

Outline I

- The Milky Way Galaxy – Disk, Bulge, Stellar Halo, Dark Halo
 - The Galactic Centre
 - Galactic Rotation
- The Local Galaxy Group
 - Local Group "Geography" & Inventory
 - The Large and Small Magellanic Clouds
 - The Magellanic Stream
 - Satellites of the Milky Way
 - The Andromeda Galaxy & M33
- Outside the Local Group









 Correlation between age and metallicity (amount of heavy elements) → can obtain information both about when and where the stars formed

The Milky Way Stellar Disk I

- Radius of the disk: > 15 kpc
- Scalelength h_r of the disk: 2–4 kpc
- Disk luminosity: 15–20 ×10⁹ L_{solar}
- Stellar Disk mass: 6 ×10¹⁰ M_{solar}
- Thin disk:
 - Scaleheight h_z: 300—400 pc
 - Contains 95% of all disk stars & all the young ones
- High metallicity
- Thick disk:
 - Scaleheight: 1000—1500 pc
 - Lower metallicity

The Milky Way Stellar Disk II

- Stars form in clusters and associations
- Open clusters:
- Few hundred stars at most
- Luminosity 100--30000 L_{solar}
- Core radius ~ few pc
- Young (Only ~5% more than 1 Gyr old)
- Mass segregationStars form in clusters and associations
- Associations:
 - Not gravitationally bound
 - Forms temporary systems

The Milky Way Bulge

- Flattened (a/b \approx 0.6), radius \sim 1 kpc
- Possibly contains bar (2-3 kpc long)
- Rotates in same direction as disk stars, but slower (≈ 100 km/s)
- Contributes 20% of the MW luminosity
- Stars several Gyr old, but younger than in halo
- Average stellar metallicity $\approx 0.5 \text{ Z}_{solar}$

Does the Milky Way have a classical bulge or pseudobulge? The jury is out...



Classical bulge: Resembling a small elliptical galaxy, formed through mergers Pseudobulge: Disk-like properties, formed internally (so-called "secular evolution"). No mergers required.

The Milky Way Halo I

- Somewhat flattened, but rounder than bulge
- Radius ≈ 50 kpc
- Stellar density $\propto r^{-3.5}$
- Total mass in halo stars: ~ 10⁹ Solar masses
- 1/1000 of all local stars belong to halo
- Eccentric orbits, sometimes retrograde

Latest stuff (not in textbook): May have two components (inner and outer halo) with different properties

The Milky Way Halo II

Globular clusters

- Up to 1 million stars
- Total mass ~ 10⁵ Msolar
- No dark matter (at least not anymore)
- Core radius < 1 pc</p>
- Tidal / truncation radius 20-30 pc
- About 150 objects known, ages 10—14 Gyr
- (oldest objects in the Galaxy) – Typically very metal-poor



Intermission: Which of these is *not* a globular cluster?

The Milky Way Dark Halo

- Radius > 100 kpc
- Contributes ~ 90% of the mass inside 100 kpc
- Content unknown...

The Milky Way Gaseous Disk

- $4-8 \times 10^9$ solar masses HI
- 2–4 × 10⁹ solar masses H_2 (but uncertain)
- Dust ~ 1 % of HI mass











- Infrared light shows a dense star cluster which peaks at the center, near Sagittarius A*.
- The high velocities of the stars require a mass of ~2 x 10⁶ M_{solar} within 1 pc
- Stars are only 1000 AU apart
- Collisions every ≈ 10⁶ years!
- The centre of the star cluster may host a Supermassive Black Hole (although somewhat lightweight)











The Local Group Inventory

- Radius ~1.2 Mpc
- Held together by gravity decoupled from Hubble flow
- 3 spirals: Milky Way, M31, and M33
- Two more massive galaxies:
 Irregular Large Magellanic Cloud
 Small (dwarf) elliptical galaxy M32
- The rest are dwarf galaxies (dI, dE, dSph) with $M_V > -18$

The Local Group Inventory

- The Local Group does not contain: -Blue compact dwarf galaxies
 - –Dwarf spirals
 - -Massive ellipticals
 - -Active galaxies





The Magellanic Clouds

	LMC	SMC
Diameter	24 deg.	7 deg.
Distance	50 kpc	63 kpc
Total mass	6×10 ⁹ s.m.	2×10^9 s.m.
Luminosity	~10% of MW	~1% of MW
HI mass	7 × 10 ⁸ s.m.	6.5×10 ⁸ s.m.
Z	0.70 solar	0.25 solar
M(HI)/M(total)	0.09	0.32

The Magellanic Stream & Bridge

- Magellanic Bridge:
 - HI bridge between LMC and SMC
 - Size \approx 20 kpc
 - Mass: 2×10⁸ solar masses HI
 - Contains stars formed 10-25 Myr ago
 - Could have formed 200 Myr ago when LMC and SMC where the closest
- Magellanic Stream:
 - Gas trailing behind LMC and SMC
 - Wraps 1/3 around the sky

The 11 "Classical" Satellites of the Milky Way

- LMC
- SMC
- FornaxSagittarius
- But dark matter theory predicts
 - factor of ~ 10 more!
- Sculptor Are there dark galaxies...?
- Leo II (DDO 93)

Leo I (DDO 74)

- Sextans
- Carina
- Ursa Minor
- Draco (DDO 216)







The Andromeda Galaxy & M33





M31 (Andromeda)

M33 (NGC 598)

Andromeda, Milky Way, M33 - The Big Spirals of the Local Group-

- Hubble type: Sb, Sbc/Sc, Sc
- Luminosity: 1.5 \times MW, 1 \times MW, 0.35 \times MW
- Andromeda & The Milky Way have warped disks, probably caused by interaction with M32 and Magellanic Clouds
- Milky Way & Andromeda may collide in ~ 5 Gyrs



