Luke Leisman 2013 Undergraduate ALFALFA Workshop

## **The Local Universe**

#### Acknowlegements

My thanks to Brian Kent, the original creator of this talk (I think)

 Also to Ann Martin and Greg Hallenbeck for their successive iterations and genius improvements

### **My Local Universe**



http://archiehopeful.wordpress.com/2011/09/06/confession-of-a-regaliac/

#### **Astronomers' Local Universe**



http://en.wikipedia.org/wiki/File:Velocity-redshift.JPG



## **Astronomers' Local Universe** What's in it?

- Galaxies
- Galaxy Clusters/groups
- Voids

- A brief tour
  - What's Alfalfa got to do with this?

#### What is a Galaxy?

The Wikipedia Definition: "A **galaxy** is a massive, gravitationally bound system consisting of stars, an interstellar medium of gas and dust, and dark matter." Various morphologies (spiral/elliptical) and sizes (dwarfs/giants)



#### What do Galaxies Look Like?

#### M81: X-Ray, UV, Visible, Visible, NIR, MIR, FIR, Radio



From the IPAC Multiwavelength Museum

### Types of Galaxies: Spirals

- Thin disks
- Bars
- Central luminous bulge (and ratio to the brightness of the disk)
- Tightness of the spiral





M33 © IAC/RGO/Malin

### Types of Galaxies: Ellipticals

- Ellipticals: look like smooth, featureless "blobs"
- Older (redder) stellar populations
- Tend to have little neutral gas (HI) – so ALFALFA doesn't see these!
  - More rare in the early Universe



487 in the Virgo Cluster

#### Types of Galaxies: Irregulars

 Irregulars: Many different properties, often because of interactions or other unusual events nearby.





NGC 1427A

mage of Sagittarius Dwarf Irregular Galaxy (SagDI

## Types of Galaxies: Irregulars

 LMC and SMC are satellite galaxies of our own – disrupted by gravitational interaction with the Milky Way



#### LMC and SMC

## Dwarf Galaxies

- Smaller size than giant galaxies
- Lower surface brightness
- Most common galaxies!





Sagittarius Dwarf

## Groups of galaxies

- Galaxies can be gravitationally bound to each other, and undergo interactions and collisions.
- Separations across intergalactic distances range from 50 kpc up to 1 Mpc.
- ALFALFA science goals include studying the effects within the group environment –
  - What is HI mass function?
  - How do unseen HI clouds/starless galaxies effect dynamics?
  - Are there unseen tidal remnants or debris?
  - What are sizes of HI disks?

## **Clusters of Galaxies**

- Around half the galaxies in the Universe are found in clusters or groups.
- Clusters have a higher density than "loose" groups

   brightest galaxies are S0s and ellipticals instead
   of spirals
- Abell Catalog contains 4073 rich clusters
- Gravity binds the members, as well as hot intracluster gas (seen in the X-ray)

## **Filaments and Voids**

125 Mpc/h







The Local Group has about 45 members ranging from large spiral galaxies to small dwarf irregulars. Most are dwarf spheroidals.

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(1) Milky Way (17) NGC 205 (2) Draco (18) M32 (19) Andromeda I (3) Ursa Minor (4) SMG (20) Andromeda II (5) LMG (21) Andromeda (M31) (6) Carina (22) M33 (7) Sextans (23) LGS 3 (8) Ursa Major (24) IC 1613 (25) NGC 6822 (9) Pegasus (10) Sculptor (26) Sextans A (27) Leo A (11) Fornax (12) Leo I (28) IC 10 (13) Leo II (29) DDO 210 (14) Maffei (30) Wolf-Lundmark-(15) NGC 185 Melotte (16) NGC 147 (31) IC 5152

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#### 10 million ly **The Virgo Supercluster** Virgo II Groups NGC 67<u>44</u> NGC 7582 Ī NGC 5128 local Group Sculptor Maffei M81 .eo l aroups NGC 1023NISI 2997 Dorado eo II Groups ornax Cluster idanus Cluster http://www.atlasoftheuniverse.com/virgo.html

rpowell

## Virgo Cluster

cz ~ 1035 km/s

- Δv ~ 1000 km/s
- 1300 catalogued members
- Most galaxies are dwarf elliptical type



#### Fornax Galaxy Cluster

NGC 1380

NGC 1382

NGC 1381

NGC 1399 NGC 1379

NGC 1427A

NGC 1387

NGC 1404

NGC 1389

NGC 1365

#### **Clusters and** superclusters nearby



Astronomy: Roen Kelly; after M. Hudson

## Distribution of Galaxies

~450,000 galaxies (SDSS)



### ALFALFA View of the Local Universe





### ALFALFA View of the Local Universe











#### Summary

#### The Local Universe:

- Contains Galaxies, Galaxy Clusters, and Voids
- Consists of The Milky Way and it's satellites, the Local Group, the Virgo Supercluster, and beyond

#### Alfalfa:

- Maps the local universe
- Discovers new members
- Studies its properties

## Beyond OurNeighborhood • The Universe is expanding! $CZ = H_0 d$



## A sim ple calculation: Redshift

$$z = \frac{\lambda_{obs} - \lambda_0}{\lambda_0} = \frac{f_0 - f_{obs}}{f_{obs}}$$

Measure the shift in a spectral line – f0 is the rest frequency ( $\lambda 0$  the rest wavelength)

Extragalactic objects often identified by their *cz* measurement. ALFALFA covers cz = -2000 to 18000 km/s (out to ~ 250 Mpc) However, there are other factors to take into account in the local Universe – peculiar velocities! Deviations can be quite large depending on the galaxy, and whether it is part of a group or a field galaxy





## M66 Group: The Leo Triplet



## M66 Group: The Leo Triplet



# Our Neighborhood: The Local Group (solid)



## D istances to nearby galaxies

