Final Exam Study Guide
Final is Comprehensive!

• Covers content of the entire course
• Please be sure to look at the Study Guides for the first three in-class exams
  – All of that material will be on the final exam
• Study the questions on previous exams carefully!
• This guide covers only the additional material that will be on the final exam from the last two weeks of class
The Milky Way:

• The **Milky Way** is our Galaxy
  – Diffuse band of light crossing the sky
  – Galileo: Milky Way consists of many faint stars

• The Nature of the Milky Way
  – Philosophical Speculations: Wright & Kant
  – Star Counts: Herschels & Kapteyn
  – Globular Cluster Distribution: Shapley
The Milky Way and Other Galaxies:

• Disk & Spheroid Structure of the Galaxy

• Pop I Stars:
  – Young, metal-rich, disk stars
  – Ordered, nearly circular orbits in the disk

• Pop II Stars:
  – Old, metal-poor, spheroid stars
  – Disordered, elliptical orbits in all directions

• Gives clues to the formation of the Galaxy.
Other Galaxies:

- Three basic types of Galaxies:
  - Spirals
    - Disk and spheroid component
    - Rotation of disk allows measurement of galaxy mass
  - Ellipticals
  - Irregulars
- Differ in terms of
  - Relative Gas content
  - Star Formation History
  - Internal Motions
- Galaxies tend to group into Clusters
  - Groups, clusters, and superclusters
  - Galaxies can collide and merge
- Some galaxies have “active” nuclei
  - Powered by large Black holes in the center
Special Relativity:

• **Postulates of Special Relativity:**
  – The laws of physics are the *same* for all uniformly moving observers.
  – The speed of light is the *same* for all observers.

• **Consequences:**
  – Different observers measure *different* times, lengths, and masses.
  – Only *spacetime* is observer independent.
General Relativity:

• **General Relativity:**
  – Modern Theory of Gravitation
  – Matter tells spacetime how to curve.
  – Curved spacetime tells matter how to move.

• **Tests of General Relativity:**
  – Perihelion Precession of Mercury
  – Bending of Starlight near the Sun
  – The Binary Pulsar (Gravitational Waves)
Expansion of the Universe:

- **Hubble’s Law:**
  - Galaxies are receding from us.
  - Recession velocity gets larger with distance.

- **Hubble Constant:**
  - Rate of expansion of the Universe.

- **Cosmological Redshift:**
  - Redshift distances
  - Redshift maps of the Universe.
Cosmology:

• Cosmological Principle:
  – The Universe is *Homogeneous* and *Isotropic* on *Large Scales*.
  – No special places or directions.

• General Relativity predicts an expanding universe.

• Cosmological Constant
  – Non-zero
  – Dark Energy
Big Bang:

• **Big Bang Model of the Universe**
  – Starts in a hot, dense state
  – Universe expands and cools
• **Expansion and Redshift**
• **Critical Density**
  – Geometry of the Universe
• **Hubble Time = Maximum age of the Universe**
Evidence for the Big Bang:

• Fundamental Tests of the Big Bang
• Primordial Nucleosynthesis
  – Primordial Deuterium & Helium
  – Primordial light elements (Li, B, Be)
• Cosmic Background Radiation
  – Relic blackbody radiation from Big Bang
  – Temperature: $T = 2.726$ K
End of Universe:

- The Fate of the Universe depends on the density of matter and dark energy physics

- **Closed Universe:**
  - Enough matter to stop the expansion
  - Collapses in a “Big Crunch”

- **Open Universe:**
  - Expands forever
  - Ends in a cold, disordered state
  - Dark Energy seems to make this outcome more likely