Milky Way
Herschel 18th Century View of Milky Way

<~ 6000 ly
Shapley 1918 - Globular Cluster Positions

Shapley’s Globular Cluster Distribution

[Diagram of globular cluster positions with a scatter plot and an inset image of a globular cluster]
Discovery of “Spiral Nebulae”

Lord Rosse

1845
Herber Curtis - Harlow Shapley 1920 Debate

Shapley

- Sun not @ center of MW
- Galaxy larger than thought from Cepheid Observations
- “Spiral Nebulae” are within the MW
- Interstellar absorption not important for distances

Curtis

- Sun close to center of MW
- Cepheids not reliable distance indicator
- “Spiral Nebulae” are external galaxies
- Interstellar absorption not important for distances
Trumpler’s Study of Open Clusters

Diagram showing the relationship between diameter and distance, with a scatter plot of data points and two straight lines representing the relationship.
Interstellar Dust Grain
Extinction through a dusty cloud
Extinction through a dusty cloud
Scattering off a dusty cloud

Why is this cloud blue?
Interstellar Extinction

\[ m - M = -2.5 \log_{10}(F(d)/F(10pc)) \]

\[ m - M = 5 \log_{10}(d/10) \quad \text{where } d \text{ in pc} \]

The amount of dust extinction at a wavelength is given by \( A_\lambda \) [mag]

\[ m_v^{\text{obs}} - M_v = 5 \log_{10}(d/10) + A_v \]

\[ m_v^{\text{obs}} = m_v^{\text{true}} + A_v \]
Interstellar Extinction Curves

![Graph showing Milky Way Extinction Curves with marked features such as the 2175Å bump, far-UV rise, visual/near-UV, and different R_v values.]
Milky Way Structure

- Few $\times 10^{11}$ stars
- $6 \times 10^{11} M_\text{sun}$
- SBbc Barred Spiral Galaxy

Diagram:
- Disk
- Sun's location
- Bulge
- Halo
- Globular clusters
- 28,000 light-years
- 1,000 light-years
Milky Way - Supermassive Black Hole!

\[ M_{\text{BH}} \sim 2 \times 10^6 \, M_{\text{sun}} \]
Milky Way Bar

have been measured. Parallaxes from 12 GHz methanol masers are indicated with dark.
The Interstellar Medium

Three Phases:

• Cold, Dense Phase
  $(10-100 \text{ K})$  $\text{H}_2, \text{H}$
  $n \sim 1 - 100 \text{ cm}^{-3}$

• Warm Phase
  $(\sim 10^4 \text{ K})$  $\text{H, H}^+$
  $n \sim 0.5 \text{ cm}^{-3}$

• Hot Phase $(> 10^6 \text{ K})$  $\text{H}^+$
  $n < 0.01 \text{ cm}^{-3}$
Atomic Hydrogen 21cm line

HI 21cm Line Formation

Excited State:
Proton and electron spins are parallel

Ground State:
Proton and electron spins are anti-parallel

Photon emitted
Hydrogen 21cm line - Milky Way Map
Hydrogen 21cm line - Circinus Galaxy
Hydrogen 21cm line - Galactic Rotation

A - blueshifted
B
C - redshifted

bluer wavelength redder
Hydrogen 21cm line - Galactic Rotation
Comparison of the rotation curves calculated by all the methods discussed (assuming $R_0 = 7.9$ kpc and $\Theta_0 = 200$ km s$^{-1}$).
Rotation Curves

- **Solid Body Rotation**: $V \propto R$
- **Keplerian Rotation**: $V \propto \frac{1}{\sqrt{R}}$
- **Galactic Rotation**: $V \sim \text{constant}$

Diagram showing the relationship between velocity ($V$) and radius ($R$) for different types of rotation.