Review

Test May 24 Rm 107 10:30am

Comprehensive

Milkyway

- Observables
  - Flux
  - Distance magnitude relation
    - $M = m - 5\log_{10}(d/10pc)$
    - M-m is the distance modulus
- H-R diagram
- Distance measurements
  - Parallax
  - M-S fitting

Milkyway cont.

- Distance measurements cont.
  - Spectroscopic parallax
  - Variable Stars
    - Cepheids
    - RR-Lyrae stars
- Luminosity and Mass functions
  - Salpeter IMF

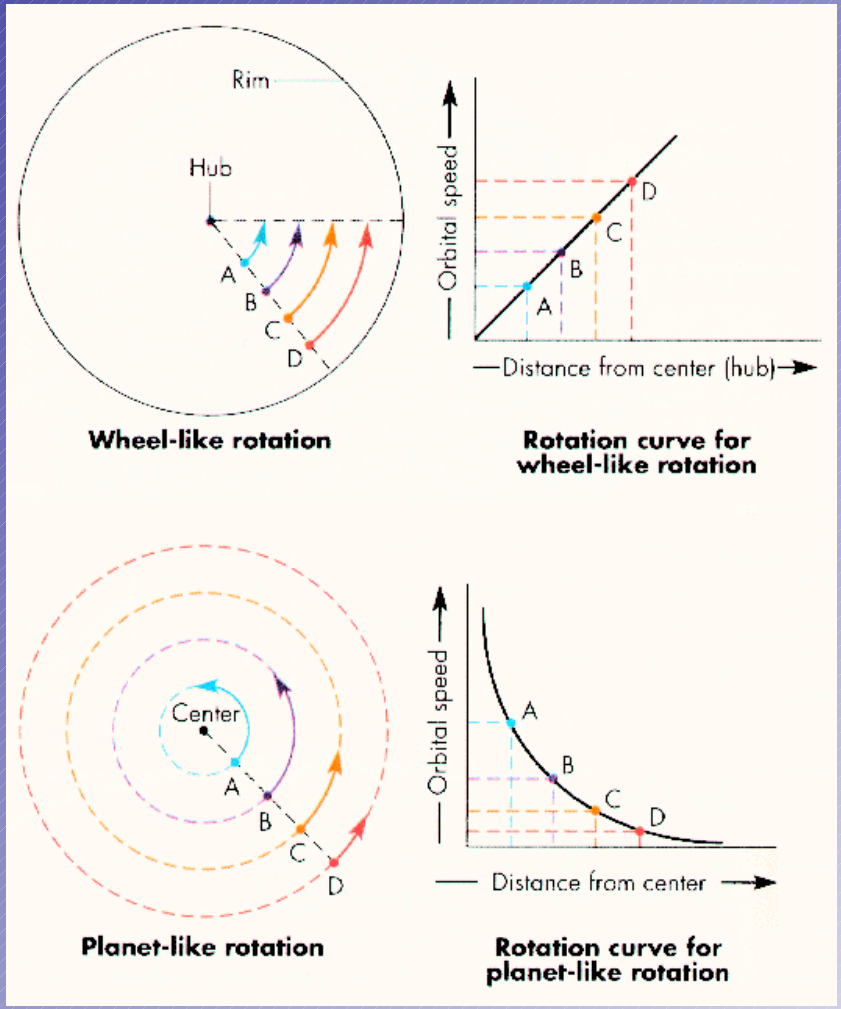
$$M_* = \int_{M_1}^{M_2} M \xi(M) dM$$

Structure of the MW

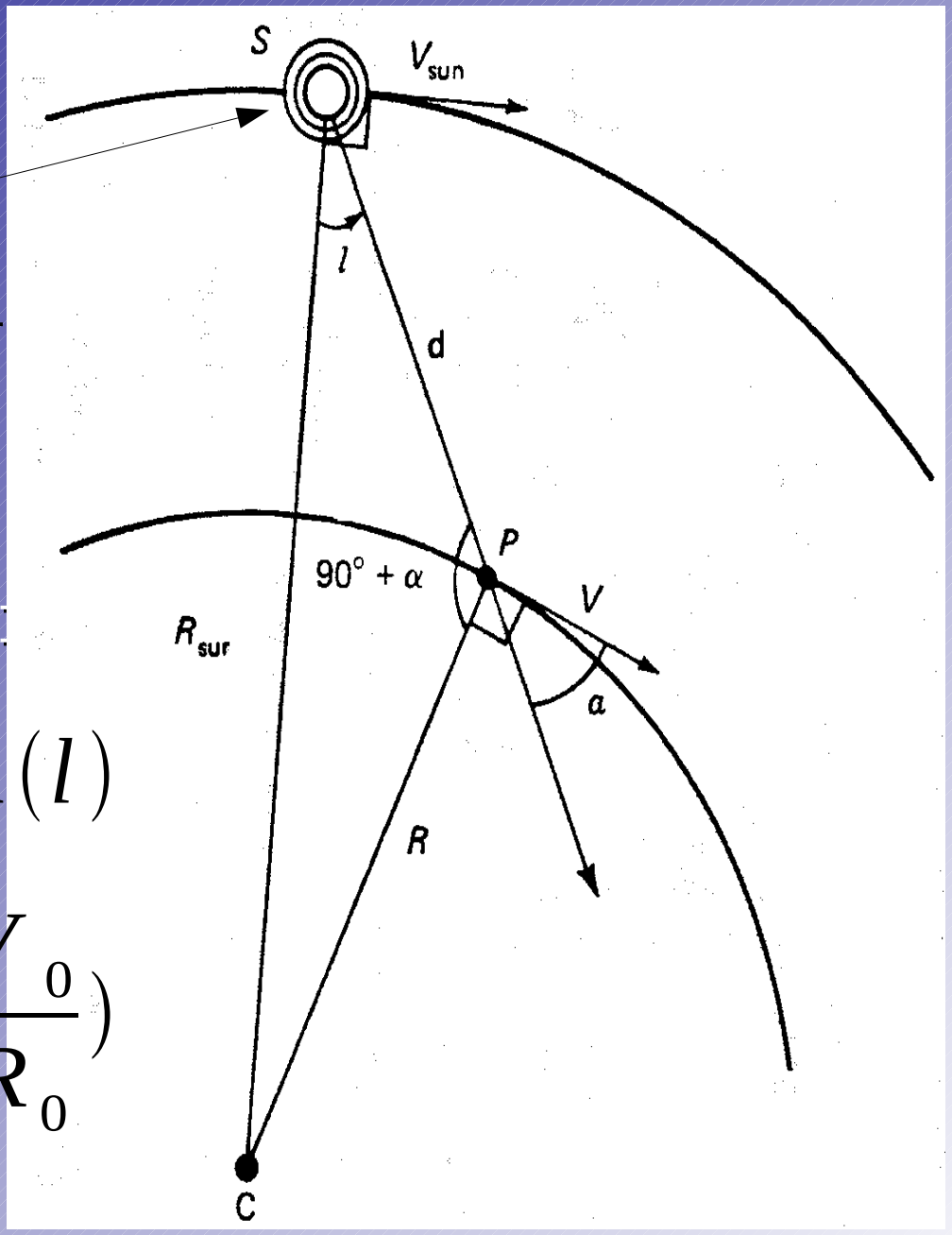
- Bulge
  - Old Spherical component
- Disk
  - Young star forming region
- Halo
  - Old metal poor stars
- Review stellar populations

Galactic Rotation

- Differential rotation



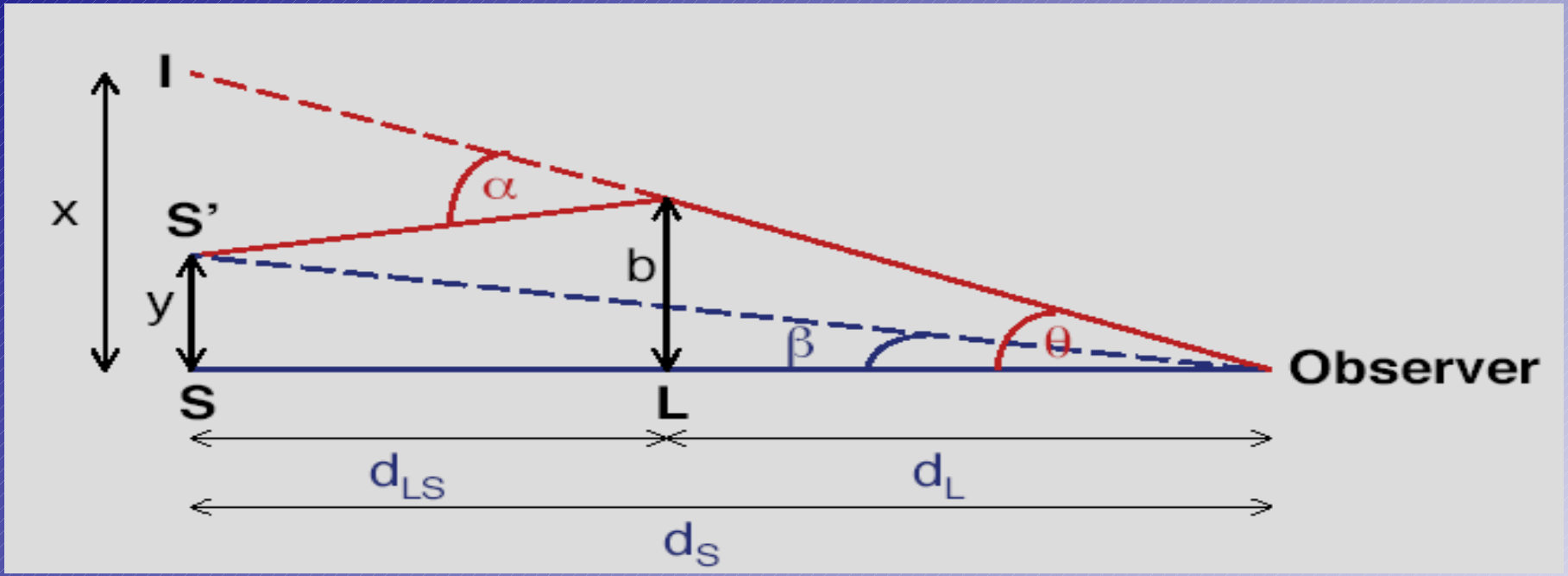
- Galactic Rotation Curve
  - At R_{sun} the lsr has a velocity of V_0
  - A star at P has an apparent velocity o



$$V_r = V\cos(\alpha) - V_0 \sin(l)$$

$$V_r = R_0 \sin(l)\left(\frac{V}{R} - \frac{V_0}{R_0}\right)$$

Gravitational Lensing



$$\theta_{\pm} = \frac{1}{2}\left(\beta \pm \sqrt{\beta^2 + 4\theta_E^2}\right)$$

Dark Matter

- Baryons
  - Brown dwarfs
  - Machos
  - Rocks
  - Black Holes
- Non-baryonic
  - WIMPS
  - Axions ...

Motion under Gravity

$$\nabla^2 \Phi(\mathbf{x}) = -\nabla^2 \int \frac{G\rho(\mathbf{x}')}{|\mathbf{x}-\mathbf{x}'|} d^3\mathbf{x}'$$

$$= 4\pi G \rho(\mathbf{x})$$

$$2\langle KE \rangle + \langle PE \rangle = 0$$

Relaxation Times

Stellar Orbits

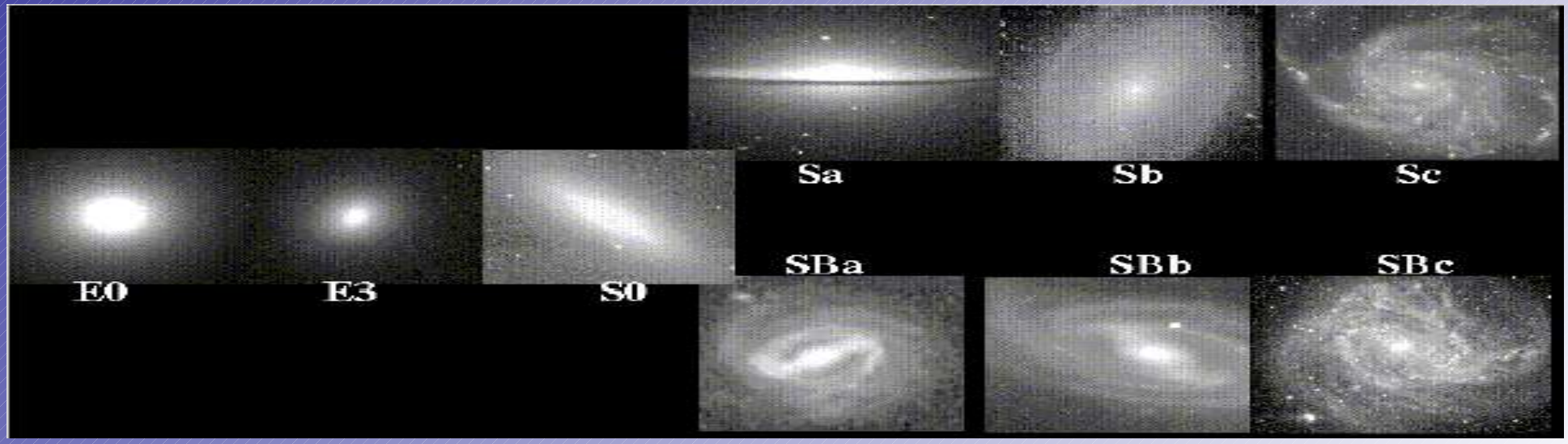
- Galactic Potentials and Epicyles
  - Effective potentials
  - Epicycles

Local Group

- ~36 galaxies near the MW & M31
  - dwarf sphericals
  - Magallanic type spirals
  - Irregulars
- Tidal distruption
- Star formation

Galaxy Classification

- Ellipticals
  - E0-E7
- Spirals
  - Sa --> Sc --> Sd



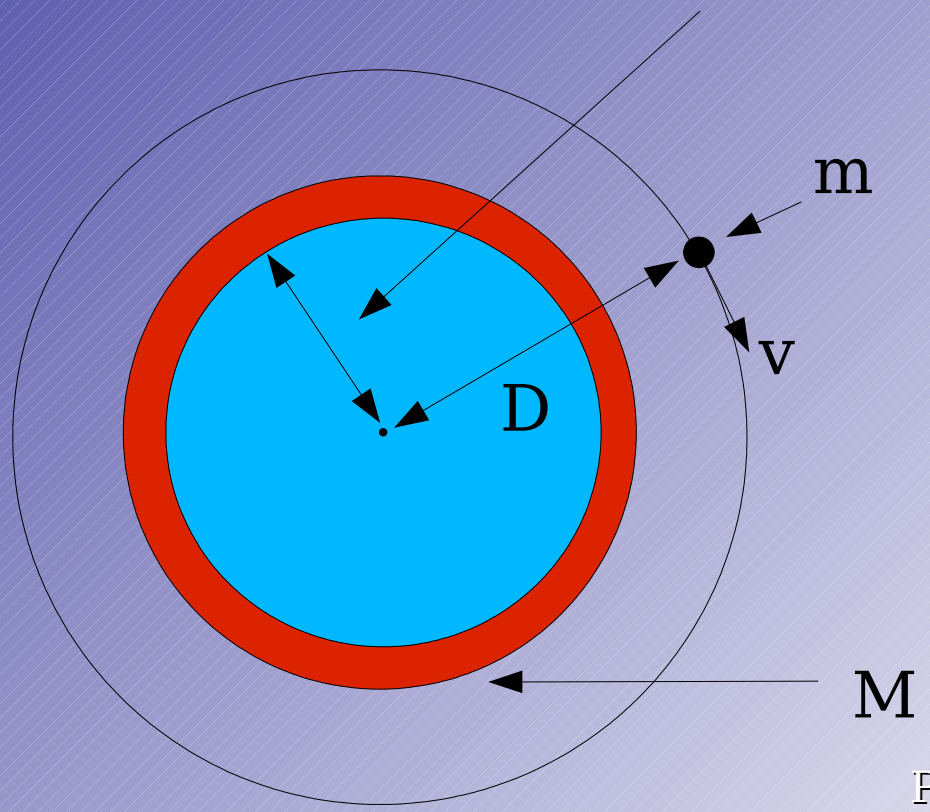
Galaxy Classification cont.

- Trends withing the Hubble Sequence
- Problems
- Revisions
  - DeVaucouleurs'
  - Van den Bergh (DDO system)

Tidal Stripping

$$x = \pm D \left[\frac{m}{M(3 + m/M)} \right]^{\frac{1}{3}} \approx \pm \left(\frac{m}{3M} \right)^{\frac{1}{3}} l$$

x is called the Jacobi limit or the Roche limit and is written as r_J



- Galaxy Photometry
  - Fit functions
  - Spiral Galaxies
    - Bulge
    - Disk
  - Elliptical Galaxies
    - Sersic's Law
    - n=4 deVaucouleur's law

$$I(r)=I(r_e)\exp[-b(\frac{r}{r_e})^{\frac{1}{n}}-1]$$

Gas in Spirals

- HI gas
  - Measured with radio spectral observations
- Observations needed for rotation curve
- Spider diagrams
- CO gas
- Hα rotation curves
- Stellar kinematics

Rotation Curves

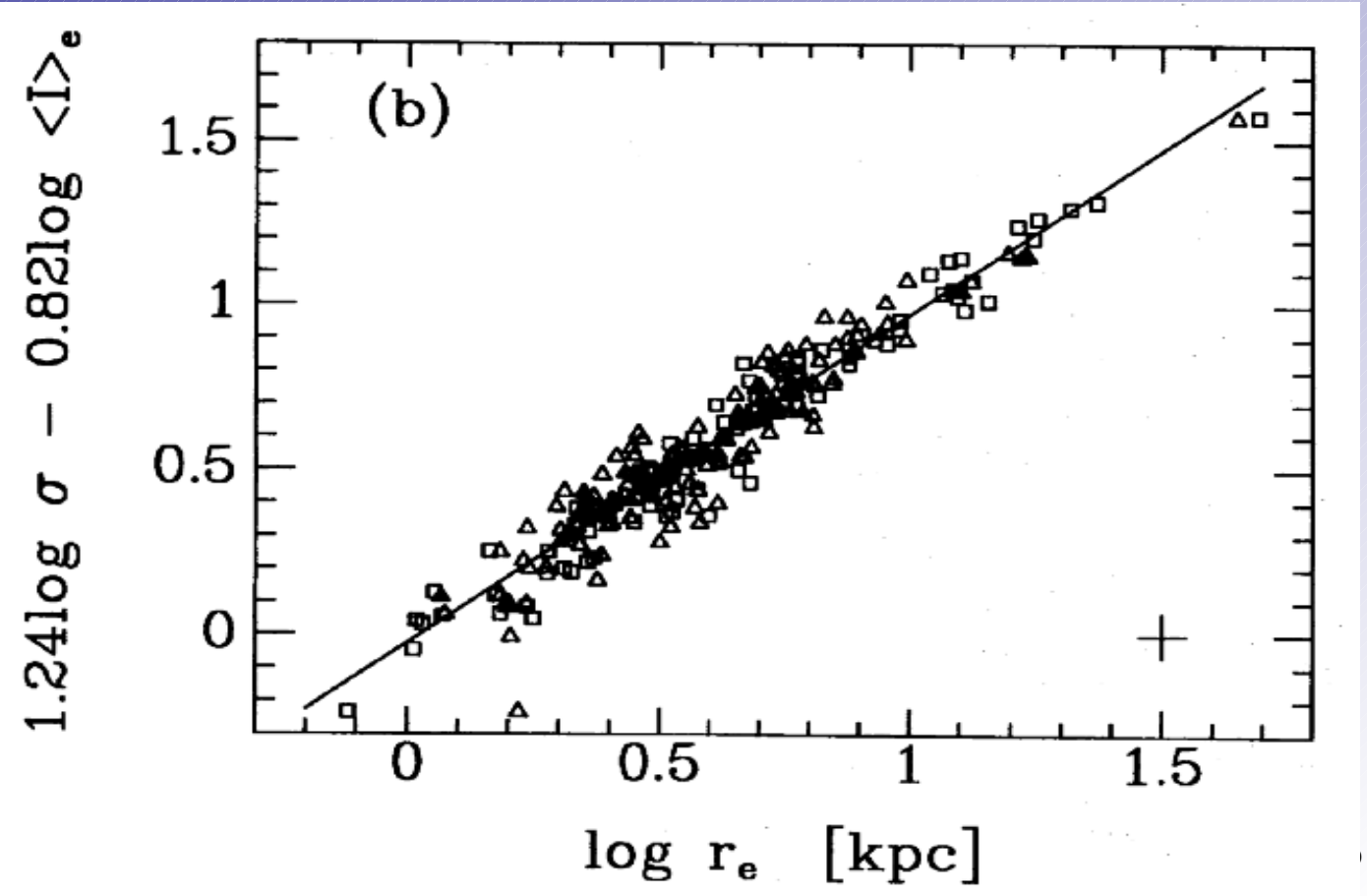
- Evidence for dark matter
  - rotation velocity is constant, so that means $M_r \propto r$
  - Implies extra mass beyond visible mass

- Galaxy Distances
  - Hubble Law
  - Tully-Fischer Law
- Spiral Structure
  - Grand design spirals (~10%)
  - Multi-arm spirals (~60%)
  - Flocculent spirals (~30%)
  - Leading and Trailing Arms
- Spiral Theory
    - Spiral wrapping
    - Density waves
    - Star formation

Ellipticals

- Can be complex systems
  - Multiple components
    - X-rays
    - Dust
    - Young stars
- Distribution of B/A
- Isophotal Shapes
- Elliptical Kinematics
  - Faber-Jackson relation

$$\frac{L_v}{2x10^{10}L_{sun}} \approx \left(\frac{\sigma}{200km\,s^{-1}}\right)^4$$

Ellipticals cont.

- Fundamental Plane
- $R_e \propto \sigma^{1.24} I_e^{-0.82}$