ASTR 1040 Recitation: Galaxies

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Announcements

- Next week: in Fiske (no Tues rec)
- (optional) Review Session Next Wed, 6-8pm in G-126?

Spiral Galaxies

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NGC-1566, $\sim$40 Mly

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Pinwheel, M101 / NGC-5457, $\sim$21 Mly

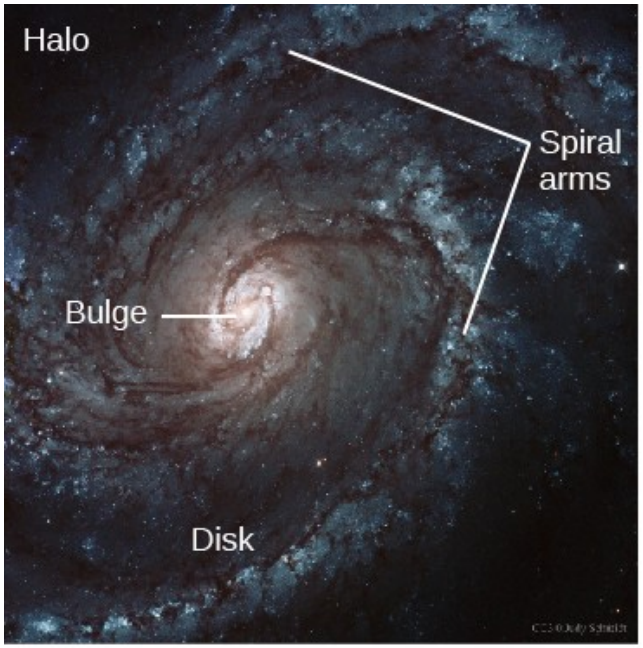
Spiral Galaxies

NGC-1376, $\sim$180 Mly

Spiral Galaxies

Sombrero, M104 / NGC-4594, $\sim$10 Mly

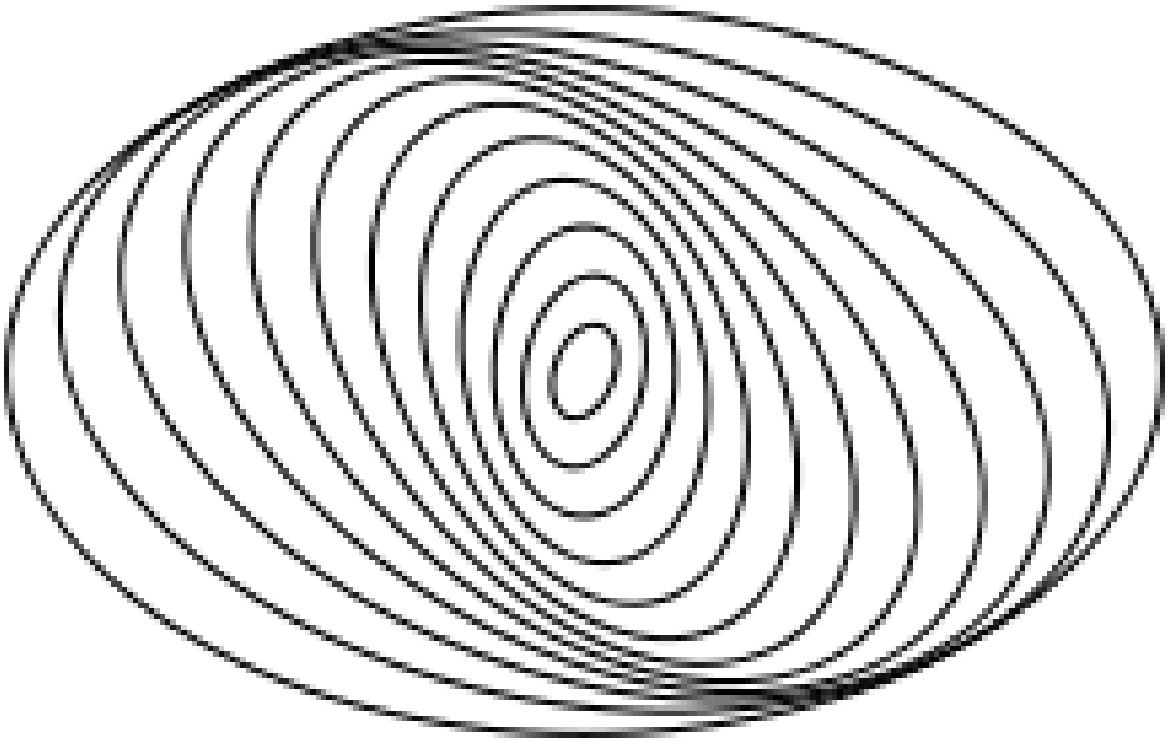
Spiral Galaxy Structure



(a)

(b)

Why Spiral Arms?



Density Waves

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  - Young stars, active star forming

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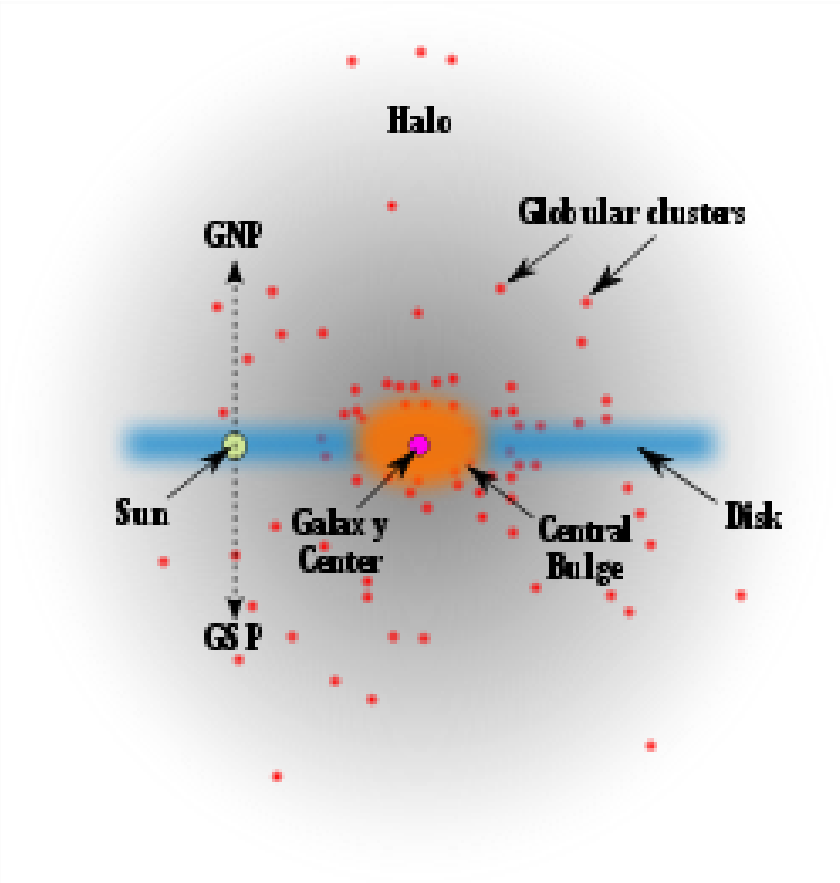
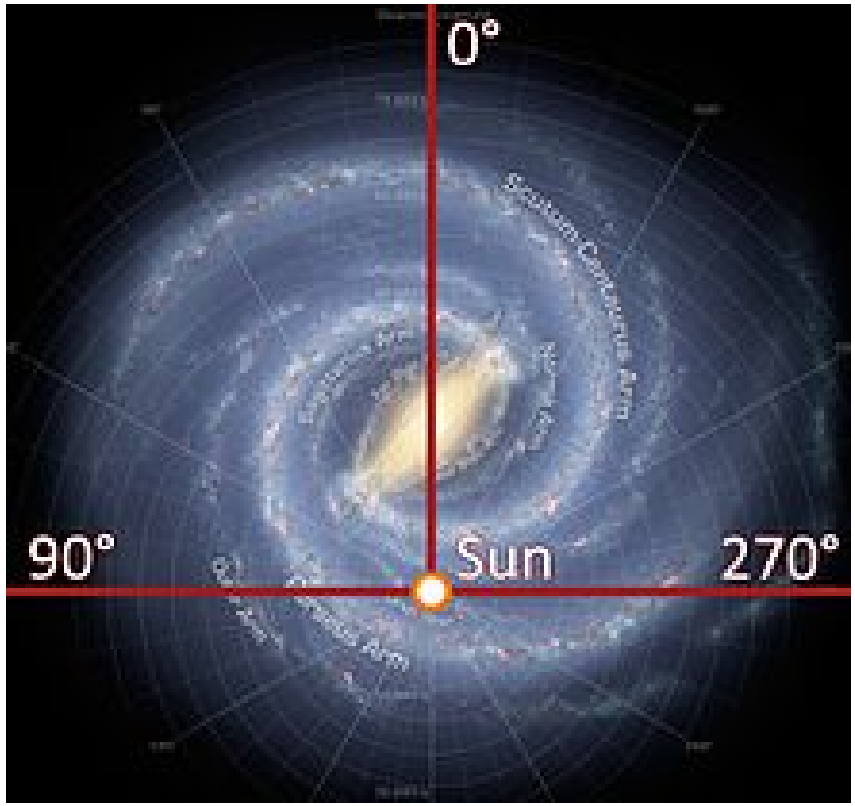
- Near-spherical dark matter halo

The Milky Way



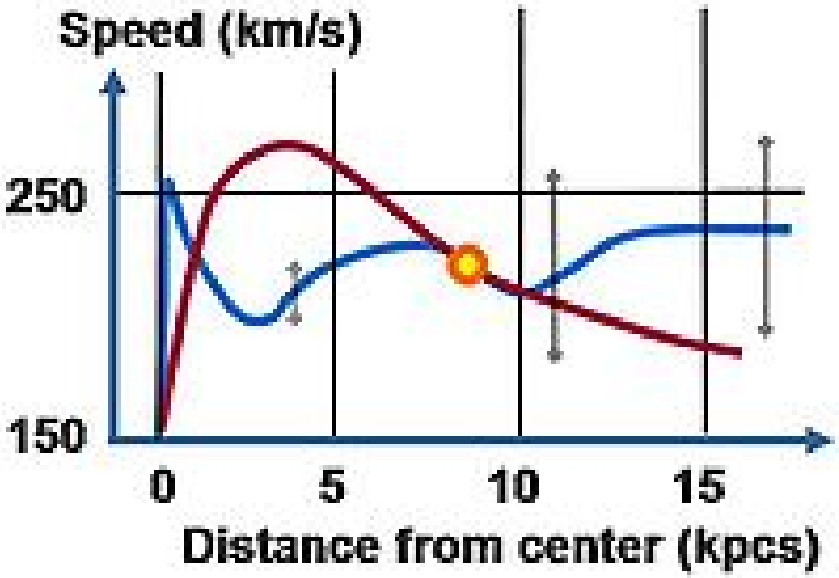


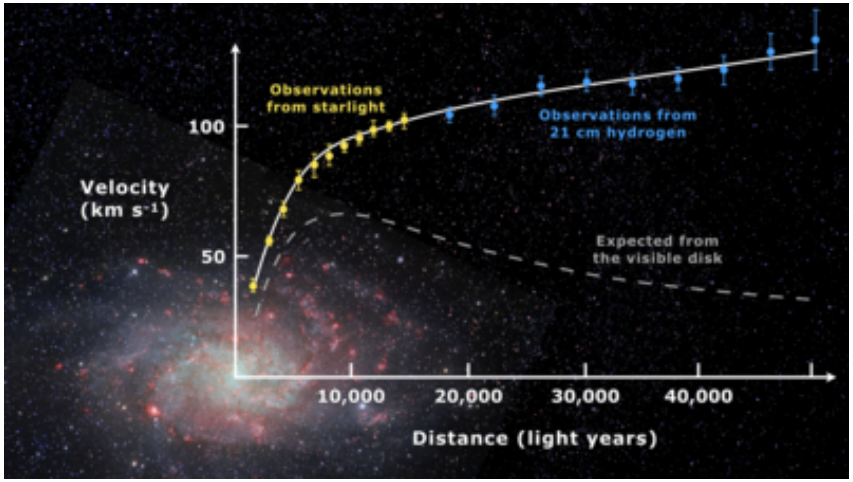
The Sun is $r \approx 8.5$ kpc, and travelling at $v \approx 220$ km/sec

Measuring Our Own Galaxy

- $F_{\mathrm{grav}} = F_{\mathrm{circ}}$
- $\frac{GMm}{r^2} = \frac{mv^2}{r}$
- $M(r) = \frac{rv(r)^2}{G}$
- Measure r & $v \Rightarrow$ infer mass enclosed

Rotation Curves





Practice Problem: General Rotation Curves

Derive how the density changes as a function of the velocity. Assume a circular orbit and that the velocity is a function of radius.

$$\omega(r) \equiv v(r)/r \qquad\qquad F_{\rm circle} = m\, a_{\rm circle} = m\, v^2/r$$

1. What is the force balance in terms of the mass enclosed?
2. How is the enclosed mass related to density?
3. Combine parts 1) & 2) to get an equation for the density.

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1. Force balance: $F_{\rm gravity} = F_{\rm circle} \Rightarrow \frac{v(r)^2}{r} = \frac{GM}{r^2}$
2. Enclosed mass related to density? $\frac{{\rm d}M}{{\rm d}r} = 4\pi r^2 \rho(r)$
3. Combine parts 1) & 2) to get an equation for the density:
   - Solve 1) for M, then ${\rm d}/{\rm d}r$: $\frac{{\rm d}M}{{\rm d}r} = \frac{1}{G}\frac{{\rm d}\left(rv^2\right)}{{\rm d}r}$
   - Now plug in the density: $\frac{{\rm d}M}{{\rm d}r} = \frac{1}{G}\frac{{\rm d}\left(rv^2\right)}{{\rm d}r} = 4\pi r^2 \rho(r)$
   - Solve for the density: $\rho(r) = \frac{1}{4\pi G}\frac{1}{r^2}\frac{{\rm d}\left(rv^2\right)}{{\rm d}r}$