

Announcements

Bruce Balick, balick@uw.edu, 206.543.7683
<https://faculty.washington.edu/balick/astro190/>

Newly matriculated students should see me

Lecture notes from Monday posted ASAP
First homework sent today to registered students

Mayan story of creation (optional reading**)**
<https://maya.nmai.si.edu/the-maya/creation-story-maya>

<https://www.khanacademy.org/partner-content/big-history-project/what-is-big-history/origin-stories/a/origin-story-mayan>

An Overview of Modern Cosmology

What is the Universe?

What is Cosmology?

What is Space? Motion?

What is Matter? Light, Energy?

What is Gravity?

What is the Big Bang Model?

Cosmology

- Model based on limited skeleton of observations and given form by theories of physics like gravity and light
 - the geometry and size of **space**
 - the role of **matter, light, and gravity**
 - the **state** (density, temperature, chemical properties, and bulk motions)
 - our **cosmic origin** and the future of space

Cosmology

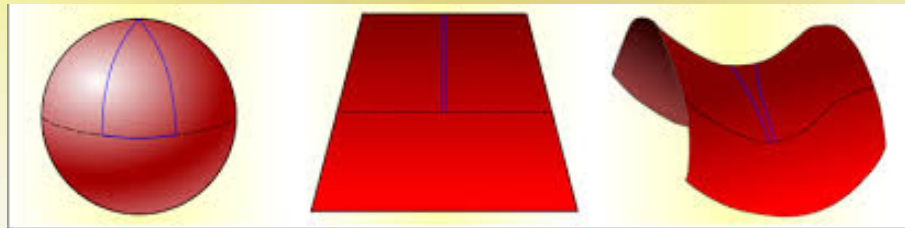
The nutshell version of the “**Big Bang**”

- A **hot** and **very uniform Universe** mysteriously and inexplicably expands (*separations increase*)
- **Gravity** (an attractive force) tries (unsuccessfully!!) to bring this expansion to a gradual end.
- Galaxies and stars start to form 380,000 y after space is no longer opaque. That’s ongoing now.
- Star formation is sustainable for another few billion years. The deaths of all stars is inevitable.
- “**Dark energy**” (acts as a repulsive force) is now overwhelming gravity.
- So the expansion of space is unstoppable.

Space: Big!

Space has various properties

- **Finite** or **Infinite**
- **Flat** or **Curved**
 - Defined by the trajectories of light
 - Influenced by the density of matter (Einstein 1917)
- **Open** or **Closed** or **Neither**



- **Static** or **Expanding** or **Contracting**
 - Measured by monitoring the separations of visible objects
 - Speed of expansion or contraction can change:
"acceleration"

Space: Big!

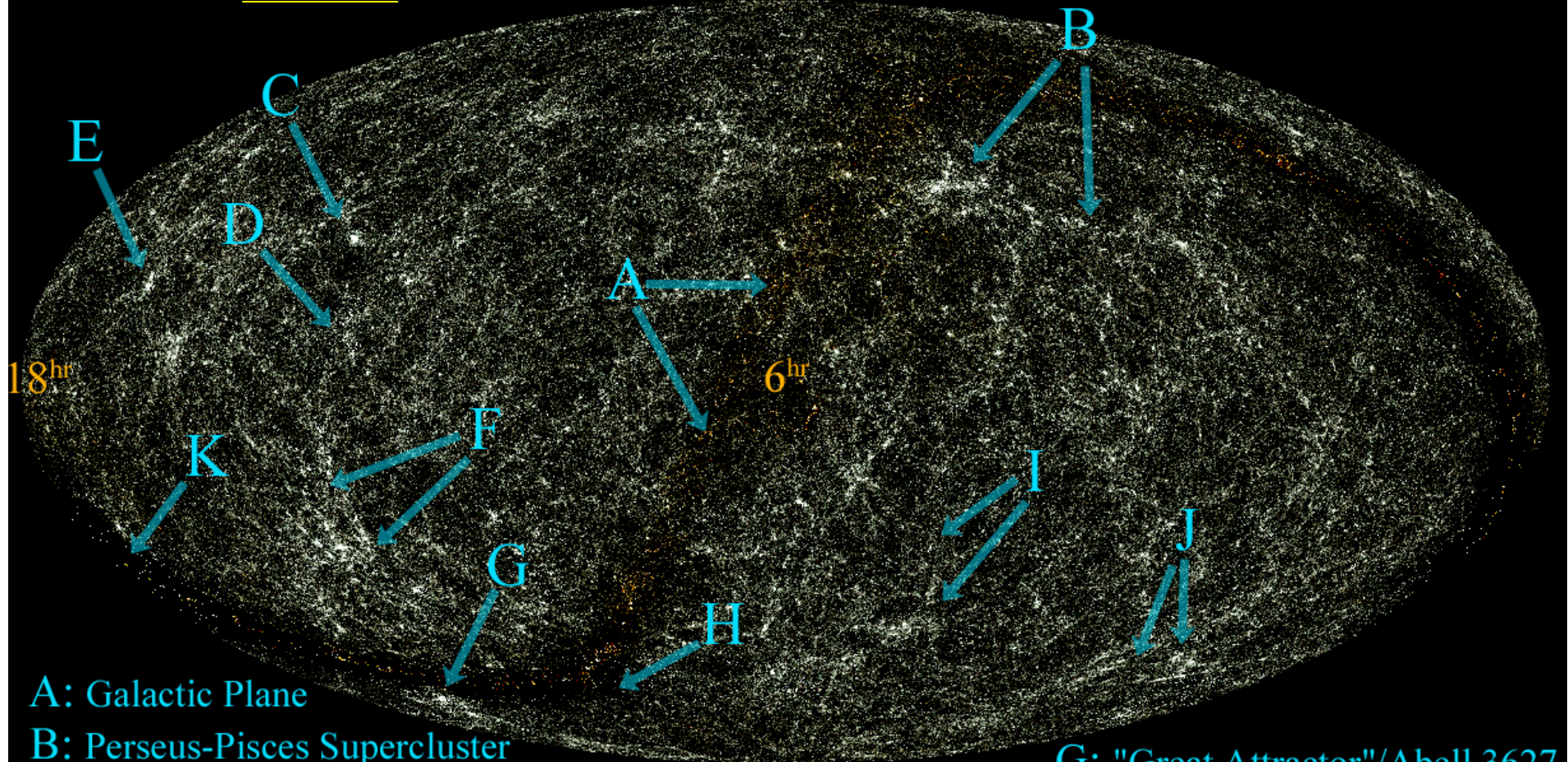
Space is tracked by **distances and their changes**

- **Distance** is measured by separations
 - measured by observations of light emitters (generally starlight)
- **Speed** is measured by monitoring changes in separations
 - measured by shifts of light colors (generally starlight)
- **Acceleration** is measured from changes in speeds

- Measuring cosmic distances is a huge challenge!
 - Need observable "standard candles or metersticks")
- Measuring cosmic speeds of separations is pretty easy
 - Doppler shifts of light
- Measuring cosmic acceleration is a sublime art

2MASS Local Universe

+90°



-90°

A: Galactic Plane

B: Perseus-Pisces Supercluster

C: Coma Cluster

D: Virgo Cluster/Local Supercluster

E: Hercules Supercluster

F: Shapley Concentration/Hydra-Centaurus Supercluster

G: "Great Attractor"/Abell 3627

H: "Local Void"

I: Eridanus/Fornax Clusters

J: Pavo-Indus Supercluster

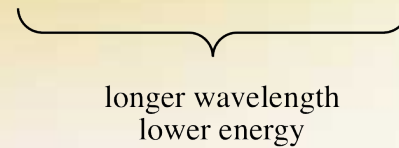
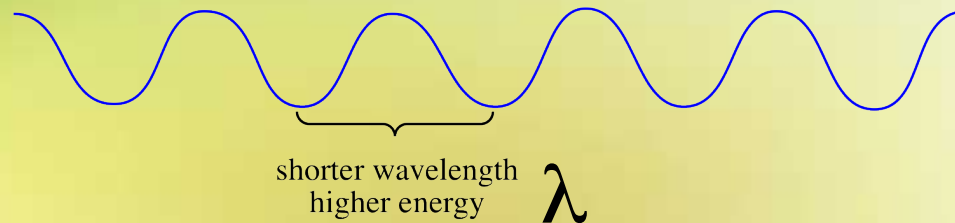
K: Galactic Center

Matter

Familiar Matter has various properties

- **Density** (mass per volume)
 - **Chemical State** (*elements*)
 - **Thermal properties** (measured by temperature)
 - **Motion** (speed, velocity); **Momentum** (density*velocity);
 - **Kinetic Energy**
 - **Distribution** (uniform, lumpy, gas or solid, atomic or fluid)
 - Most conspicuous forms today:
 - **galaxies** (clusters),
 - **stars** (clusters), planets, smaller rocky things
 - **gas** and **dust**
- ◆ **Ordinary** (familiar) **matter** and **dark matter** (5x more!)

Light as a wave



Light waves have **length, frequency, and speed**

$$\lambda * \text{freq} = \text{speed of light "c"}$$

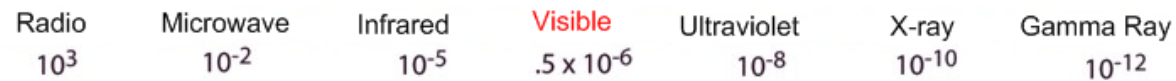
Light as a wave

The Electromagnetic Spectrum

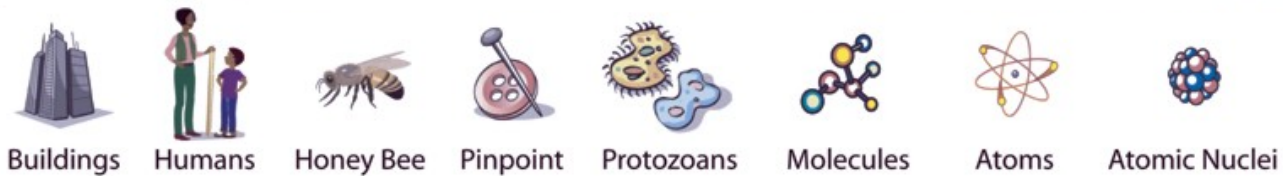
Penetrates Earth Atmosphere?



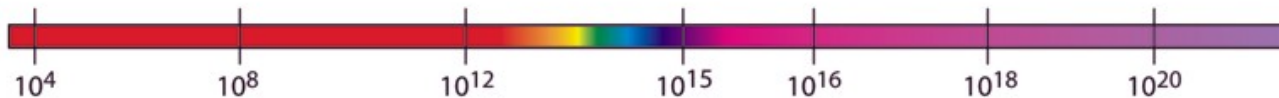
Wavelength (meters)



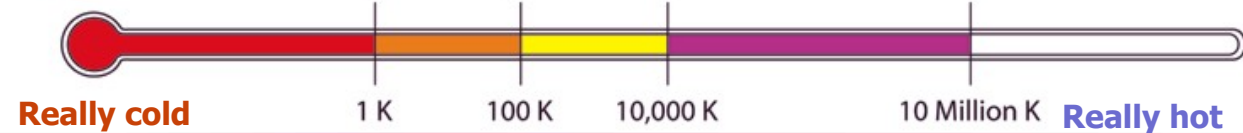
About the size of...



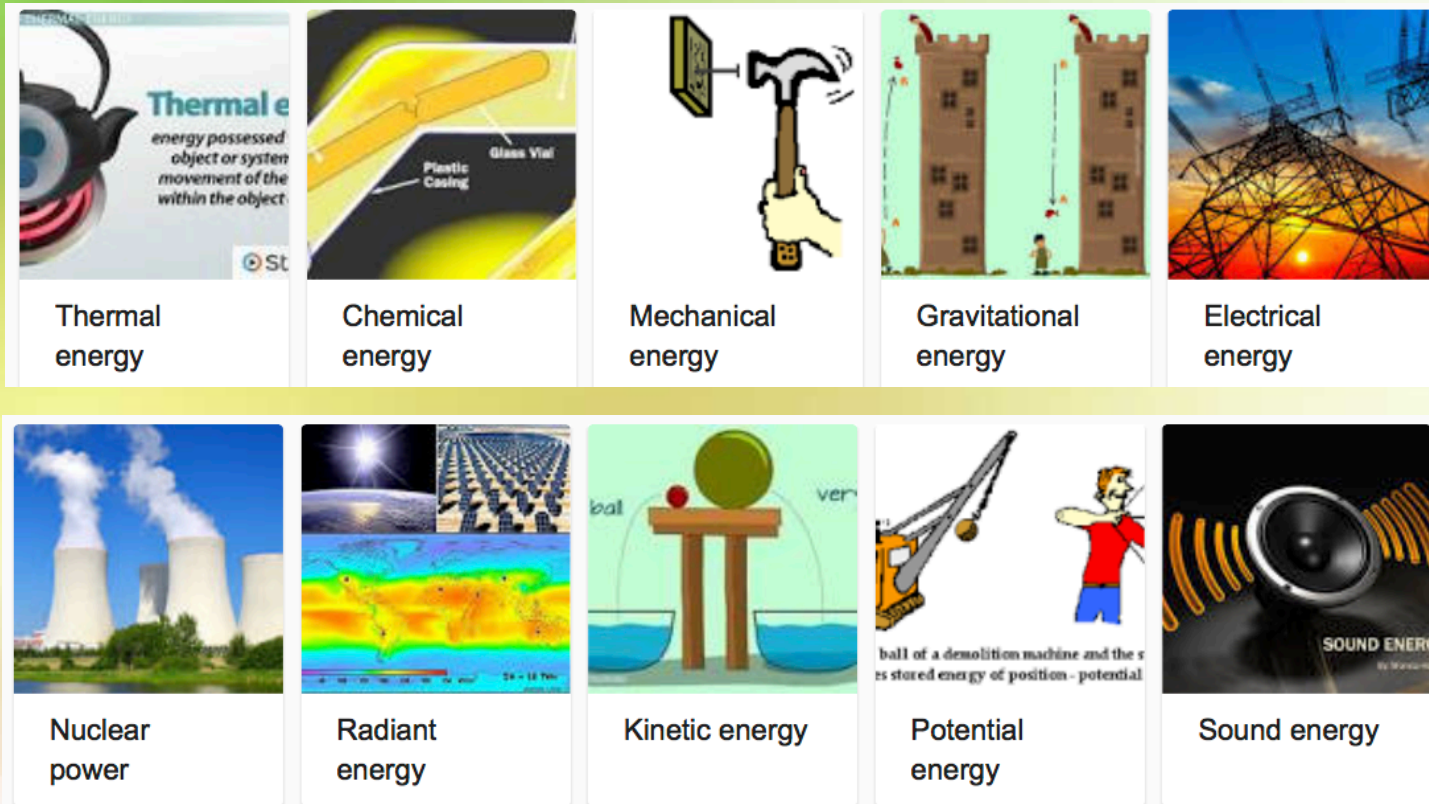
Frequency (Hz)



Temperature of bodies emitting the wavelength (K)



Energy (many forms)



Forms are convertible (e.g. electricity to heat)
Energy is "conserved" in all processes
Mass is a form of energy: $E = mc^2$

What is Gravity?

- A **Force** (makes things change their motions, *bent space*)
- Always **attractive**
- Associated with mass (and equivalent mass = energy/c²)
- One of four basic types of forces
 - Gravity, electricity-magnetism, two types of nuclear forces that bind atomic nuclei
 - The only force that is pervasive throughout space
- **Static** or **Expanding** or **Contracting**
 - Measured by monitoring the separations of visible objects
 - Speed of expansion or contraction can change: "acceleration"

The Simplest Universe

★ Infinite

★ Ageless

★ Static

★ Empty

