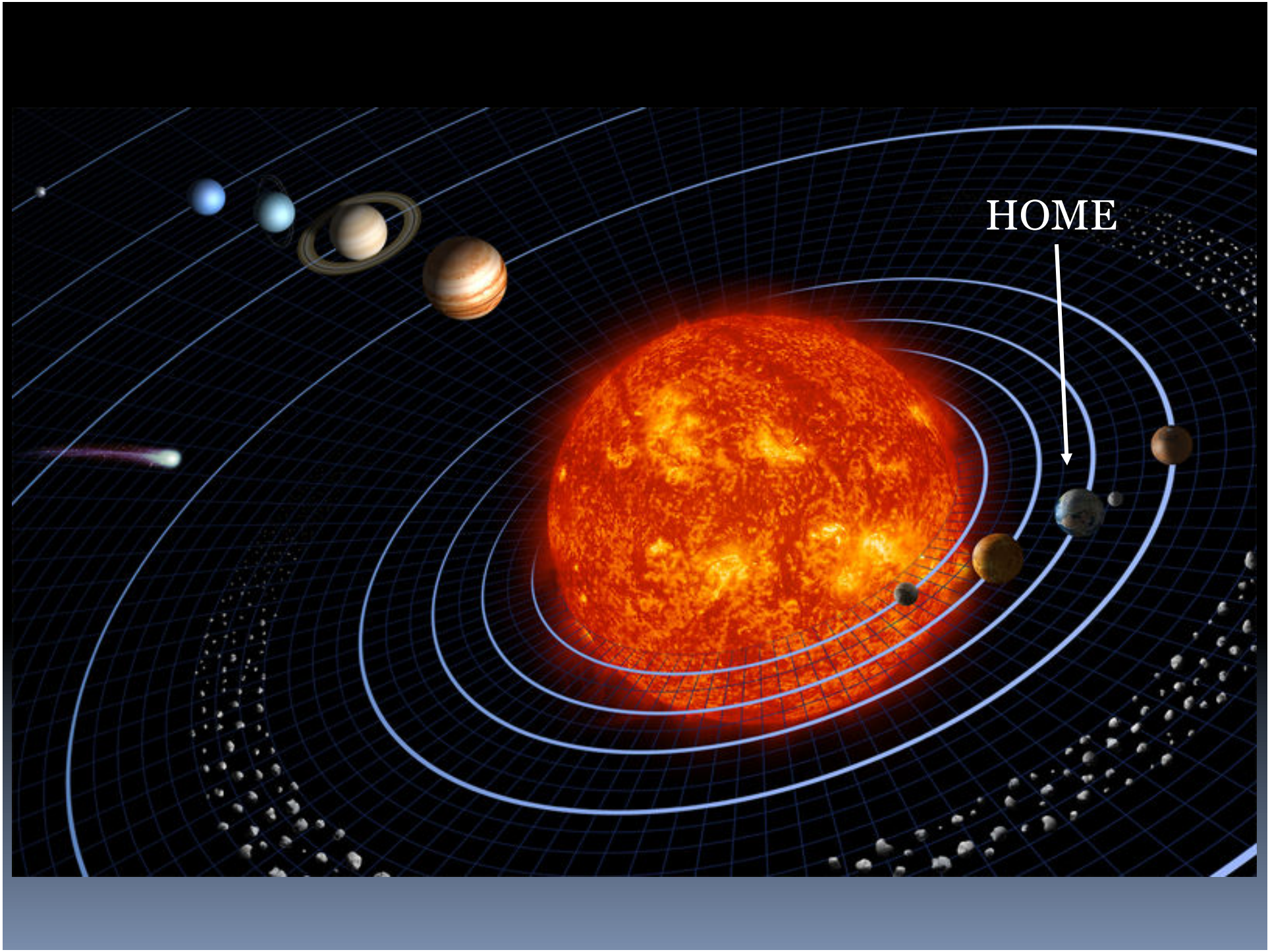
Greg Hallenbeck
2012 Undergraduate ALFALFA Workshop
(with thanks to Brian Kent and Ann Martin!)

THE LOCAL UNIVERSE


HOME

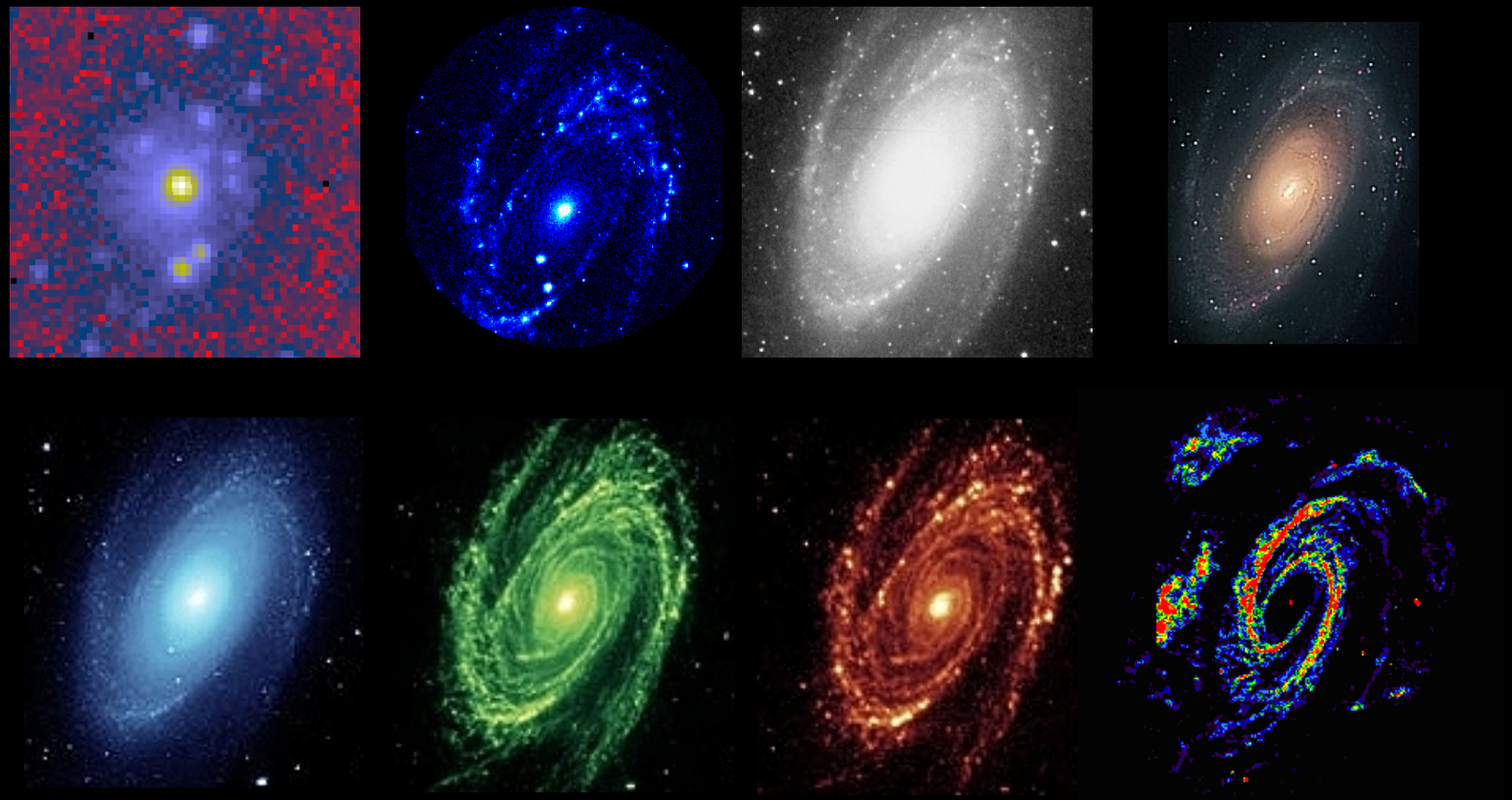
What is a Galaxy?

- 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)

M31, from Hubble

What do Galaxies Look Like?

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

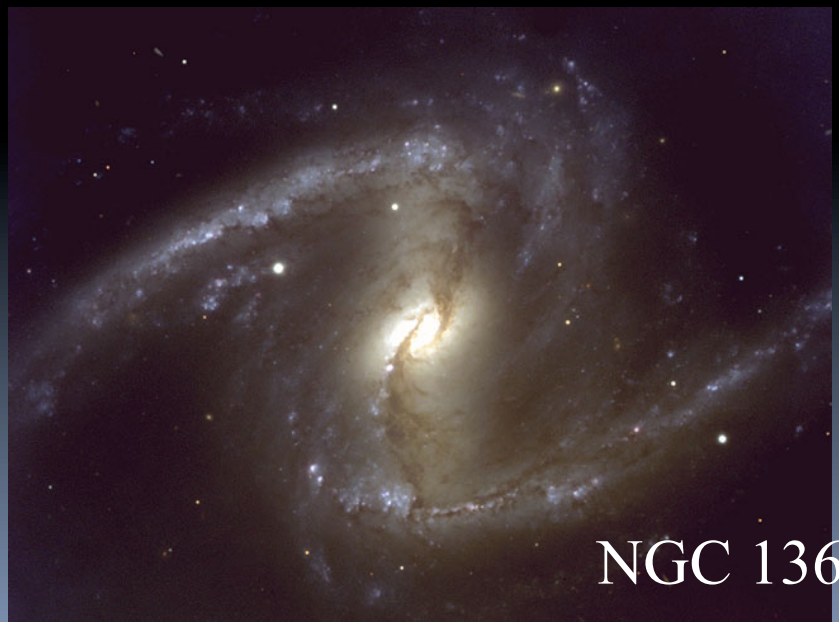


From the IPAC Multiwavelength Museum

Types of Galaxies: Spirals

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

M51



NGC 1365

M33

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

M87 in the Virgo Cluster

Types of Galaxies: Irregulars

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

NGC 1427A

HST Image of Sagittarius Dwarf Irregular Galaxy (SagDIG)

Types of Galaxies: Irregulars

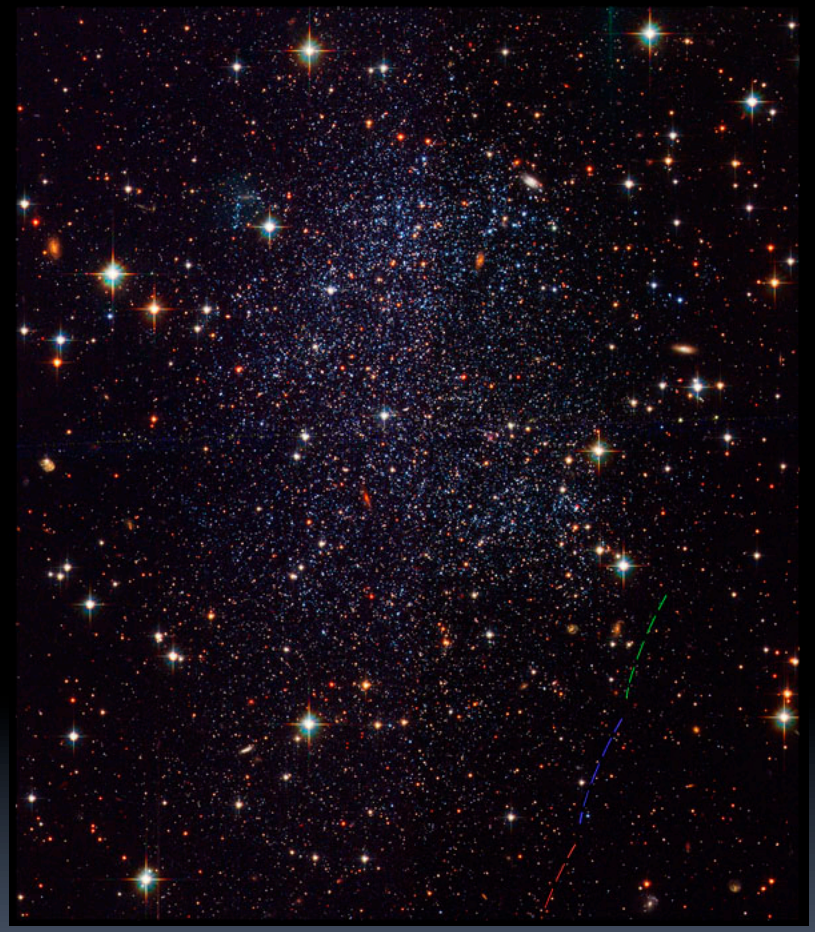
- LMC and SMC are satellite galaxies of our own – disrupted by gravitational interaction with the Milky Way

LMC and SMC

Dwarf Galaxies

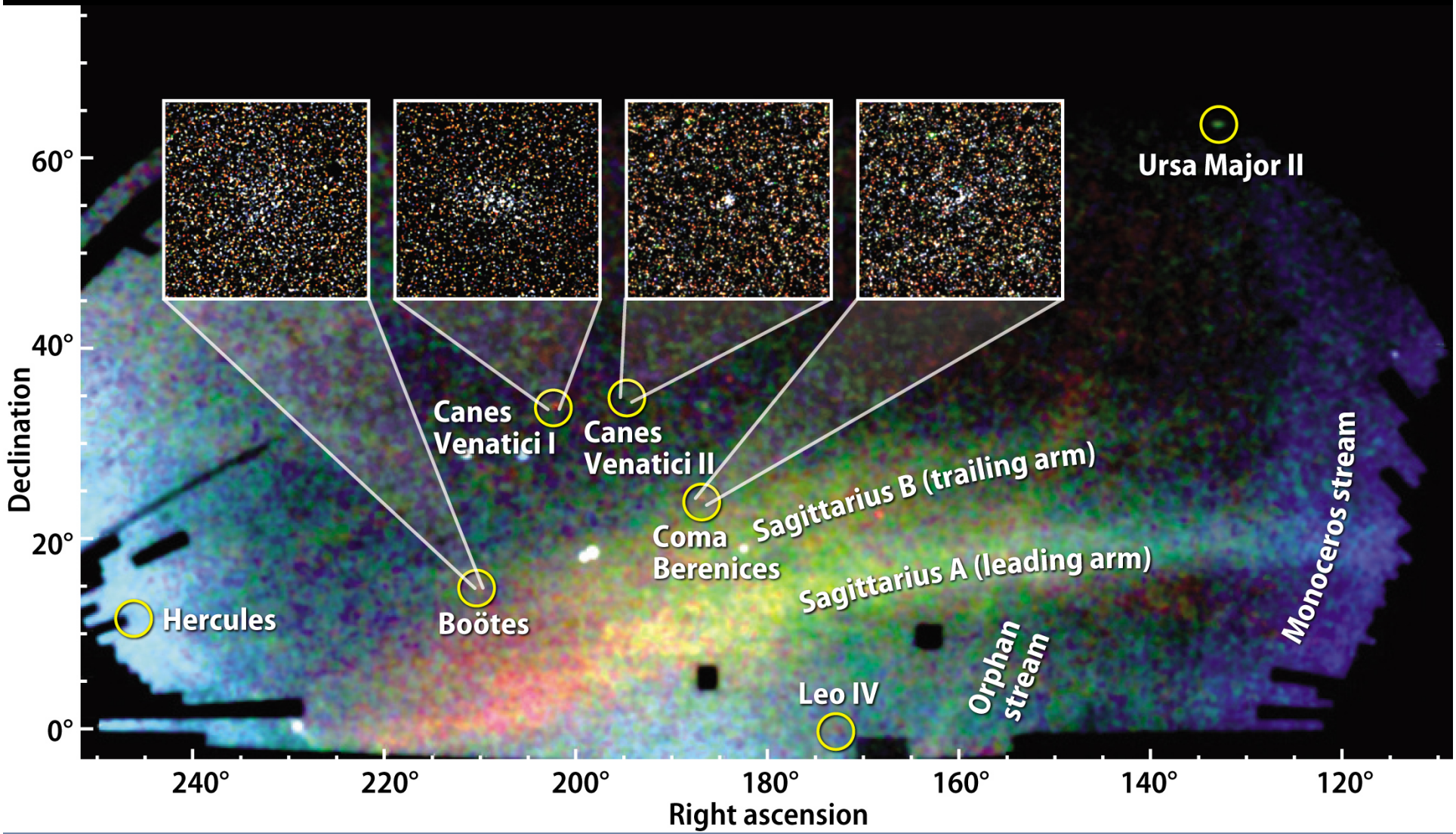
- Smaller size than giant galaxies
- Lower surface brightness
- Most common galaxies!

M32



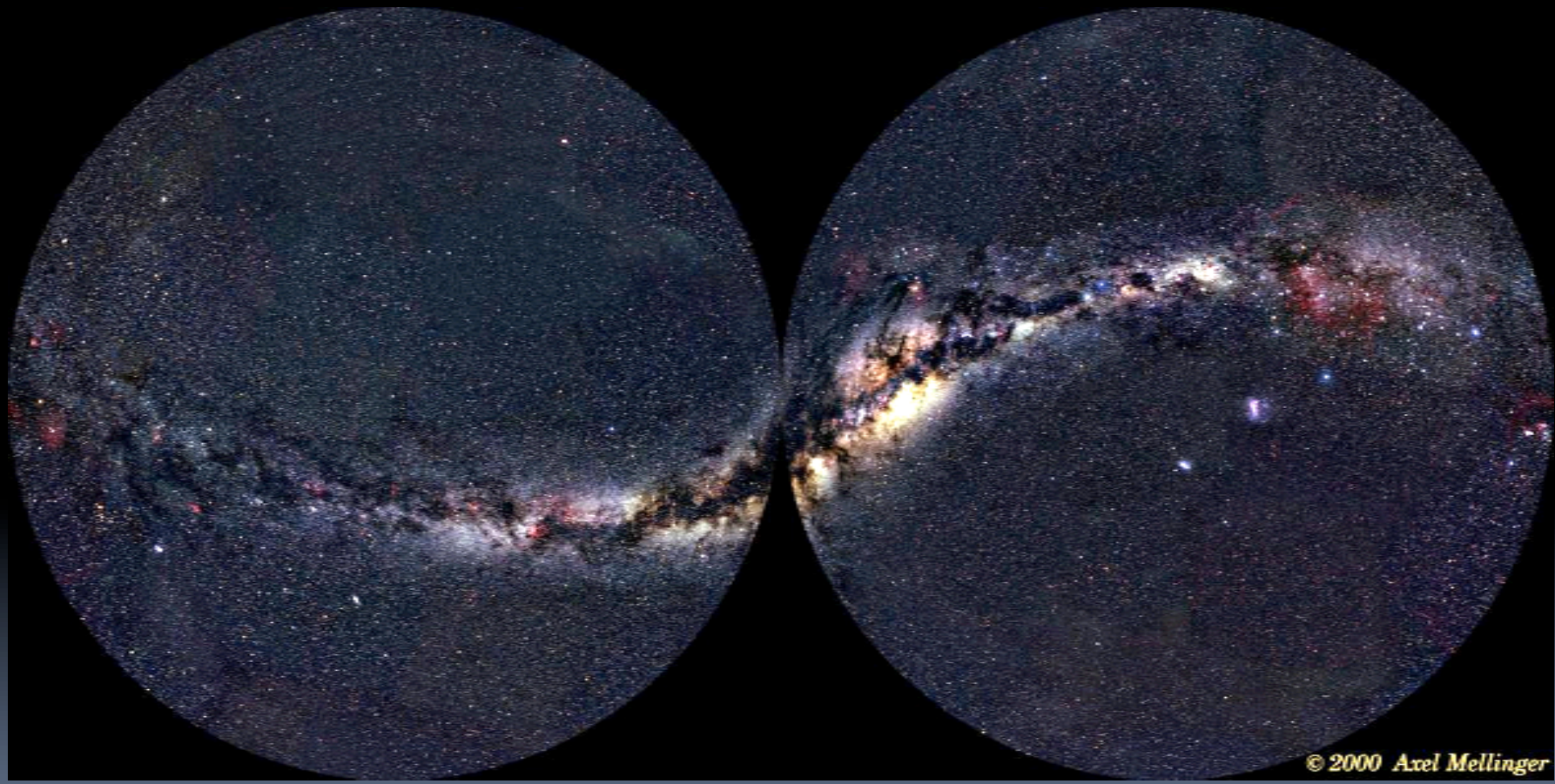
Sagittarius Dwarf

SDSS “Ultra-Faint” Galaxies



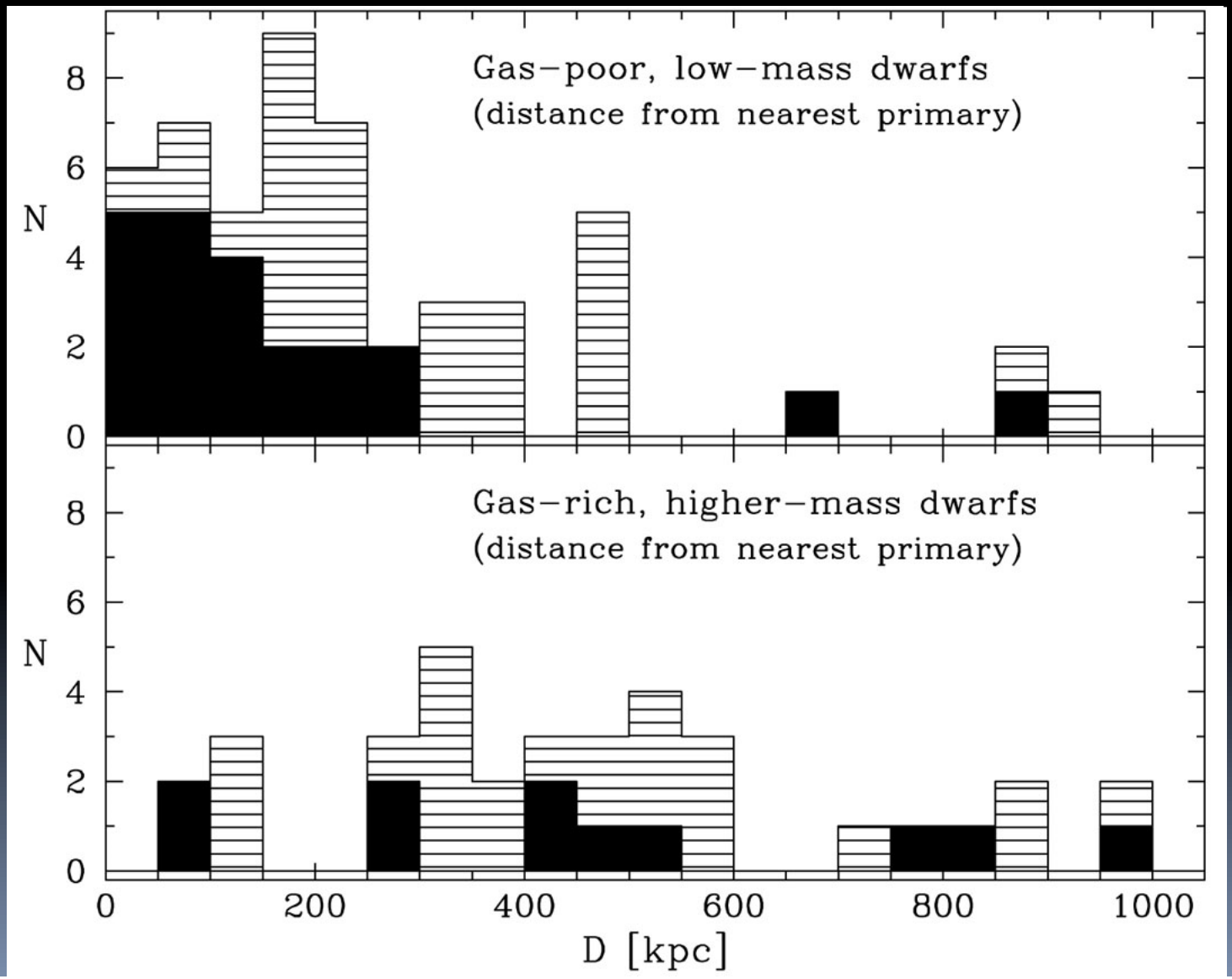
Our Galaxy: The Milky Way

An Sbc galaxy that is 30 kpc in diameter



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

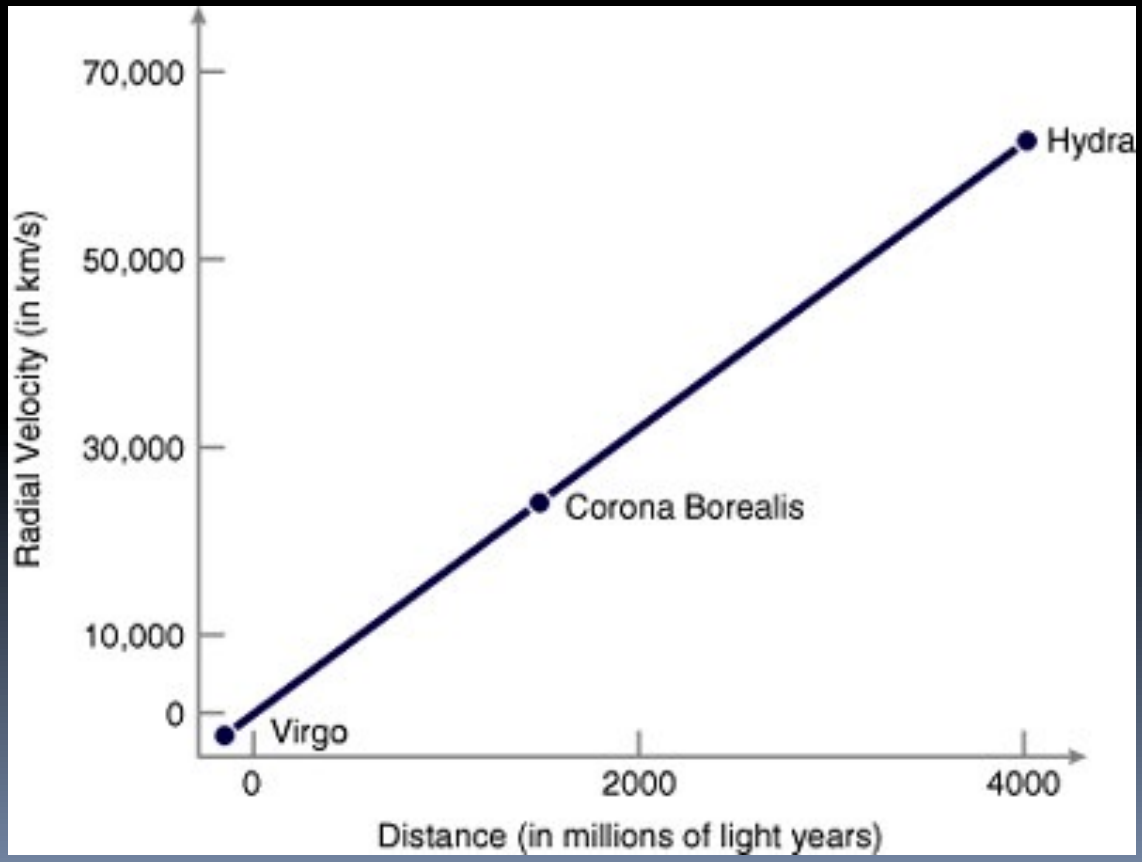
Our Neighborhood: The Local Group (solid)



Beyond Our Neighborhood

- The Universe is expanding!

$$cz = H_0 d$$



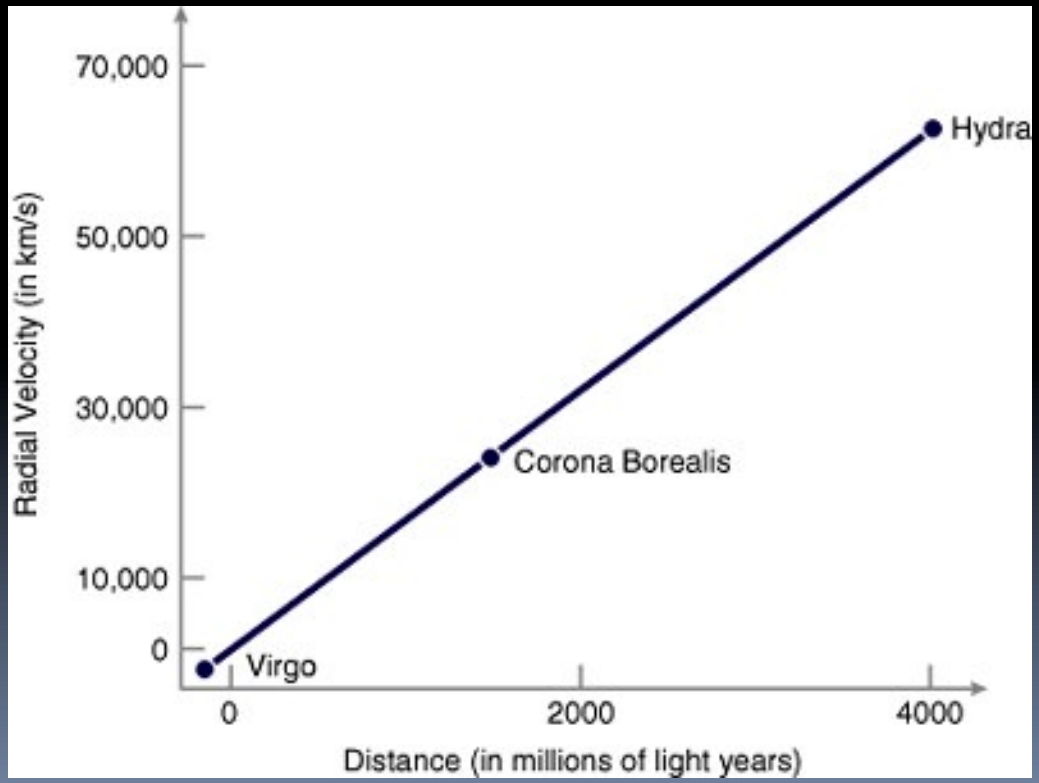
A simple calculation: Redshift

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

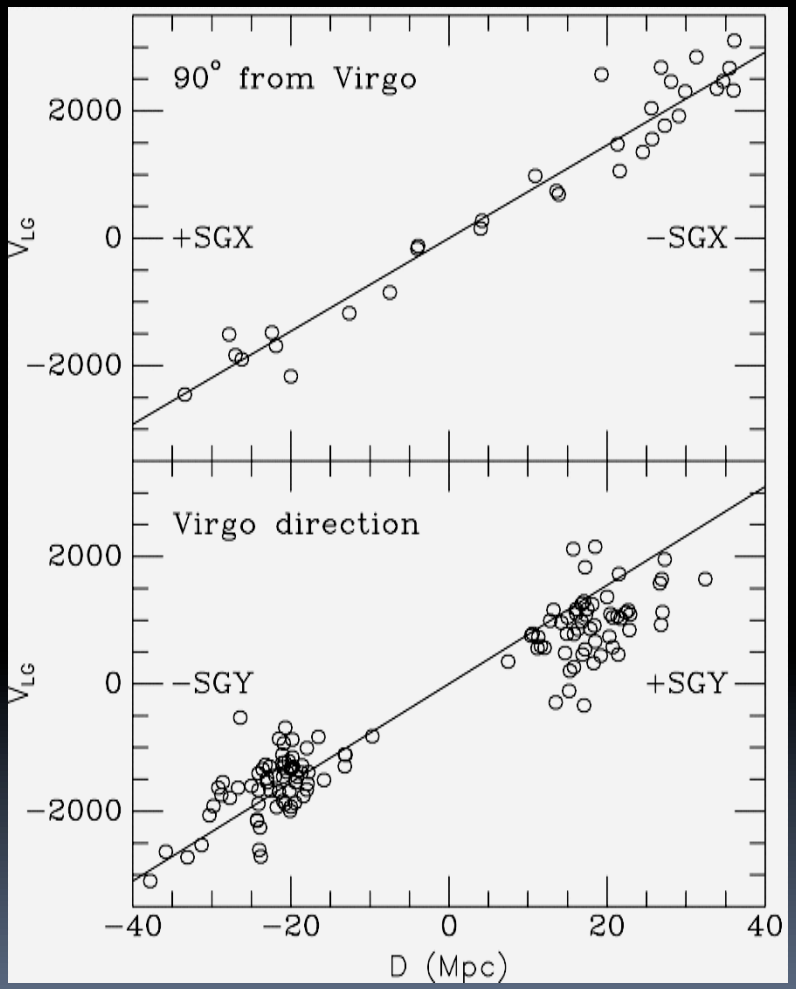
- Measure the shift in a spectral line – f_0 is the rest frequency (λ_0 the rest wavelength)
- Extragalactic objects often identified by their *cz* measurement.
- ALFALFA covers *cz* = –2000 to 18000 km/s (out to ~ 250 Mpc)

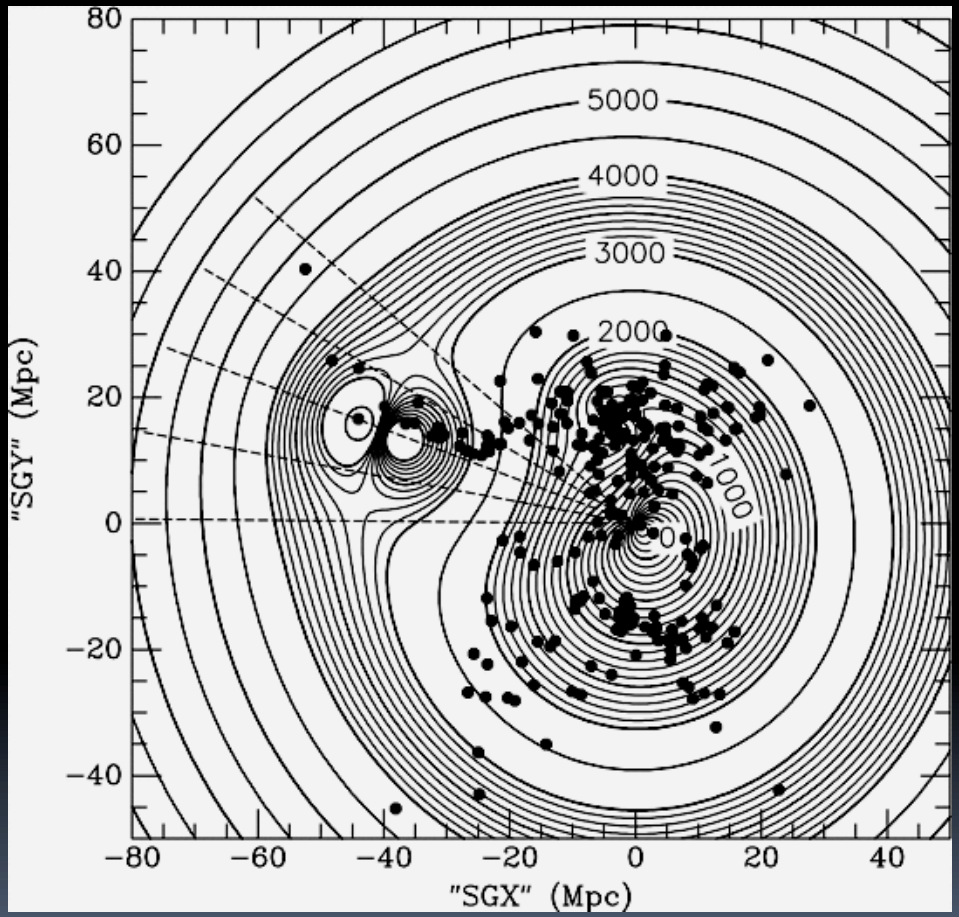
However, there are other factors to take into account in the local Universe – peculiar velocities! Deviations can be quite large depending on the galaxy, and whether it is part of a group or a field galaxy.

$$cz = H_0 d$$



Distances to nearby galaxies

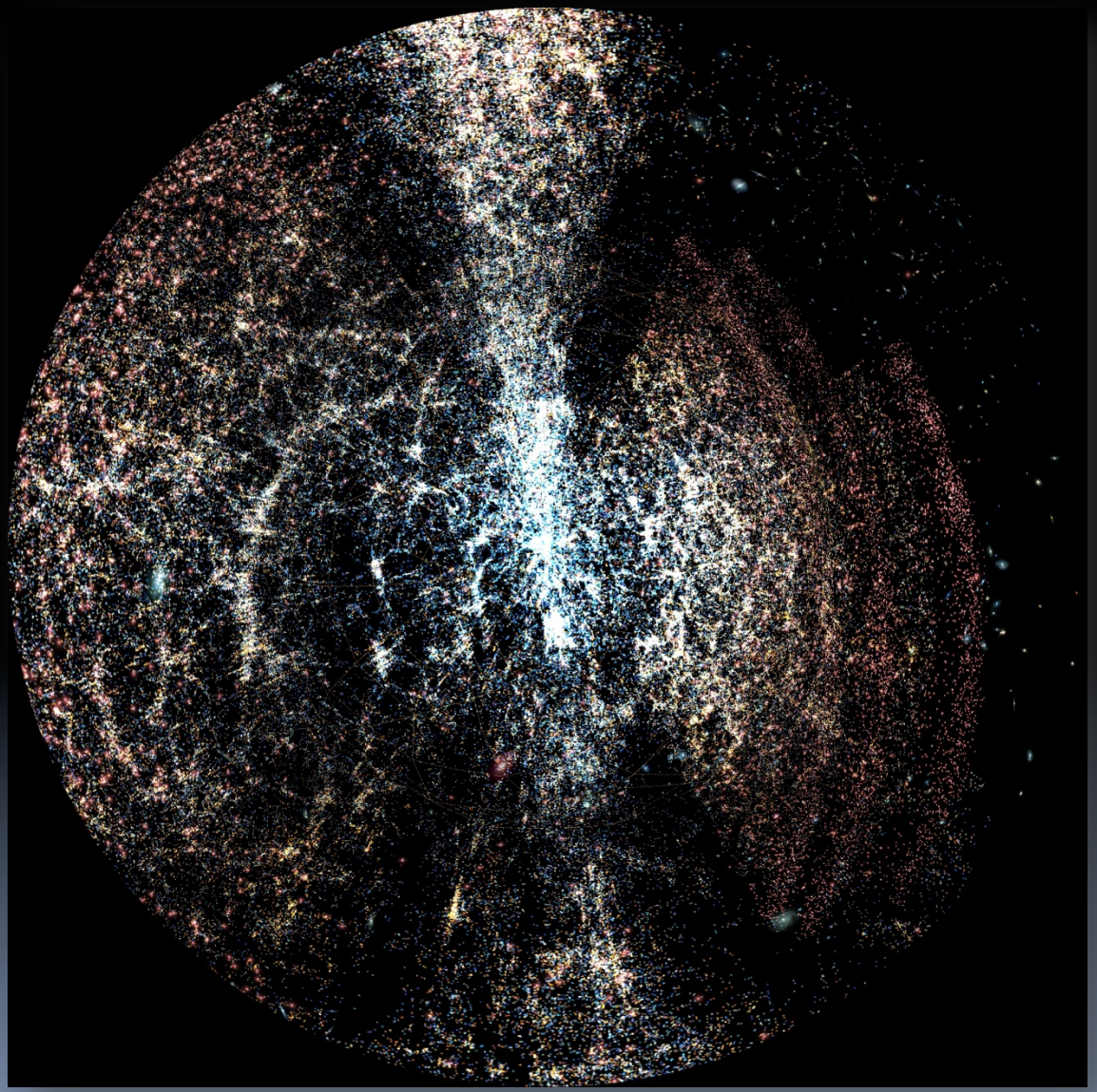




Tonry, et al. 2000

Distribution of Galaxies

~450,000 galaxies (SDSS)



Distribution of Galaxies

- Structures in the Universe: The best place to find a galaxy is next to another one!
  - Groups
  - Clusters
  - Superclusters
  - Filaments and Voids

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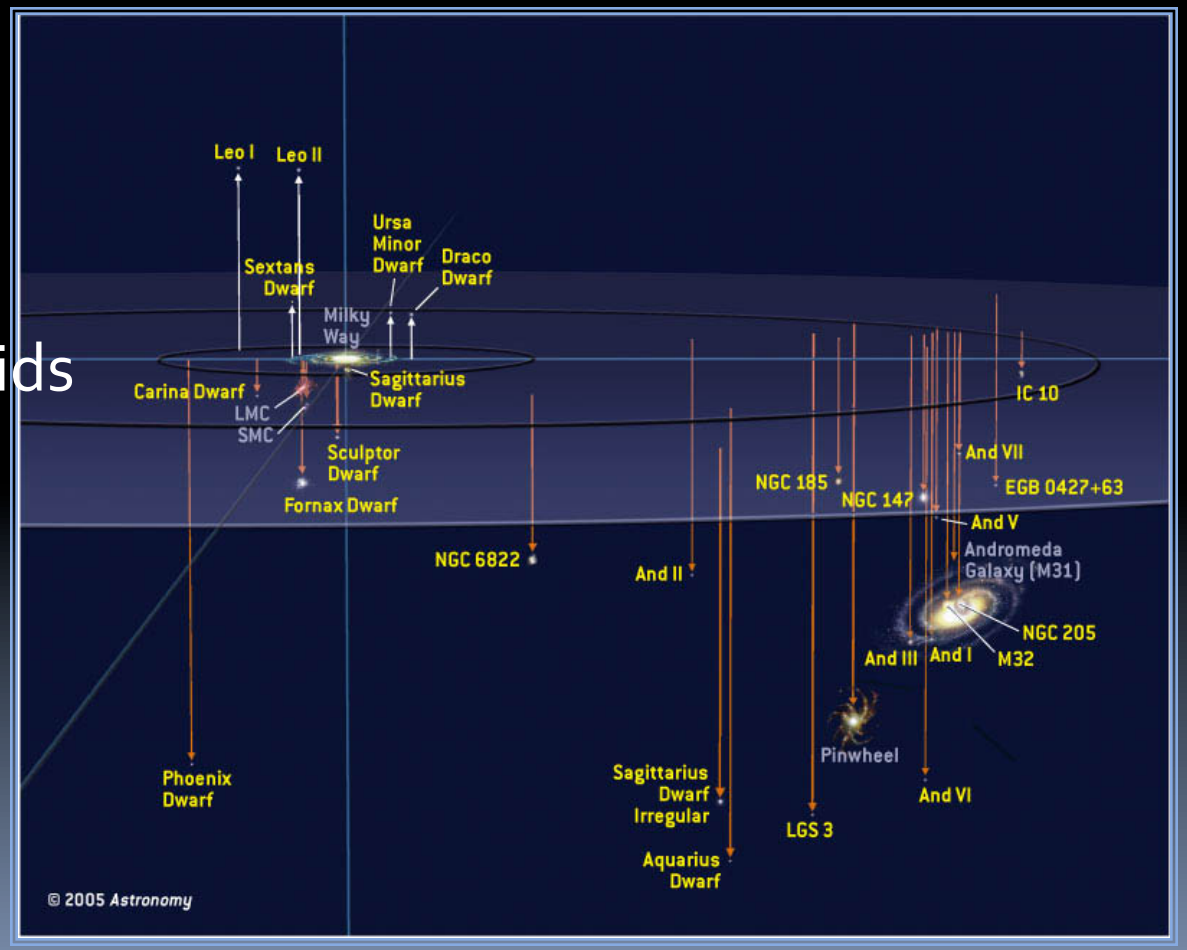
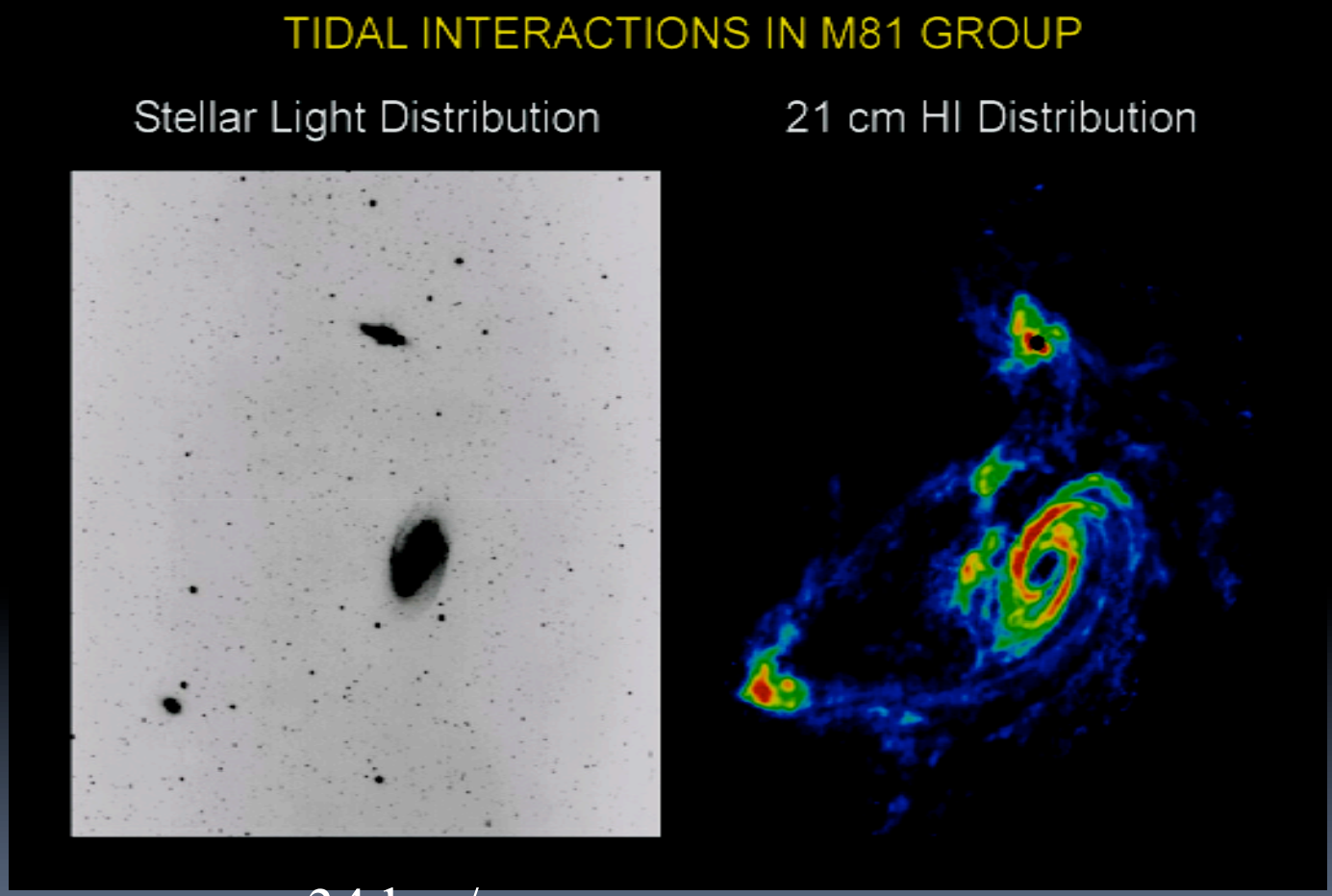


Groups of galaxies

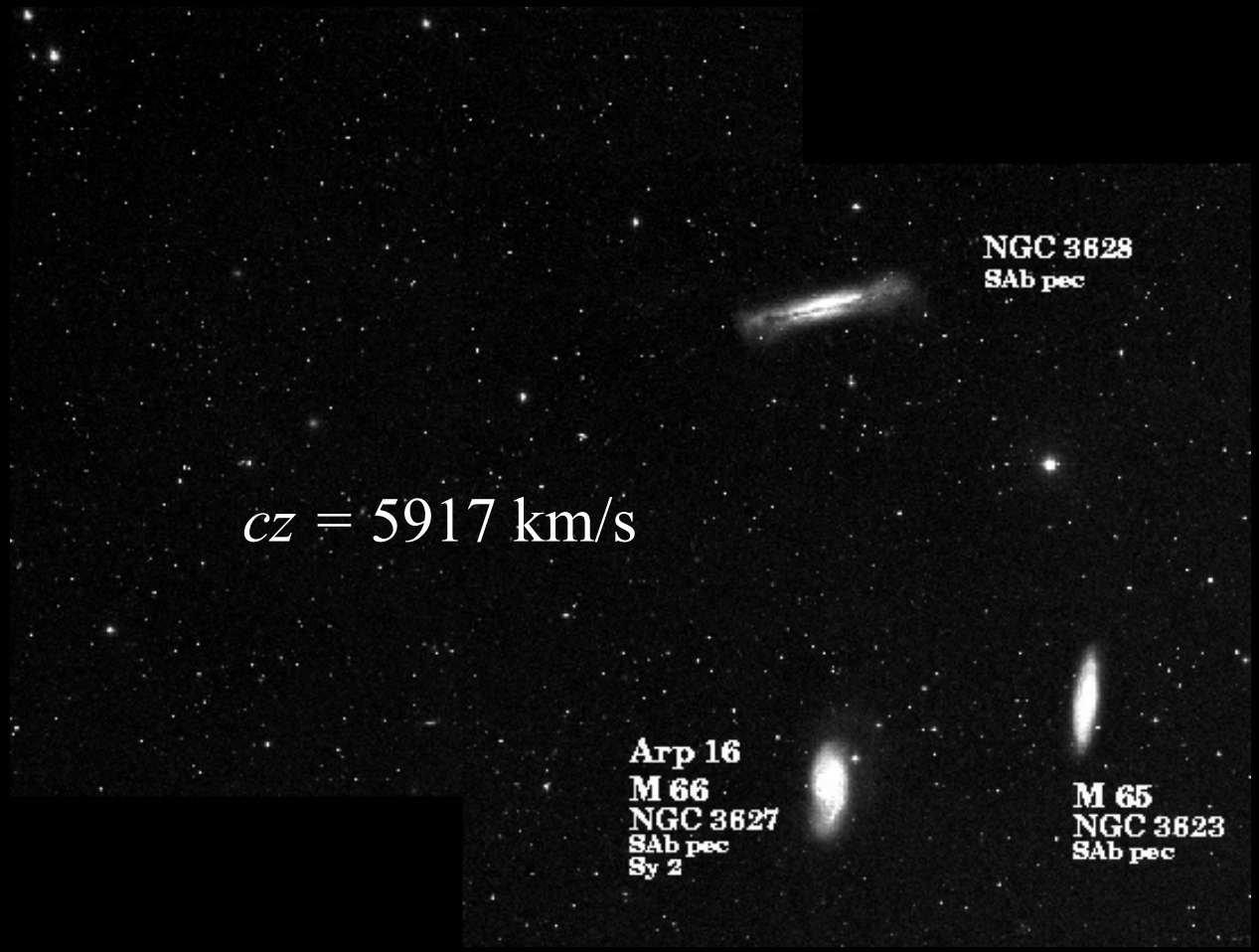
- Galaxies can be gravitationally bound to each other, and undergo interactions and collisions.
- Separations across intergalactic distances range from 50 kpc up to 1 Mpc.
- ALFALFA science goals include studying the effects within the group environment –
  - What is HI mass function?
  - How do unseen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

Groups of galaxies



cz = -34 km/s

M66 Group: The Leo Triplet



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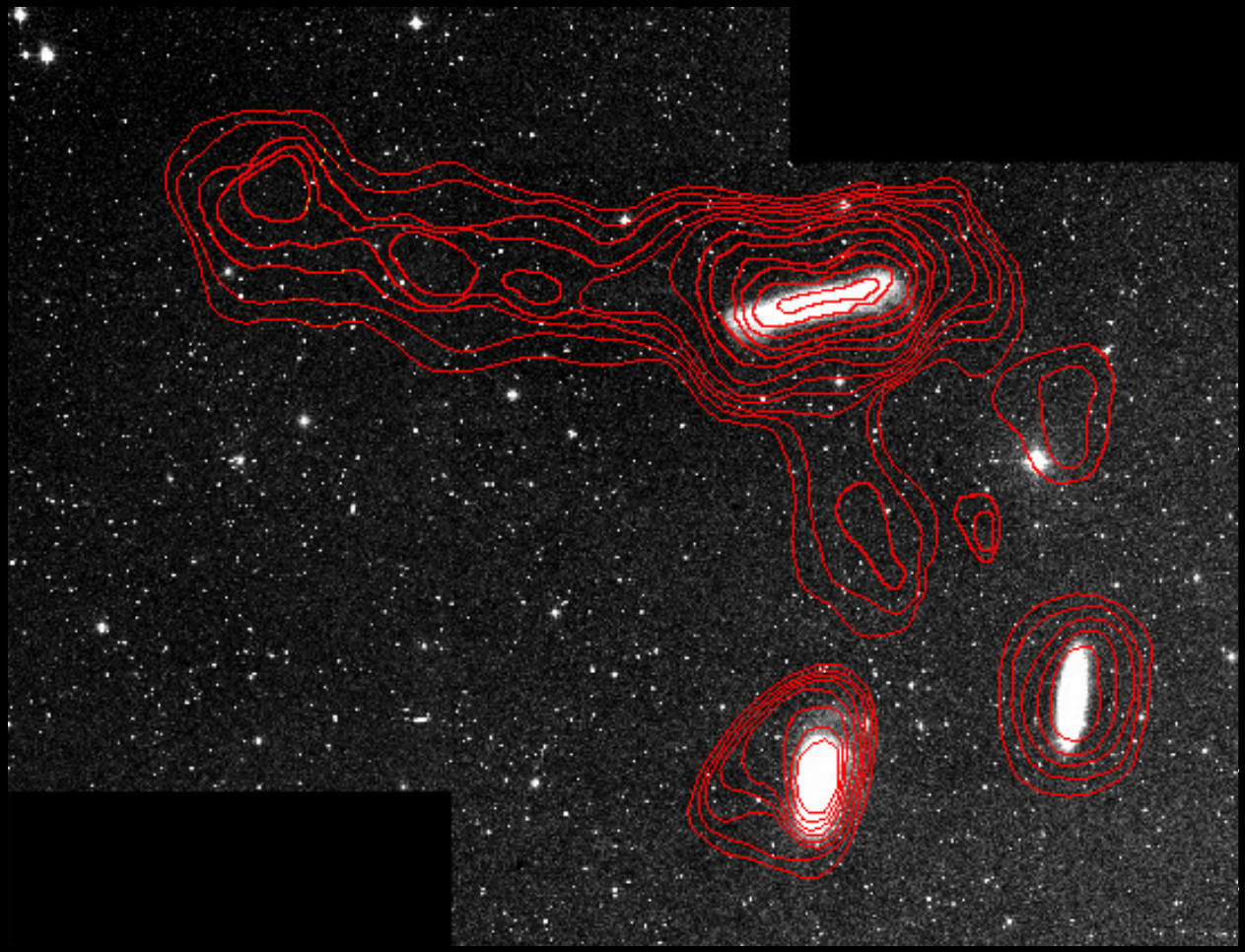

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The Virgo Cluster is the closest nearby cluster, at about 17 Mpc. It contains about 1500 member galaxies!

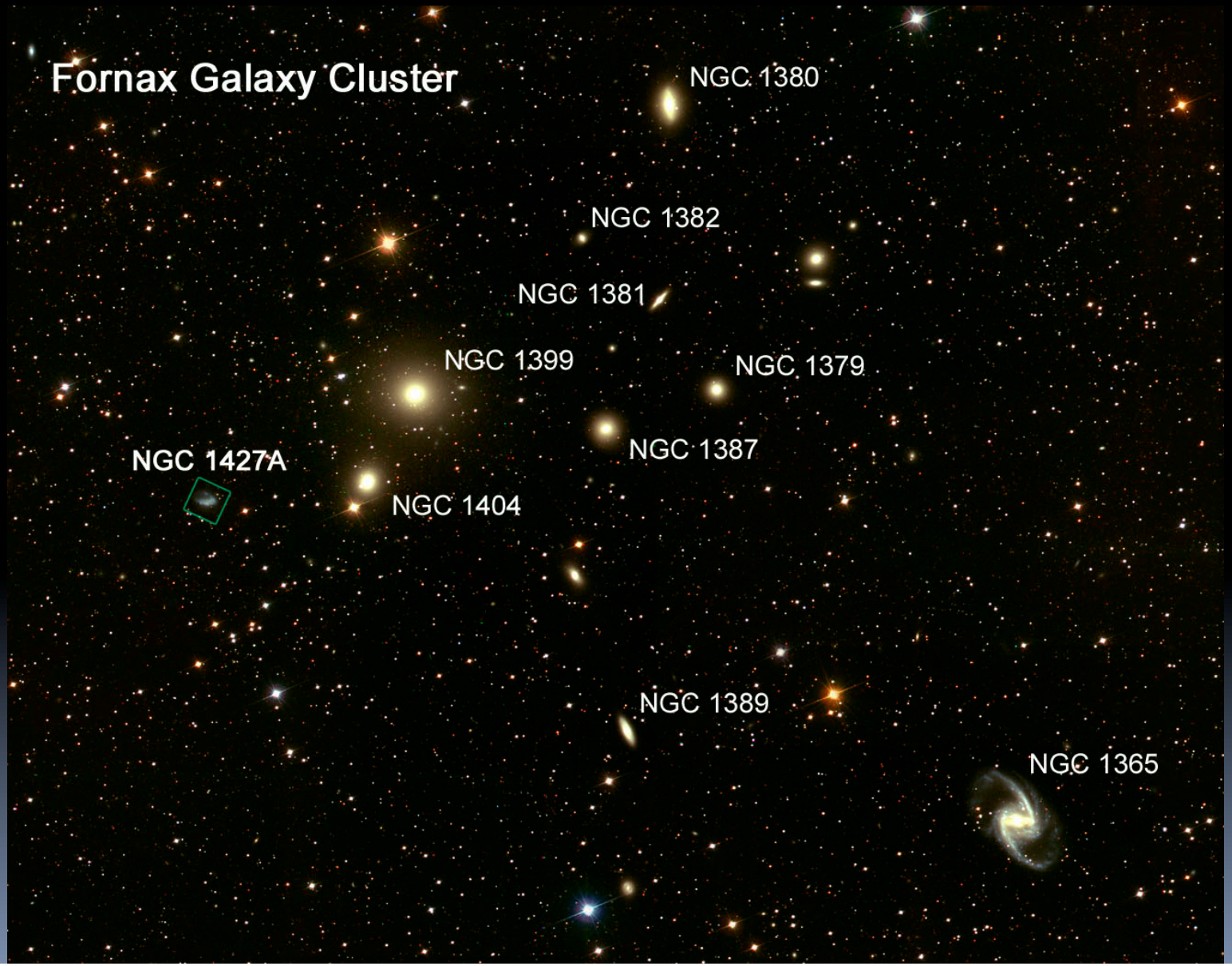
Clusters of Galaxies

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

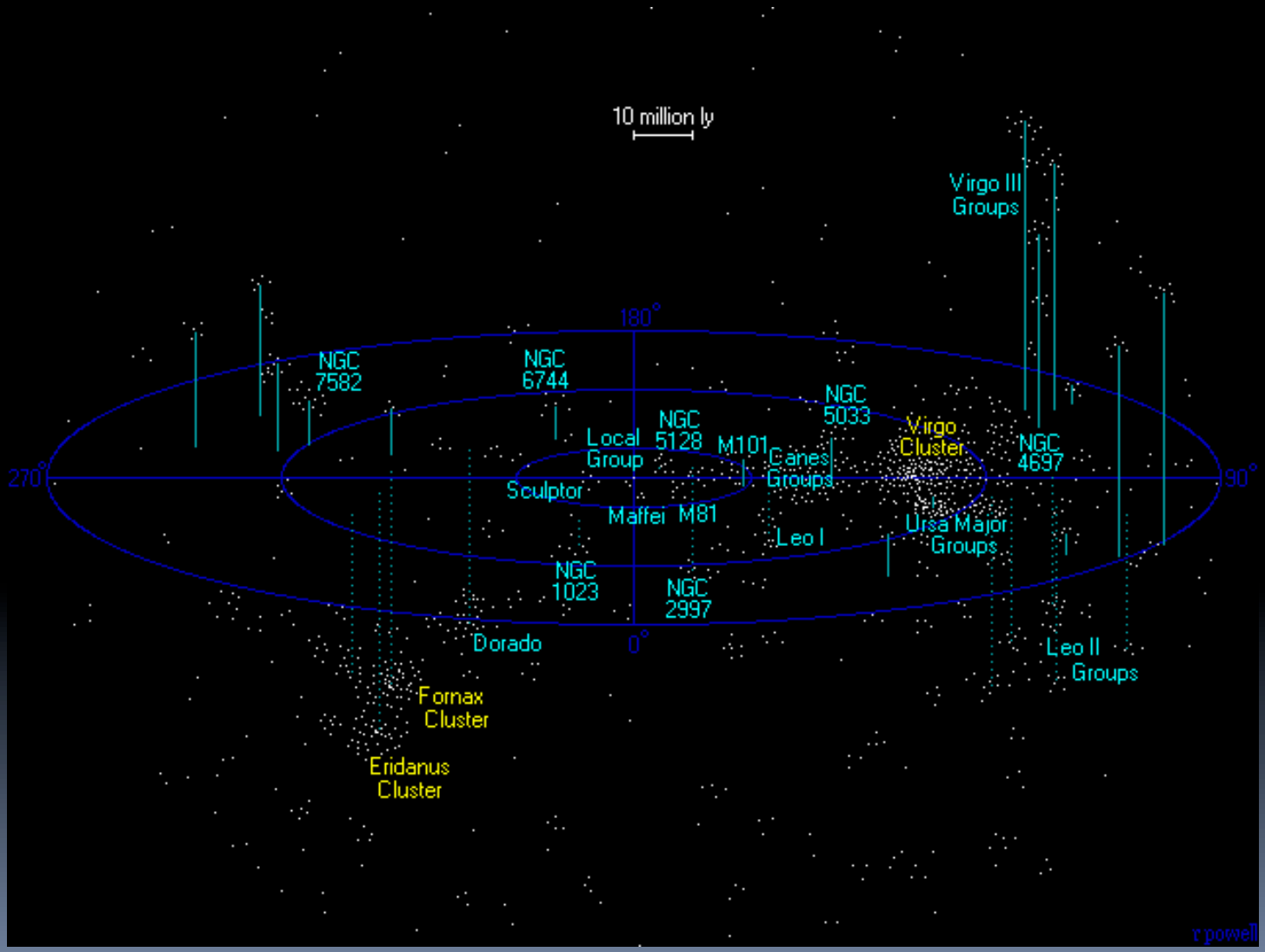
Virgo Cluster

- cz ~ 1035 km/s
- Δv ~ 1000 km/s
- 1300 catalogued members
- Most galaxies are dwarf elliptical type

Fornax cluster



Local Supercluster



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  - **Superclusters**
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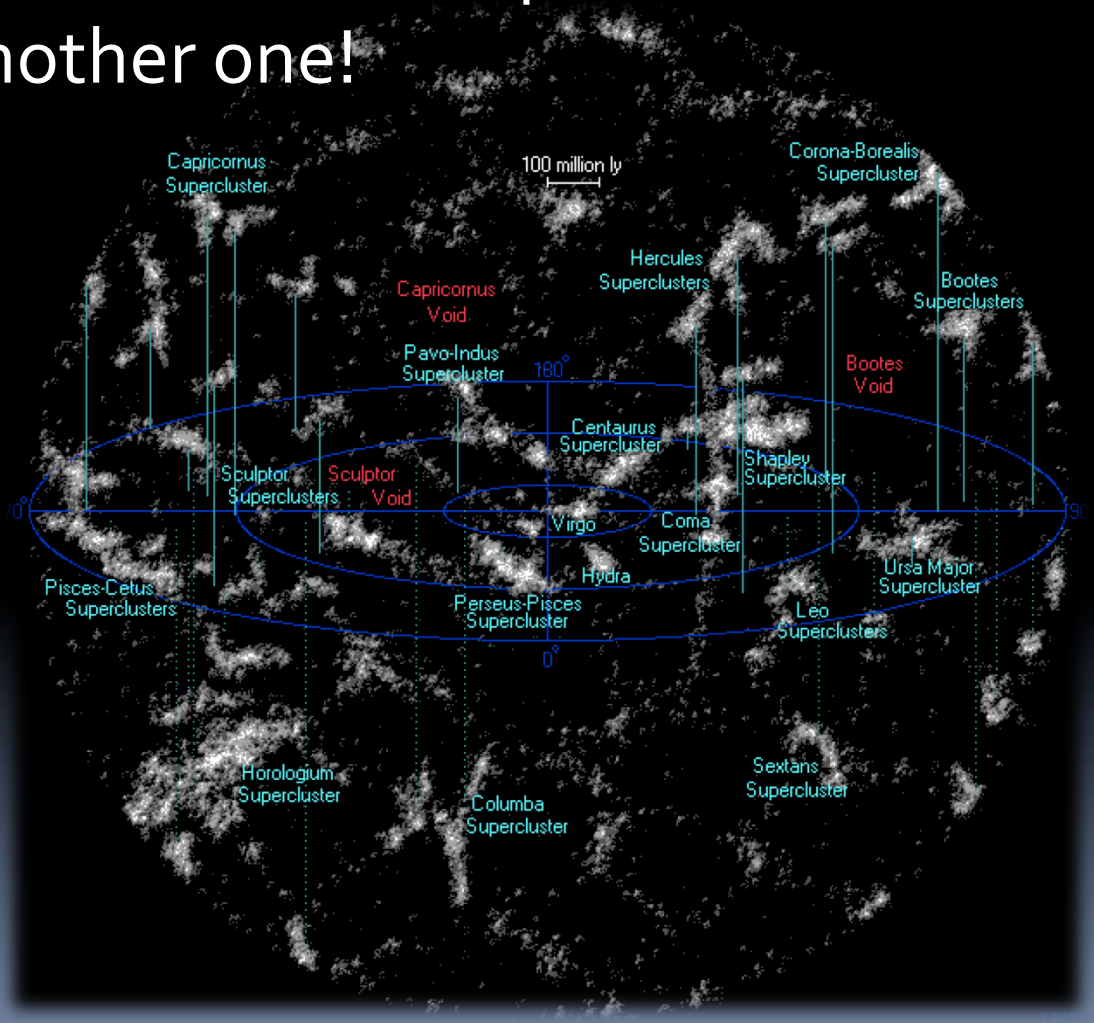

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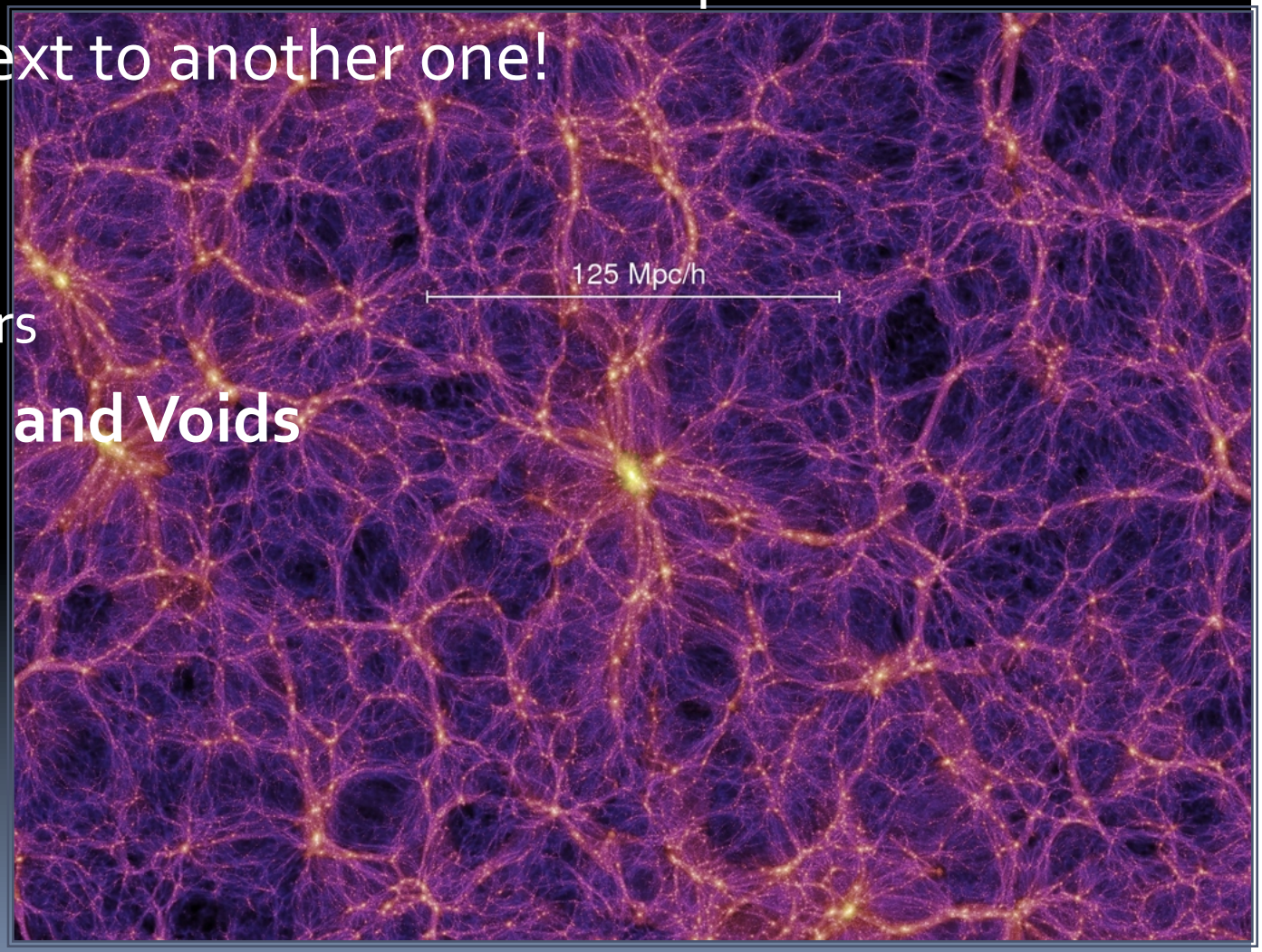
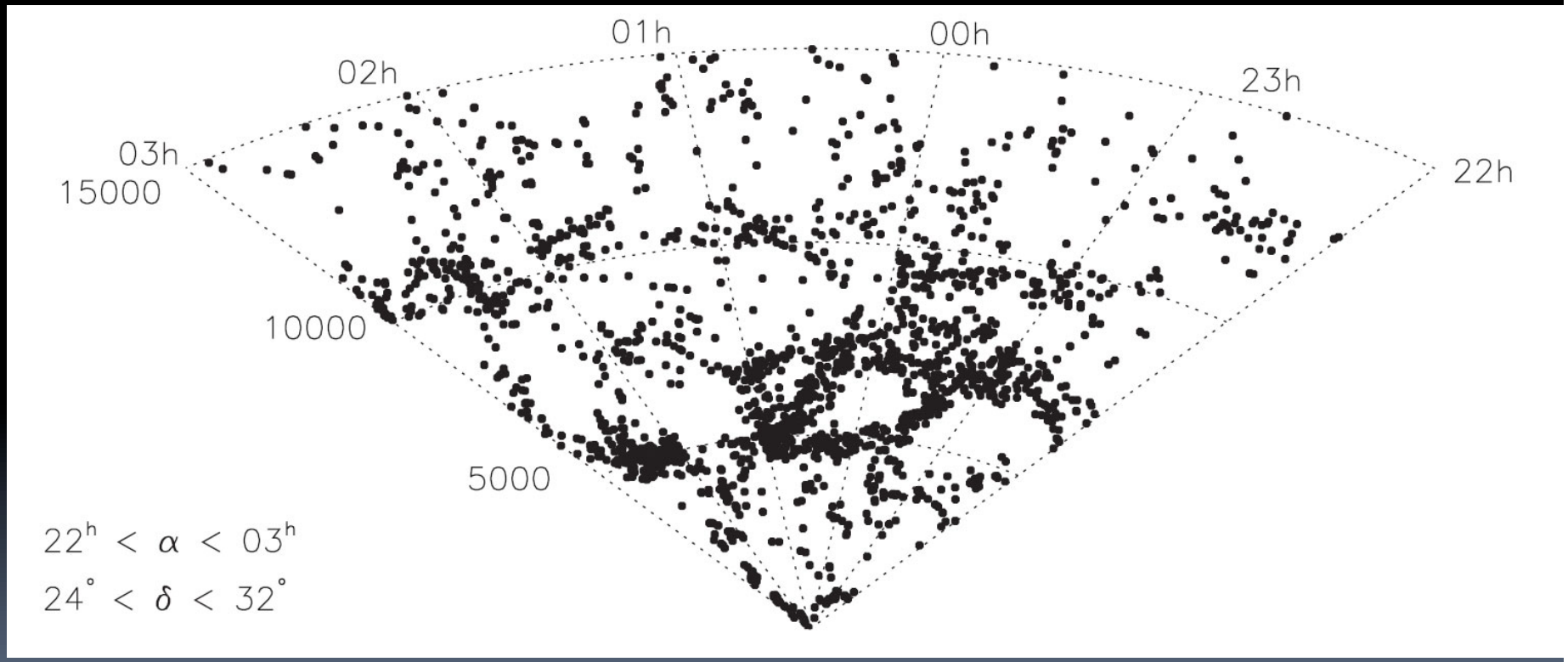
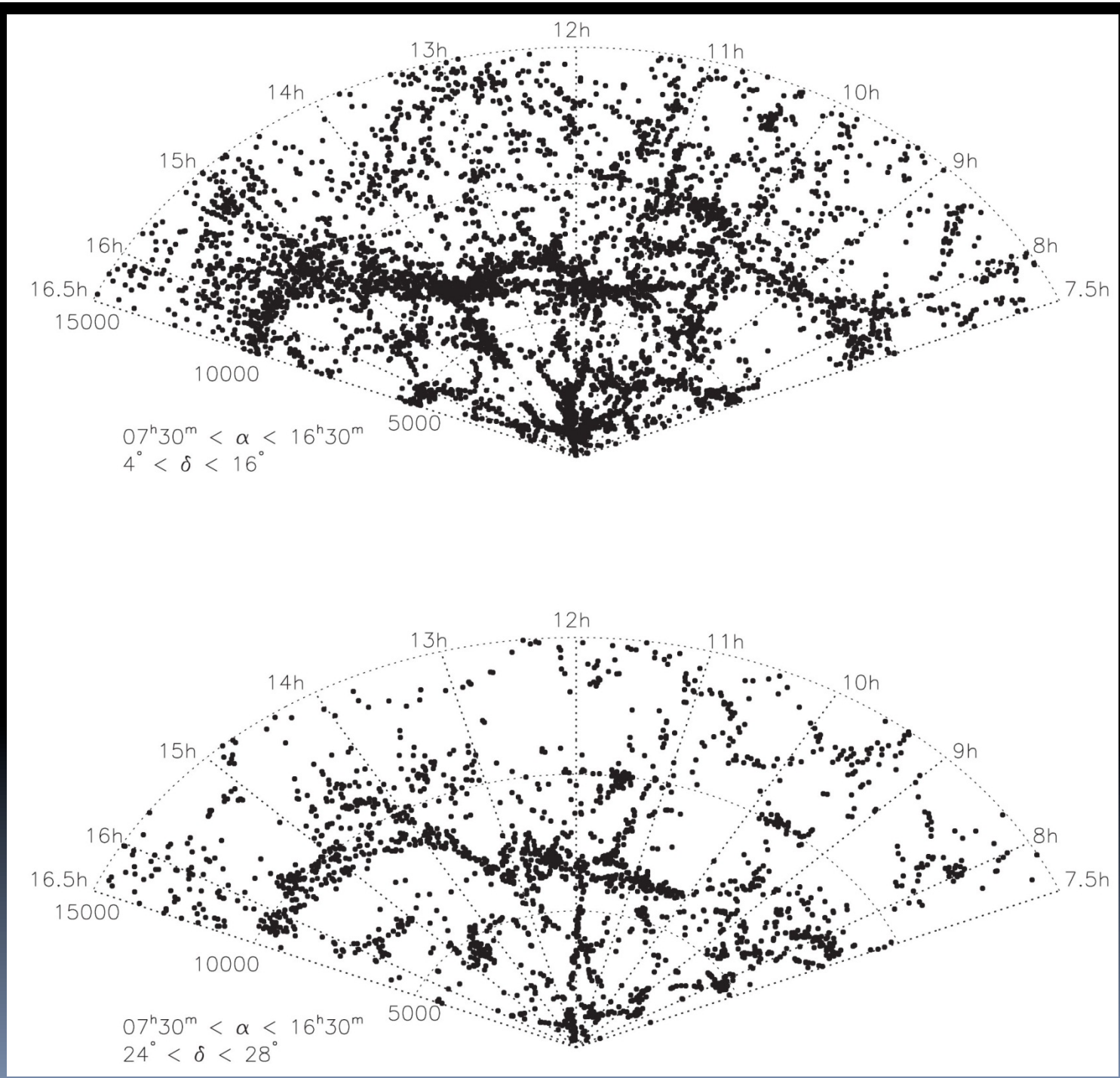


ALFALFA View of the Local Universe

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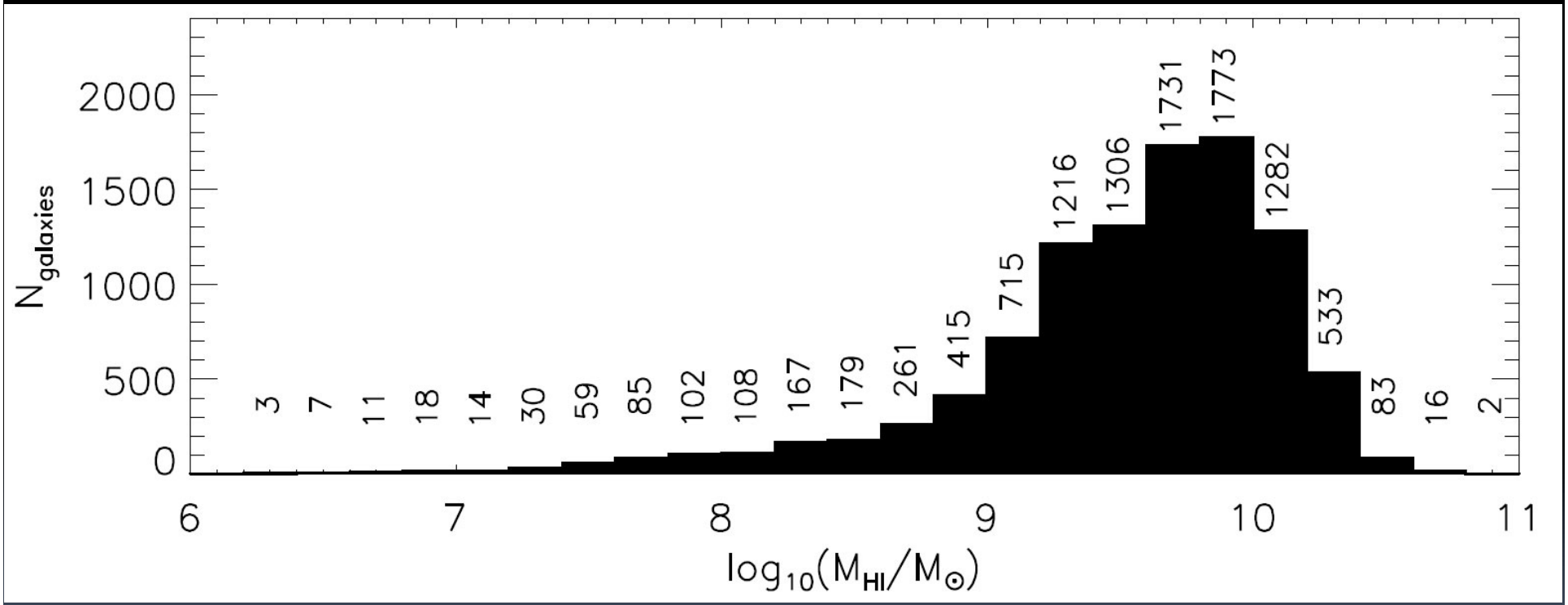
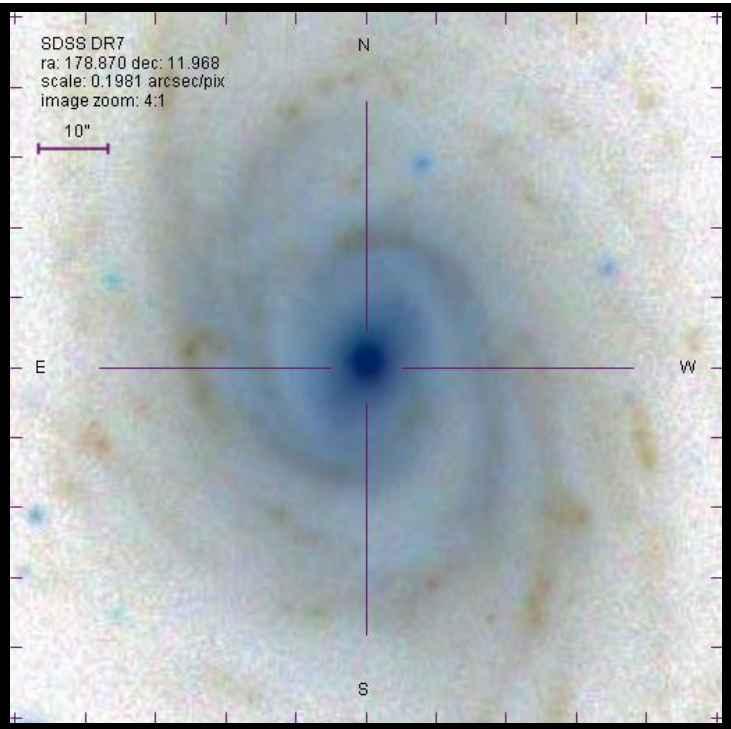
13h
11h
14h
10h
15h
9h
16h
8h
16.5h
7.5h
15000
10000
5000
$07^h30^m < \alpha < 16^h30^m$
$4^\circ < \delta < 16^\circ$
12h
13h
11h
14h
10h
15h
9h
16h
8h
16.5h
7.5h
15000
10000
5000
$07^h30^m < \alpha < 16^h30^m$
$24^\circ < \delta < 28^\circ$

ALFALFA View of the Local Universe

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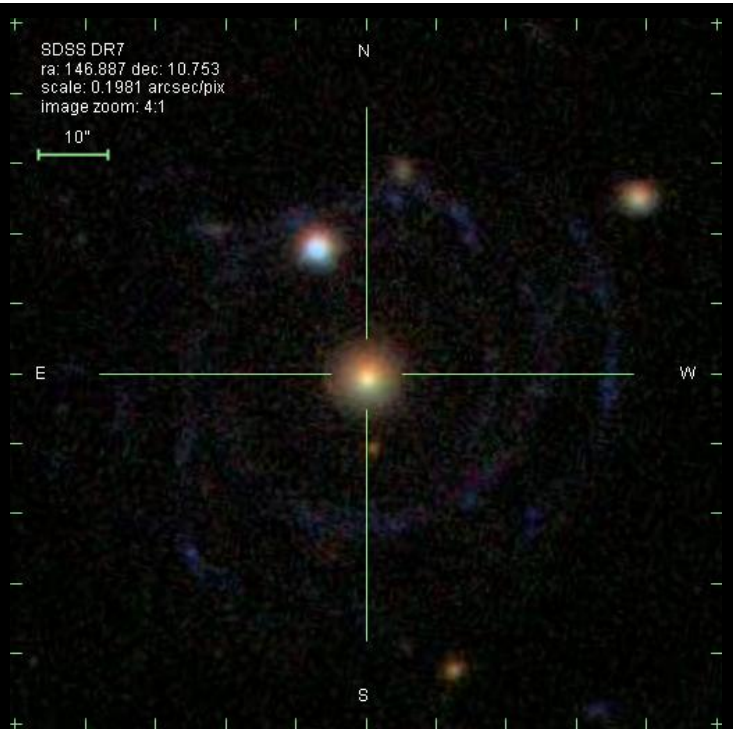
scale: 0.1981 arcsec/pix
image zoom: 4:1
10"
N
E
W
S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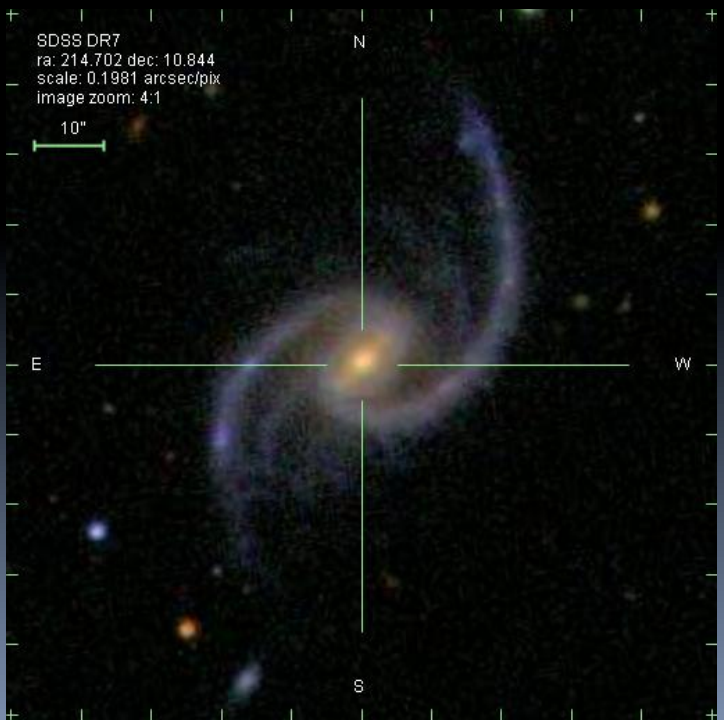
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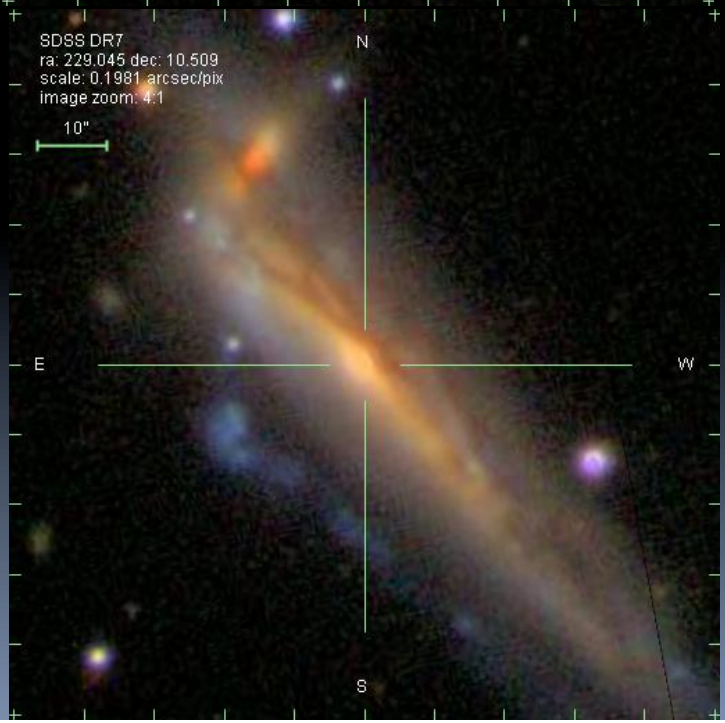
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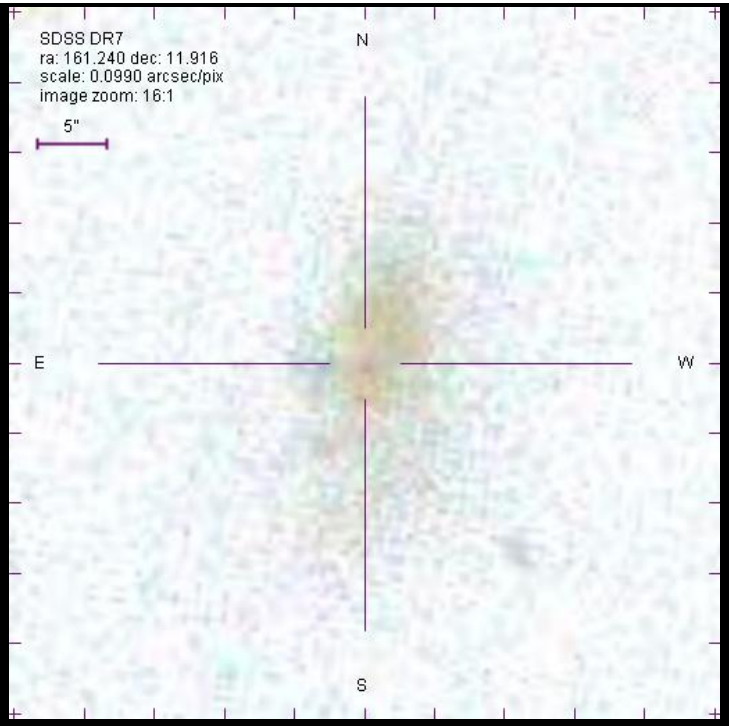
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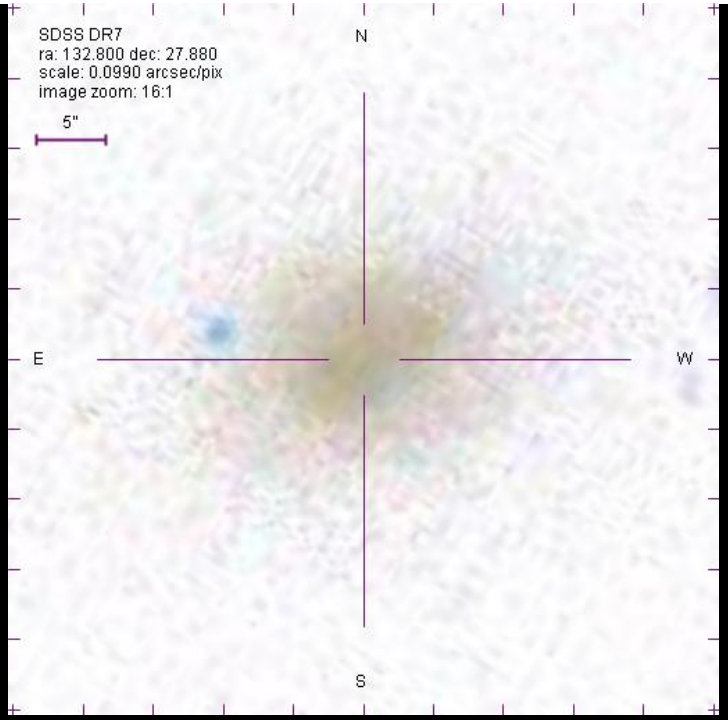
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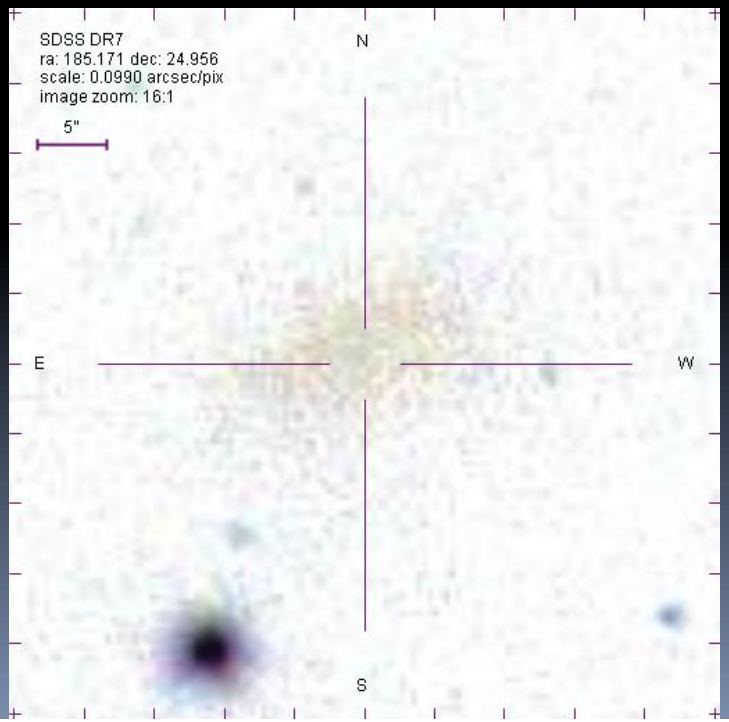
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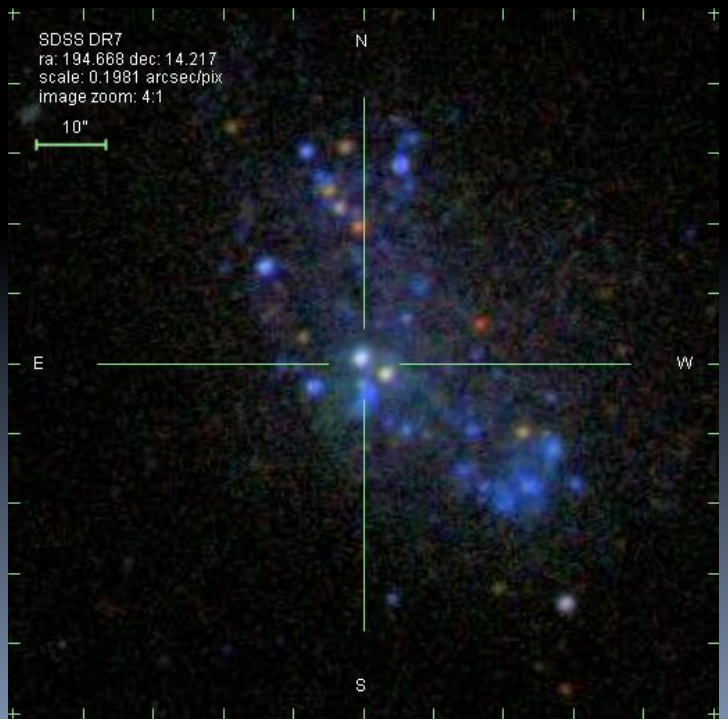
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