Astronomy II - Stars and Galaxies (Astr 1020)
Fall 2009
Prof Richard Ignace

REVIEW FOR THIRD EXAM

- Interstellar Medium - components, properties, nebulae (reflection nebulae, planetary nebulae, HII regions, supernova remnants)
- The Milky Way Galaxy -
  - the characteristic size and shape of the MW
  - measuring distances in the MW
  - Attempts by Herschel and Kapteyn to find where we are in the MW, and why they were wrong
  - How Shapley used globular clusters to get the right answer!
  - Differential rotation of the MW and the rotation curve of the galaxy
  - How we map the spiral structure of the MW (what do we use as "tracers"?), and what is going on in the spiral arms? The spiral arms as a pattern, and relation of arms to star formation
  - evidence for dark matter in the halo of the MW, rotation curve of the galaxy, terminology such as "flat rotation curve", knowing how to recognize the edge of a galaxy in terms of the rotation curve
  - conditions at the Galactic center, evidence for a supermassive black hole
  - stellar populations (Pop I vs Pop II) and properties; know that different populations have different metallicities
- *Galaxies*
  - Clusters and the Local Group – know basics about the Large Magellanic Cloud (LMC), Small Magellanic Cloud (SMC), and M31
  - Types and general properties – spirals, ellipticals, irregulars (which are most common, which have young stars, which are metal-poor vs metal-rich, and so on)
  - know about galaxy formation and evolution (such as colliding galaxies and mergers)
- *Distance Ladder* – the expanding Universe, Hubble's law, redshift, finding the Hubble constant, concept of standard candles: Cepheids, Type Ia SNe, Tully-Fisher relation
- *Active Galaxies* -
  - know the types (Seyferts, Blazars, Radio galaxies, Quasars, etc)
  - know the properties (jets, radio emission, broad/narrow lines, IR or X-ray)
  - know about the **Unified model** and our understanding of Active Galactic Nuclei in terms of mass infall onto black holes (and the relevance of the Eddington limit for this)
  - what are the arguments for SBH's (high luminosities from compact volumes!); recall properties of black Holes, such as Schwarzschild radius
- *Large Scale Structure* – mapping of galaxies and clusters of galaxies in space; know basic description in terms of voids, filaments, and sheets
- *Cosmology*
  - Special Relativity and postulates, the idea that speed of light is absolute and so events are not generally simultaneous as perceived by different observers; General Relativity, the Equivalence Principle, curvature of space, gravitational lensing

- Olber's paradox - what is the question and what are the potential resolutions
- the expanding universe, and getting the age of the Universe from the Hubble constant, H
- the Cosmological Principle – concepts of isotropy and homogeneity, what is the "steady-state model"
- Some 'highlights' – early Universe filled with light, formation of Helium, 'decoupling', formation of galaxies
- Cosmic Background Radiation (CBR) – Gamow's fireball model, discoverers Penzias and Wilson, relevance to the Big Bang model
- Critical Density and relation to curvature of space (positive, negative, zero/flat) and the 'fate' of the Universe
- the Inflationary universe - what is it, and what does it solve?
- Dark Energy - evidence for it from Type Ia SNe, the cosmological constant, quintessence; dark energy represents 70% of the 'content' of the universe, and dark matter represents 30%; the dark energy accelerates the expansion of the universe

- *Expressions to be familiar with:*
  - The Schwarzschild radius for a black hole is

$$R_S = 2GM/c^2$$

  - The Hubble law

$$v = Hd$$

  - Relation of the Hubble constant to the age of the universe

$$\text{age} \approx 1/H$$

  - z is redshift with

$$z = \Delta\lambda/\lambda_0$$

  - For density ρ of the universe, and critical density for closure ρ_{cr}, cosmologists define the parameter Ω as

$$\Omega = \rho/\rho_{cr}$$

    then $\Omega = 1$ is a "flat" universe, $\Omega < 1$ is closed, and $\Omega > 1$ is open
  - The idea that Ω consists of matter and energy contributions, such as Ω_B is for the baryon (normal) matter, Ω_{DM} is for dark matter, and Ω_{DE} is for dark energy; then

$$\Omega_{total} = \Omega_B + \Omega_{DM} + \Omega_{DE}$$

    It is currently accepted that $\Omega_{total} = 1$, with DM 30% of it and DE 70% of it.
    Kepler′s Third Law, $G\,M_{\rm Gal}\,P^2 = 4\pi^2\,a^3$

  - Rotation curves: $v_{\rm rot} = \sqrt{GM/r}$, where M is the interior mass of the orbit