Dwarf Galaxies of the Local Group

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The Local Group in brief

- Few Mpc in diameter
- ~ 40 objects
- Dominated by 2 giant spirals, MW & M31
- Mass ~ $10^{12} M_\odot$
Figure 14.17 These are the galaxies of the Local Group, arranged to represent their actual physical relationships to the Milky Way. 

Source: http://www.iastate.edu/~astro.150/images/localgroup.jpg
Why study the Local Group

- Mixture of galaxies which includes spiral, dwarfs, irregulars
- Large luminosity range
- Proximity
- Provides internal kinematics of less luminous galaxies
Are Dwarfs in the Local Group special?

- Comes in different shapes: dwarf irregular, dSph, dwarf elliptical

- Metal poor and might carry the imprint of the young universe, if haven’t been disrupted by merger

- Distribution of the dark matter

- Star formation history

- ISM enrichment in the early universe
What to include in the Local Group?

- Resolvability
- Low heliocentric velocities of bright stars
- Distances
- Dynamical considerations: radial velocities
- For luminous galaxies:
  - SNe, Tully-Fisher, Cepheids
- $M_{\text{enc}} \gg \text{MLG}$ $\Rightarrow$ they are not bound
Mass of the Local Group

- $M_{LG} \sim 3 \times 10^{12} M_\odot$ (~98 % of the actual mass)

- Zero-velocity surface $\sim 1.8$ Mpc from the barycenter

- May still be unbound if they have lesser radial velocities and large tangential velocities
Missing Galaxies

More galaxies observed than expected

Expected uniform distribution
Structure of the Local Group

MW & M31

Dwarfs

NGC 3109

View from \((l, b) = (0, 0)\)

View from \((l, b) = (90, 0)\)

View from NGP \((b = 90)\)
Luminosity function

Schechter fit

Good fit for $M_B < -14$
Color magnitude diagram

Spirals/ Irregulars
Local Group

dSph/ Elliptical

$V_0$

$(B-V)_0$
Structural properties

- dIrr are dominated by star forming regions
- NGC 3109 shows spiral structure
- Early-type (NGC 185) shows more symmetrical spheroidal component
Structural properties

- Only three LG Dwarfs contain nuclei: NGC 205, Sagittarius & M32
- M32 is believed to have a central MBH

![Image of M32](M32.png)  
Source: Lowell, UA
Structural properties

- Historically, brightness profiles for dIrr are fitted with exponential profiles

- Early-type fits with the King profile

- All galaxies with exponential scale lengths > 500 pc are dIrr

- While 90% with smaller scale lengths are early-type
ISM in Local Group Dwarfs

- $\text{H}_1$ properties progresses from dIrr to dSph as expected in a standard closed chemical enrichment model.

- Local group dSph are comparatively devoid of neutral hydrogen.

- In dIrr, $\text{H}_1$ shows clumpiness on scales of 100-300 pc.

- The most luminous dwarfs have smooth $\text{H}_1$ distribution.
ISM in Local Group Dwarfs

- Suggested column density for star formation $\sim 10^{21}$ cm$^{-2}$

- But some dwarfs with $N(H_1) > 10^{21}$ cm$^{-2}$ lack star formation, probably due to absence of trigger mechanism

- While some dSph or transition galaxies with $N(H_1) < 10^{21}$ cm$^{-2}$ shows evidence of recent star formation
ISM in Local Group Dwarfs

• In general, the $\text{H}_1$ emission is centered on optical centroids of dIrr.

• But some dIrr (e.g. Phoenix) shows big offset from the optical centroid.
Non-thermal Sources in dwarfs

- IC 10, IC 1613 shows non-thermal radiations possibly from the recent SN explosions.

- No diffuse X-ray emission is observed
ISM crisis in dSph

- NGC 147 & NGC 185 have similar luminosities, masses, SFR, sizes

- But NGC 185 contains significant ISM while NGC 147 has none

- Some dwarfs show evidence of star formation but lack any gas which could have fueled this activity

- So this gas might have come from the external sources or there are some ‘holding tanks’ or the “offset” seen in some dSph
NGC 185

NGC 147

Source: SEDS
Disturber outer regions

IC 10
NASA/IPAC ED

HI emission
Leroy et al 2006
Luminosity-metallicity (L-Z) relation

- Luminous dwarfs are more metal rich
- At given $M_v$, dIrr are metal poor than dSph
Age Indicators in Local Group Dwarfs

- Chemical enrichment (not so intuitive)

- Wolf Rayet stars: vigorous star formation during past 10 Myr

- Blue-Loop stars: 100-500 Myr (closely associated with cepheids). Luminosity decreases monotonically with age

- AGB stars are used to constrain lower age limit of ~ 1 Gyr
Star formation history

- No two Local Group dwarfs have the same SF history

- Many dIrr contains significant old population

- The most recent star formation episodes are relatively short

- Short bursts are typical in all dwarfs.

- None of the galaxies contain exclusively stars > 10 Gyr (possibly except Uminor)

- Inferred SFR in IC10 is the highest among Local Group Dwarfs
Internal Kinematics

- Expected central velocity dispersion $< 2 \text{ km s}^{-1}$

- But observed values $> 7 \text{ km s}^{-1}$ (independent of the galaxy)

- All the dwarfs require DM halo in order to fit the flat rotation curves

- Massive central BH models are incompatible with the generally smooth central surface brightness distributions
Interactions with other galaxies
Source: http://www2.sunysuffolk.edu/pappasm/AST101/Star_Properties.jpg
The LOCAL GROUP

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