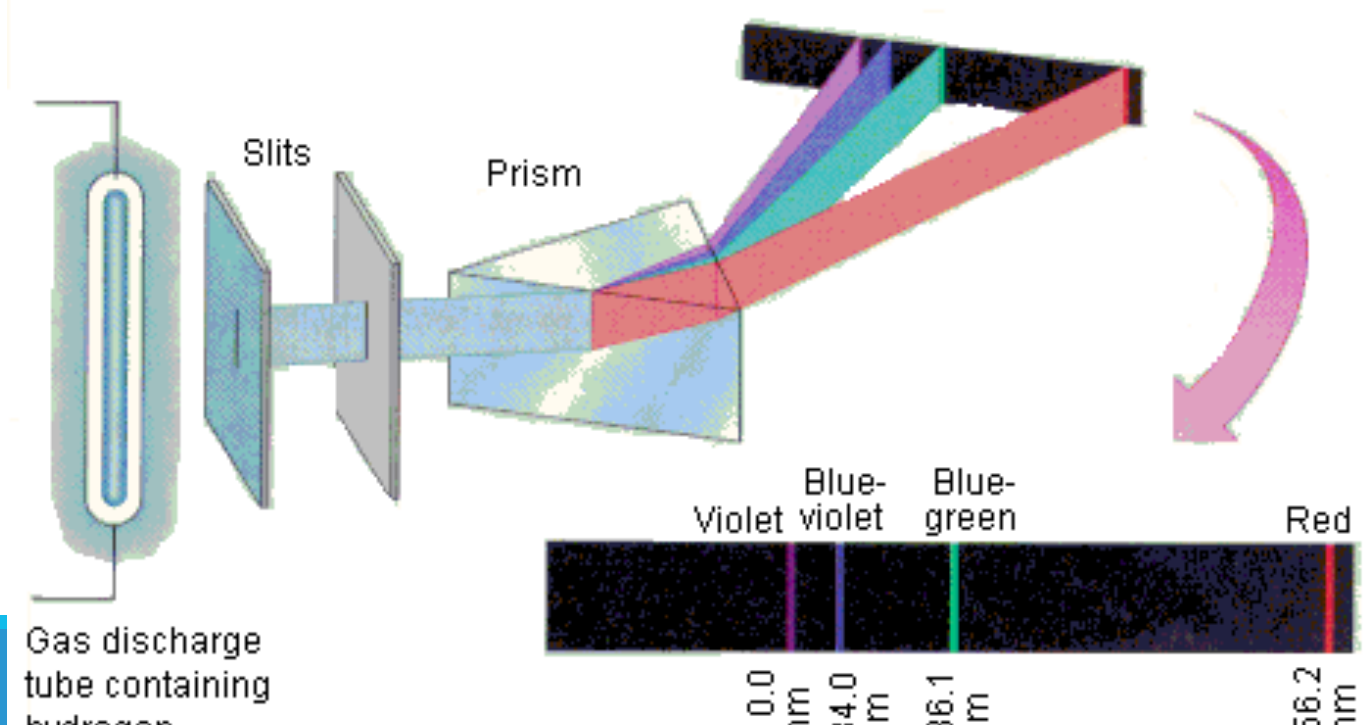
$$\lambda_{max} = \frac{2.898x10^{-3}\mathrm{m} * \mathrm{K}}{T}$$


White Light
Glass Prism
Red
Orange
Yellow
Green
Blue
Indigo
Violet

Observation of Light with Specific Wavelengths

If a low-density gas is given energy, it will also produce light—but in a different way.

Each element has specific wavelengths of light that it emits after being given energy.



Observation of Light with Specific Wavelengths

If a low-density gas is given energy, it will also produce light—but in a different way.

Each element has specific wavelengths of light that it emits after being given energy.

(a)

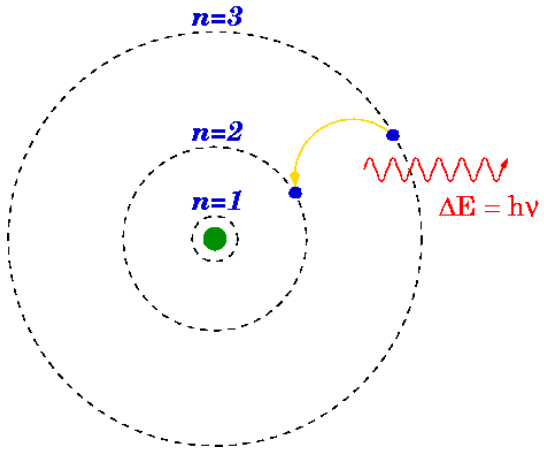
(b)

The Bohr Model of an Atom

The electron can only be in a certain order of energy levels—similar to the amount of wavelengths that can fit on a standing wave.

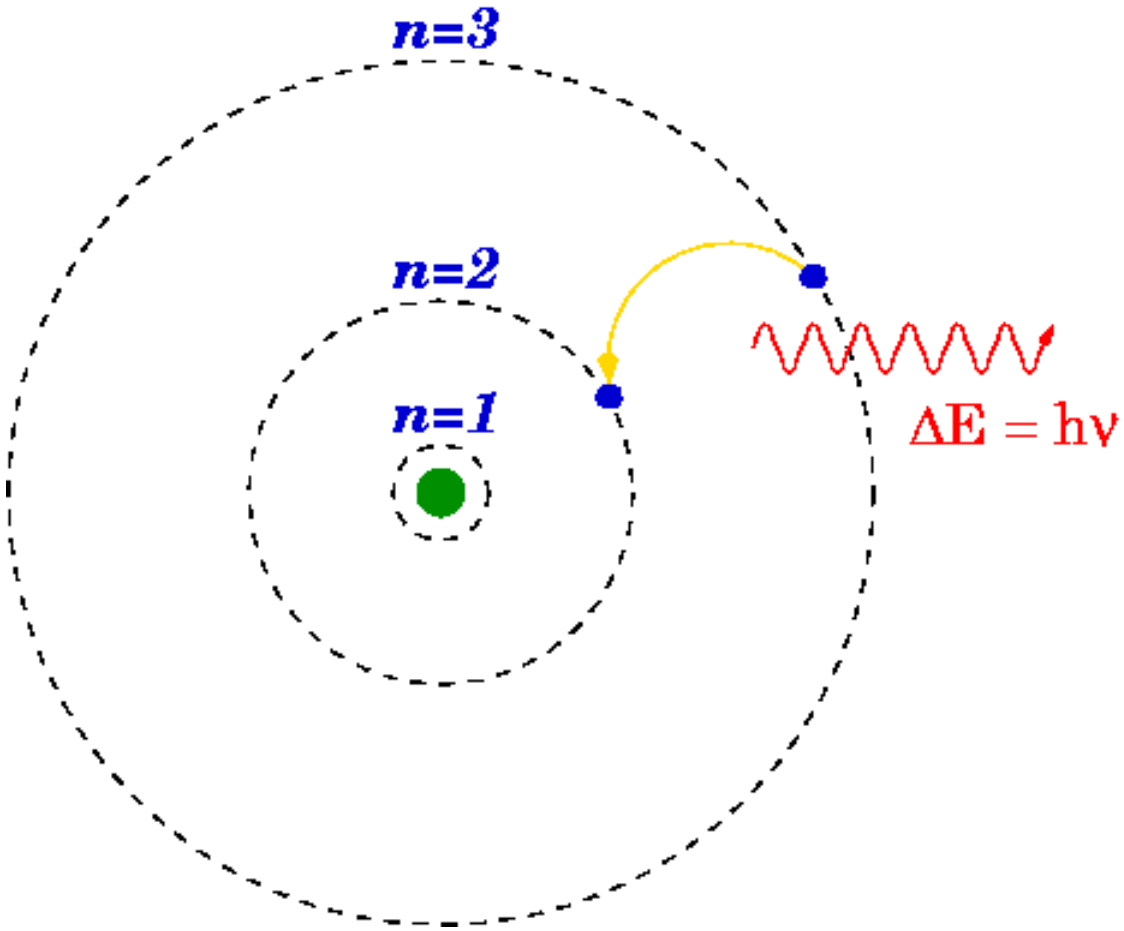
The electron normally occupies the lowest energy level—or the **ground state**—but it can be "excited" to a higher energy level.

After being excited, the electron releases the energy as a photon, and the amount of energy is equal to the difference in the energy levels.



Simulation: Bohr Model of an Atom

https://phet.colorado.edu/en/simulation/hydrogen-atom



Make A Spectrum

Hydrogen

Sodium

Helium

Neon

Mercury

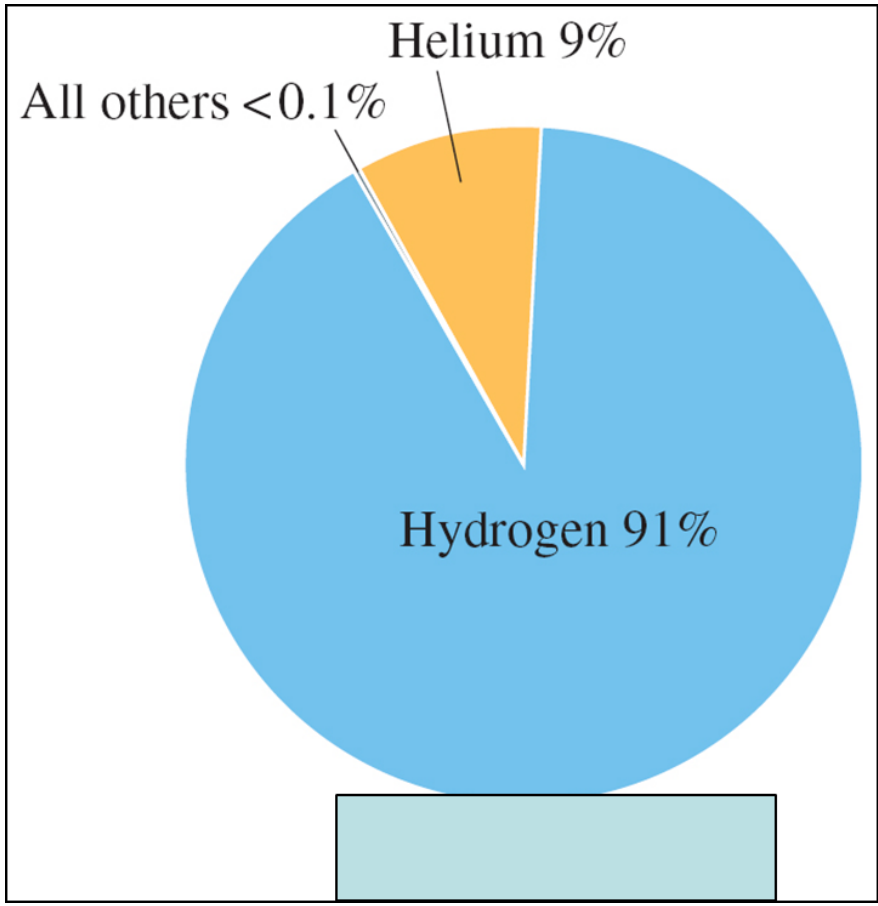
Observations of the Universe

Cosmic Abundance of Elements

Astronomers look at the Sun's radiation and they find that it is made mostly of hydrogen, some helium, and traces of other gases.

Based on the light from stars and galaxies, the universe appears to be made of approximately 91% Hydrogen, 9% Helium, and less than 0.1% other elements.

A theory of the origin of the universe must account for this abundance of hydrogen and helium.

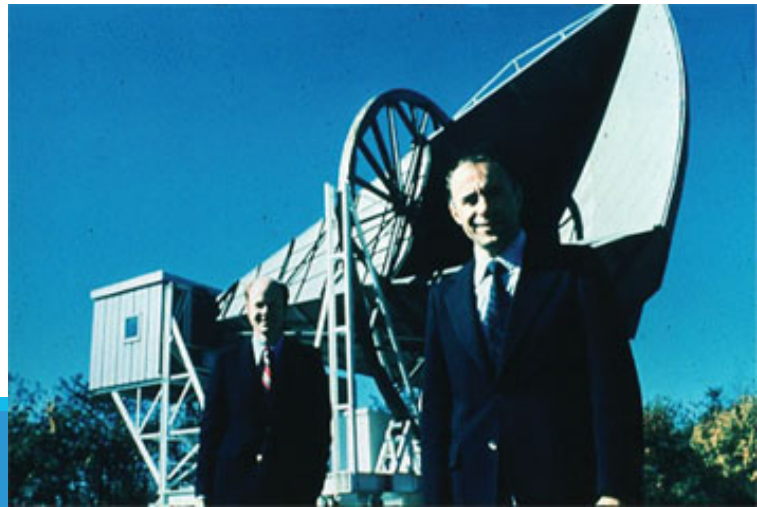


Cosmic Microwave Background

In 1964, while attempting to detect faint radio waves bounced off balloon satellites, Arno Penzias and Robert Wilson kept getting interference (like static) in their receiver.

After attempting to get rid of all possible sources of interference—including removing bird droppings—they determined that the radio noise was coming from space, and in all directions.

The radiation they were detecting looked like a thermal radiation curve with a peak wavelength of 1.07 mm. ***What does this imply about the temperature of the universe?***



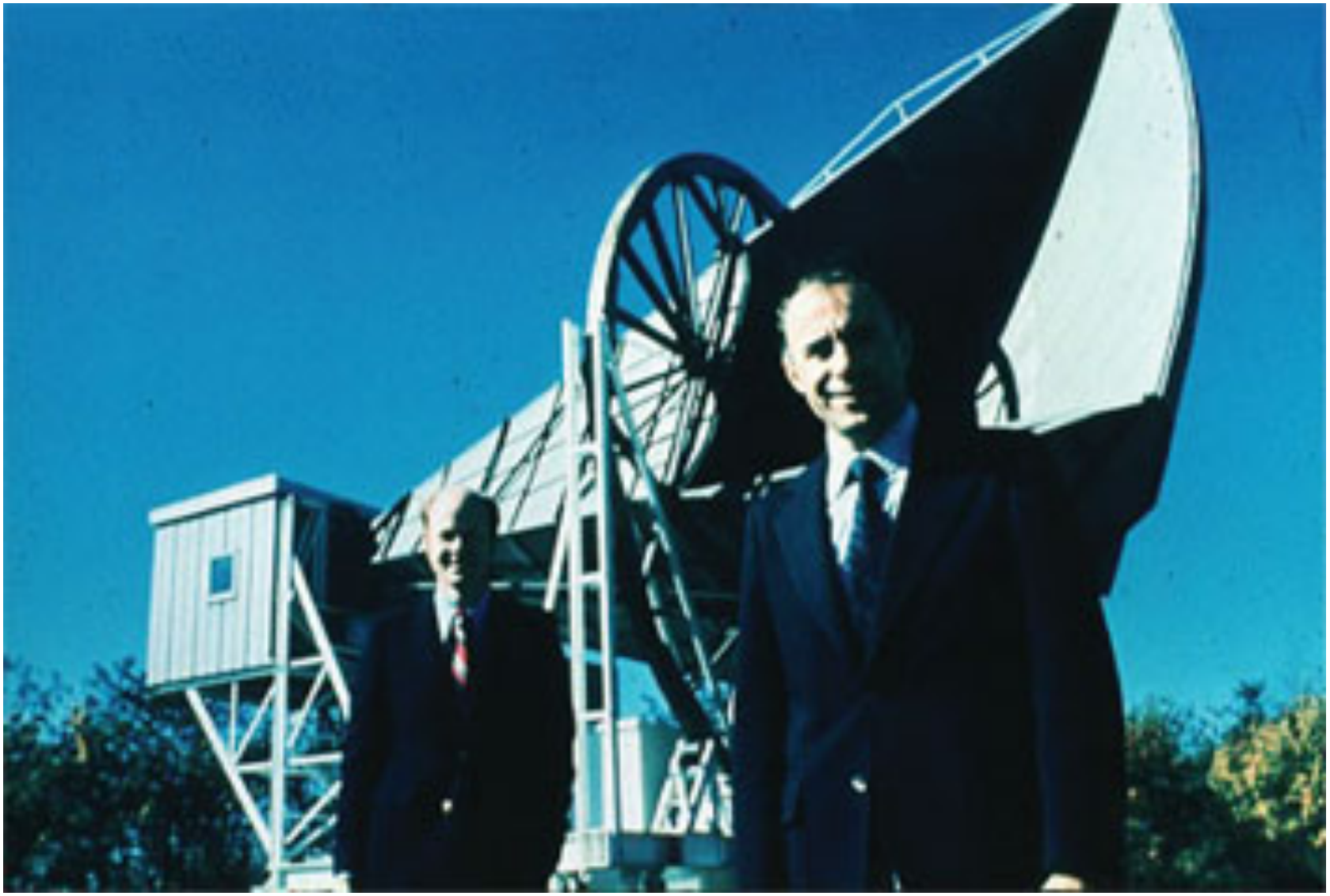
Cosmic Microwave Background

In 1964, while attempting to detect faint radio waves bounced off balloon satellites, Arno Penzias and Robert Wilson kept getting interference (like static) in their receiver.

After attempting to get rid of all possible sources of interference—including removing bird droppings—they determined that the radio noise was coming from space, and in all directions.

The radiation they were detecting looked like a thermal radiation curve with a peak wavelength of 1.07 mm. ***What does this imply about the temperature of the universe?***

The universe has a temperature of 2.7 K. Any theory of the universe's origins must account for this fact also.



Practice