It's a Zoo Out There

Lauren Nicholson
CWRU Departments of Astronomy and Physics

Excerpts from previous presentations

Outline

- Part 1: Review of Sloan Digital Sky Survey and the Galaxy Zoo Project
- Part 2: Putting it all together
- Part 3: Extragalactic Road-trip
- Conclusions, Acknowledgements

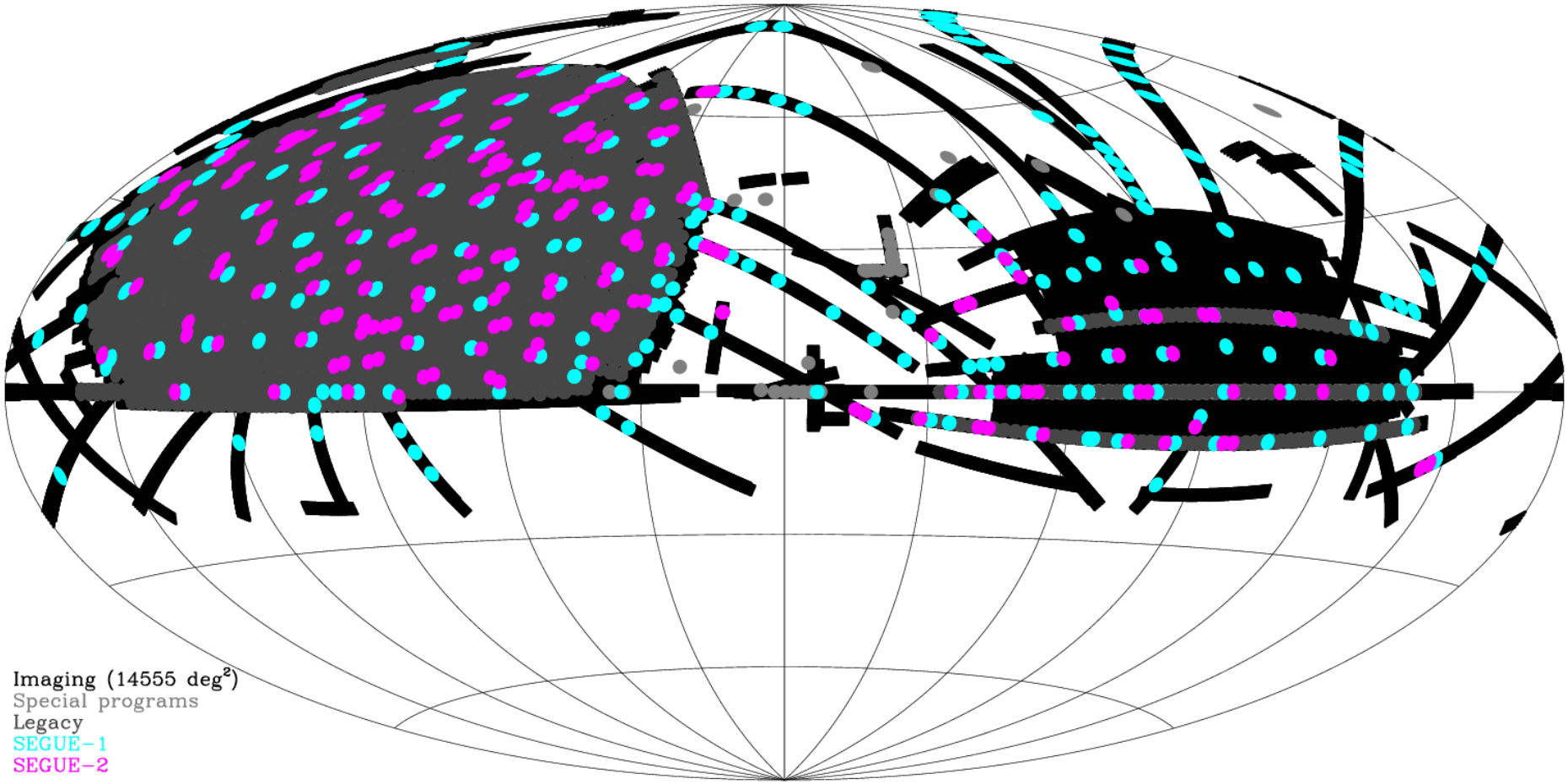
Part 1

The Sloan Digital Sky Survey (SDSS) and Galaxy Zoo (GZ)

When you have too many galaxies…

- Before SDSS, there had never been a problem Then in the first few years:
  - Sloan Legacy: 230 million objects
  - SEGUE: 240,000 objects
  - SNe: ~500 Type 1A Supernovae

- Currently on SDSSIV (2014-?), DR12
  - Largest color image of the sky ever completed
  - Over 1 billion objects
  - Contains images, optical spectra, infrared spectra, and catalog data


Imaging (14555 deg²)
Special programs
Legacy
SEGUE−1
SEGUE−2

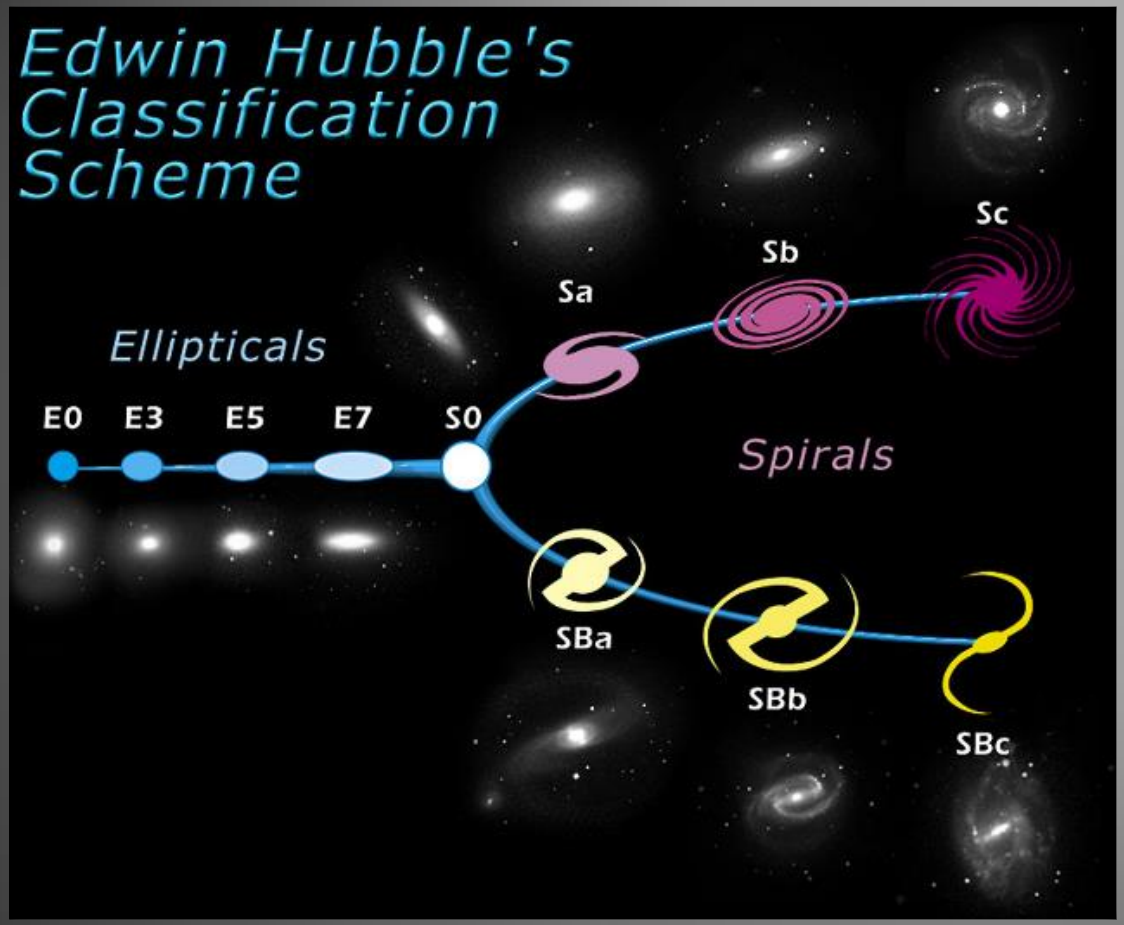
So “Galaxy Zoo” was invented

- Galaxyzoo.org
- SDSS images hosted online, anyone can register and help classify the objects
- Over 50 million classifications in the first year
- On its 4th version, with the data and results from the first three available to SDSS members

Normal spiral, red spiral, and elliptical

SDSS

Galaxyzoo.org



The Hubble classification system »

http://www.spacetelescope.org/images/heic9902o/

The Spitzer Infrared Nearby Galaxies Survey (SINGS) Hubble Tuning-Fork

The Spitzer Space Telescope observed 75 galaxies as part of its SINGS (Spitzer Infrared Nearby Galaxies Survey) Legacy Program. The galaxies are presented here in a Hubble Tuning-Fork diagram, which groups galaxies according to the morphology of their nuclei and spiral arms. The designation of these galaxies and their placement in the diagram is based on their visible-light appearance. The main goal of the SINGS program is to characterize the infrared properties of a wide range of galaxy types. The images of the galaxies are composites created from data taken by IRAC (the Infrared Array Camera) at 3.6 and 8.0 μm, and MIPS (the Multiband Imaging Photometer for Spitzer) at 24 μm.

The infrared range probed by these and other observations taken for the SINGS project allows for the detailed study of star formation, dust emission, and the distribution of stars in each galaxy. Light from old stars appears as blue in the images, while the lumpy knots of green and red light are produced by dust clouds surrounding newly born stars. The elliptical galaxies on the left are almost entirely made of old stars, while spiral galaxies like our own Milky Way are rich in young stars and the raw materials for future star formation.

More information can be found at:
http://sings.stsci.edu/

Unbarred Spirals

Weak Bulge

Strong Bulge

Intermediate Spirals

Strong Bulge

Ellipticals

Irregulars

Weak Bulge

Barred Spirals

Poster and composite images created from SINGS observations by Karl D. Gordon (Oct 2007)
Blue=IRAC 3.6μm (stars)
Green=IRAC 8μm
(aromatic features from dust grains/molecules)
Red=MIPS 24μm (warm dust)

SPITZER SPACE TELESCOPE

SINGS Team

Robert Kennicutt, Jr. (Principle Investigator), Daniela Calzetti (Deputy Principle Investigator), Charles Engelbracht (Technical Contact), Lee Armus, George Bendo, Caroline Bot, Brent Buckalew, John Cannon, Daniel Dale, Bruce Draine, Karl Gordon, Albert Grauer, David Hollenbach, Tom Jarrett, Lisa Kewley, Claus Leitherer, Aigen Li, Sangeeta Malhotra, Martin Meyer, John Moustakas, Eric Murphy, Michael Regan, George Rieke, Marcia Rieke, Helene Roussel, Kartik Sheth, J.D. Smith, Michele Thornley, Fabian Walter & George Helou

Background

- Edwin Hubble (1926), Classification of Extra-Galactic Nebulae
- Telescopes improve, start to find these “middle” S0s.
- Gunn and Gott (1972), Dressler et al (1980 and 1997):
  - Presumed to be caused by a spiral being disrupted by other galaxies as it enters and moves within a cluster

S0s

- Display the characteristics of both spirals and ellipticals
- Transition in which stellar formation was shut down by an outside force?
- Models not effective, mechanism for formation still strongly debated
- Several attempts have been made to study them (Barr et al and Moran et al 2007), but exceptionally difficult to find

Enter SDSS

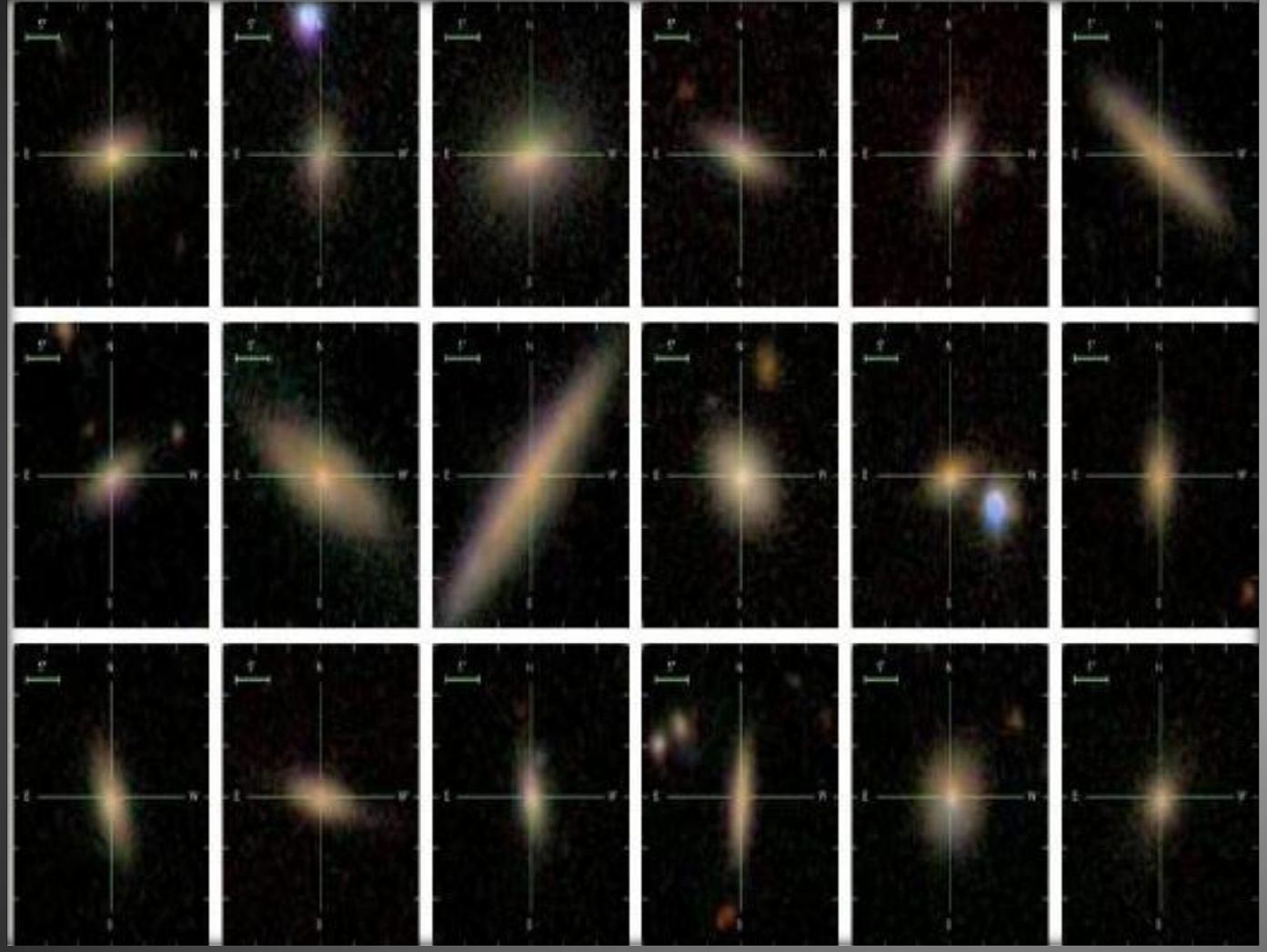
- An extensive sample just became probable instead of impossible.
- For a large sample of galaxies containing all classifications, there is normally a strong, monochromatic relation between increased clustering and increased luminosity

- Within the DR7 data, noticed something odd
  - $-17 > r\_Mag > -19$ had higher-than-predicted clustering
  - These dim galaxies are more clustered than their brighter counterparts on small scales

- Hogg et al (2003) found that there was a tendency for faint red galaxies to be found in dense clusters
- Zehavi et al (2005 and 2011) and Berlind et al (2005) elaborated upon that with their conclusions that these SDSS galaxies represent the recent accretion of satellites into massive halos that results in truncated star formation and do represent a transitory phase
- Russ et al 2010 disagrees

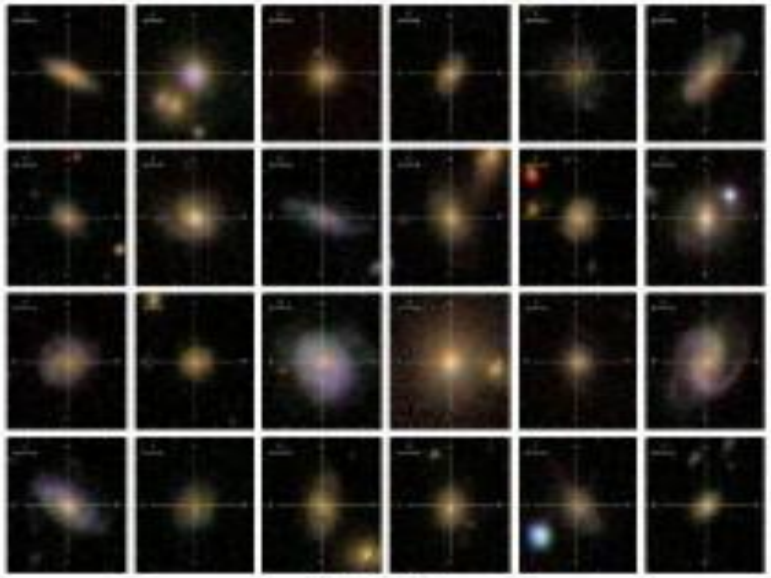
Part 2

Using Galaxy Zoo Results for our SDSS galaxies

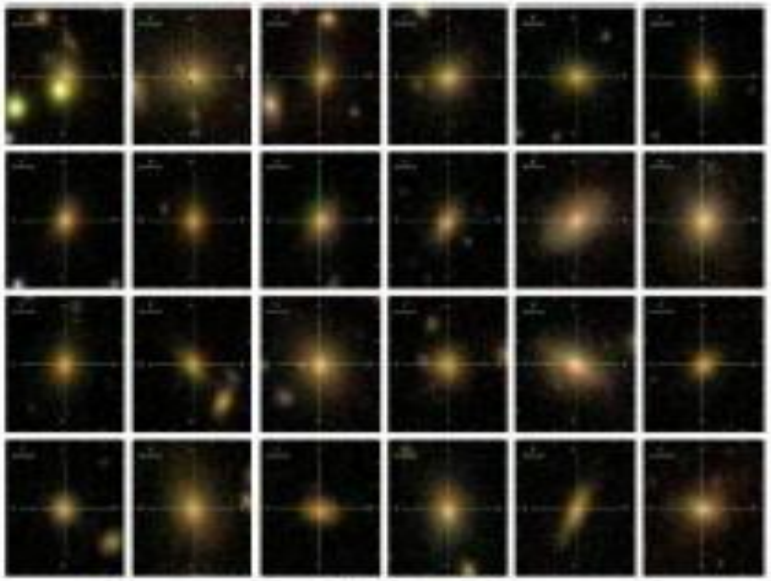


Fuzzy Red Blobs

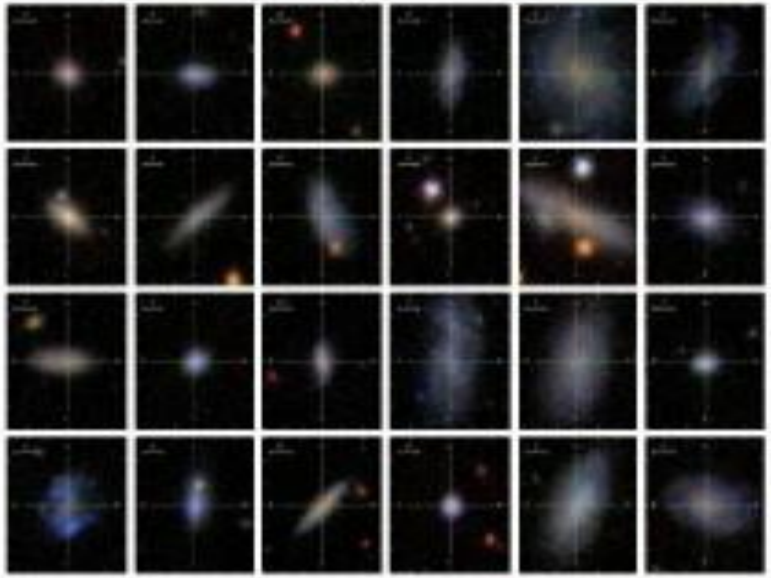
Janoweicki and Zehavi, 2011



Bright Blue



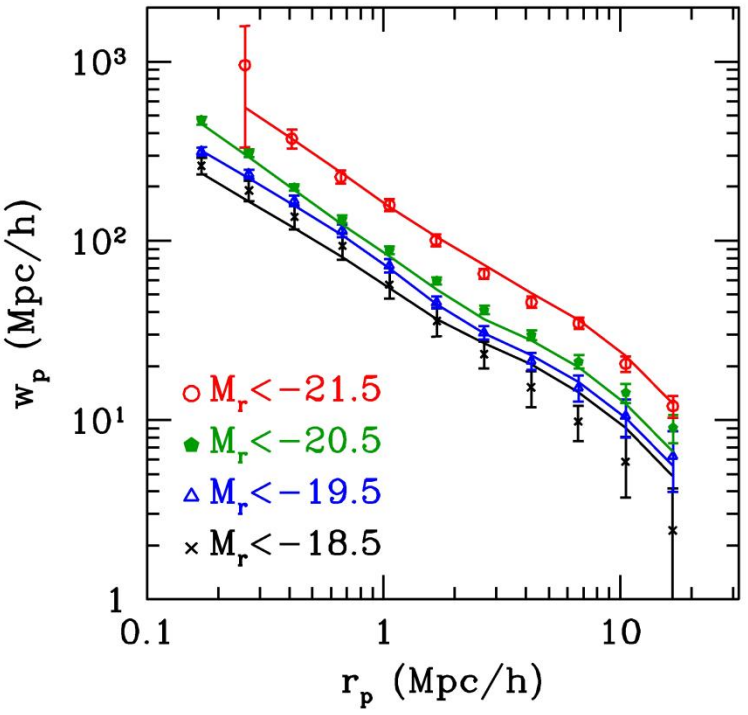
Bright Red



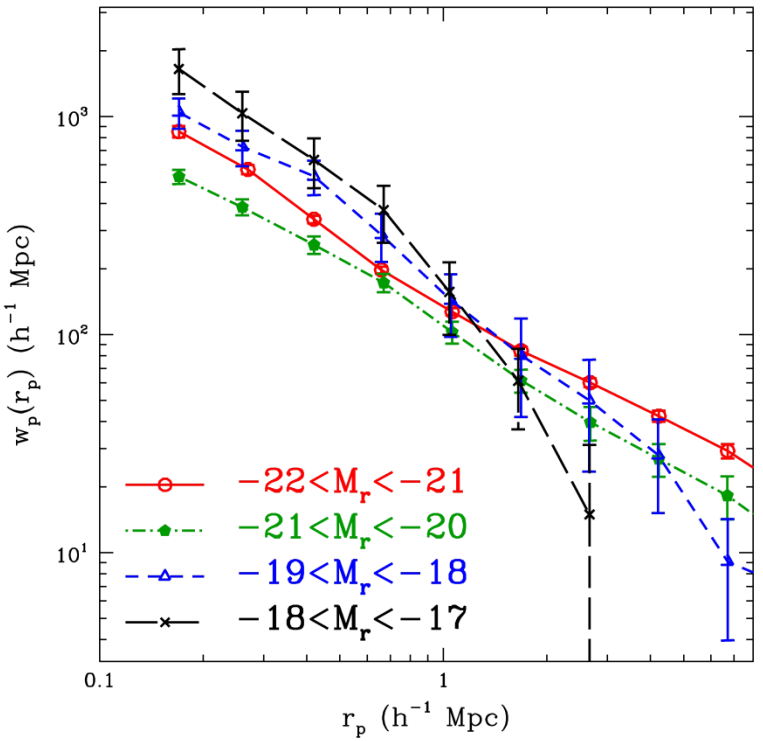
Dim Blue

Dim Red

Clustering as a function of separation between galaxies



From Zehavi et al 2011, showing the observed clustering correlation function vs the scale of separation for the entire sample of galaxies separated by magnitude.



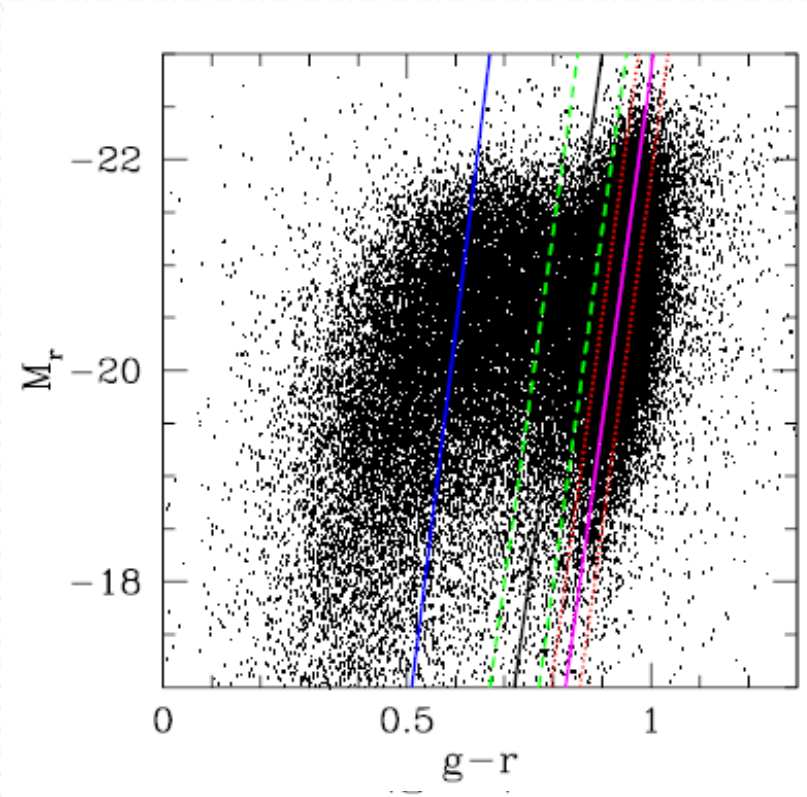
From Zehavi et al 2011, showing the observed clustering correlation function vs the scale of separation for only the red galaxies of the sample.

My Part: Datamining and Analysis

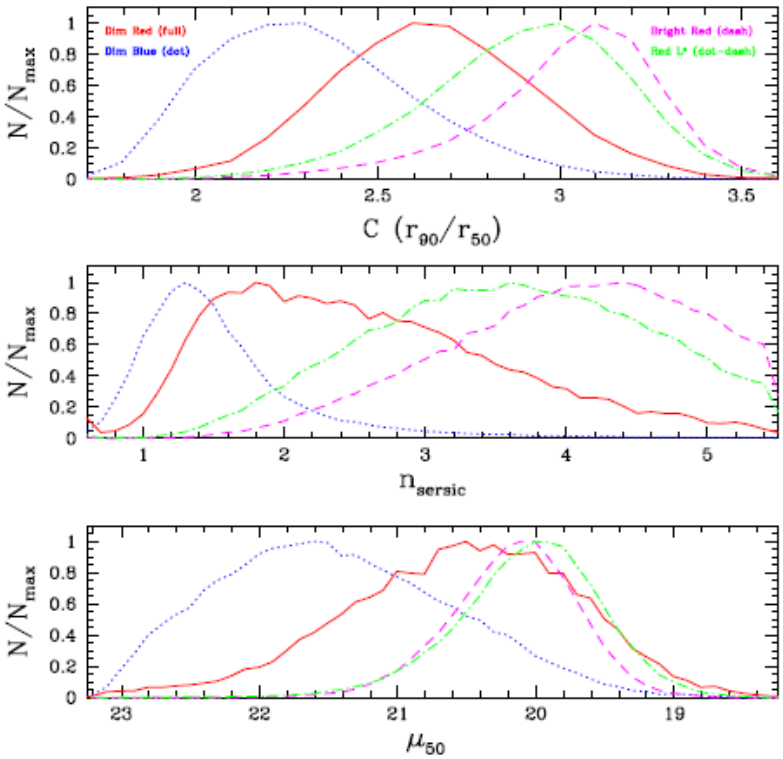
- Using the newly-released statistics from the Galaxy Zoo programs, I hoped to learn more about the group of dim red galaxies found in the SDSS data.
- Once the morphologies and the properties noted by the participants are joined with their spectra and observed SDSS properties, I analyzed them relative to the other categories of galaxies

- Properties that GZ users classified:
  - Smooth or featured
  - Spiral Arms
    - Number, how tightly wound
  - Bulge
    - Size, Shape
  - Edge-on
  - “Weird” features
  - Uncertainty in how to classify, etc

SDSS Physical Properties

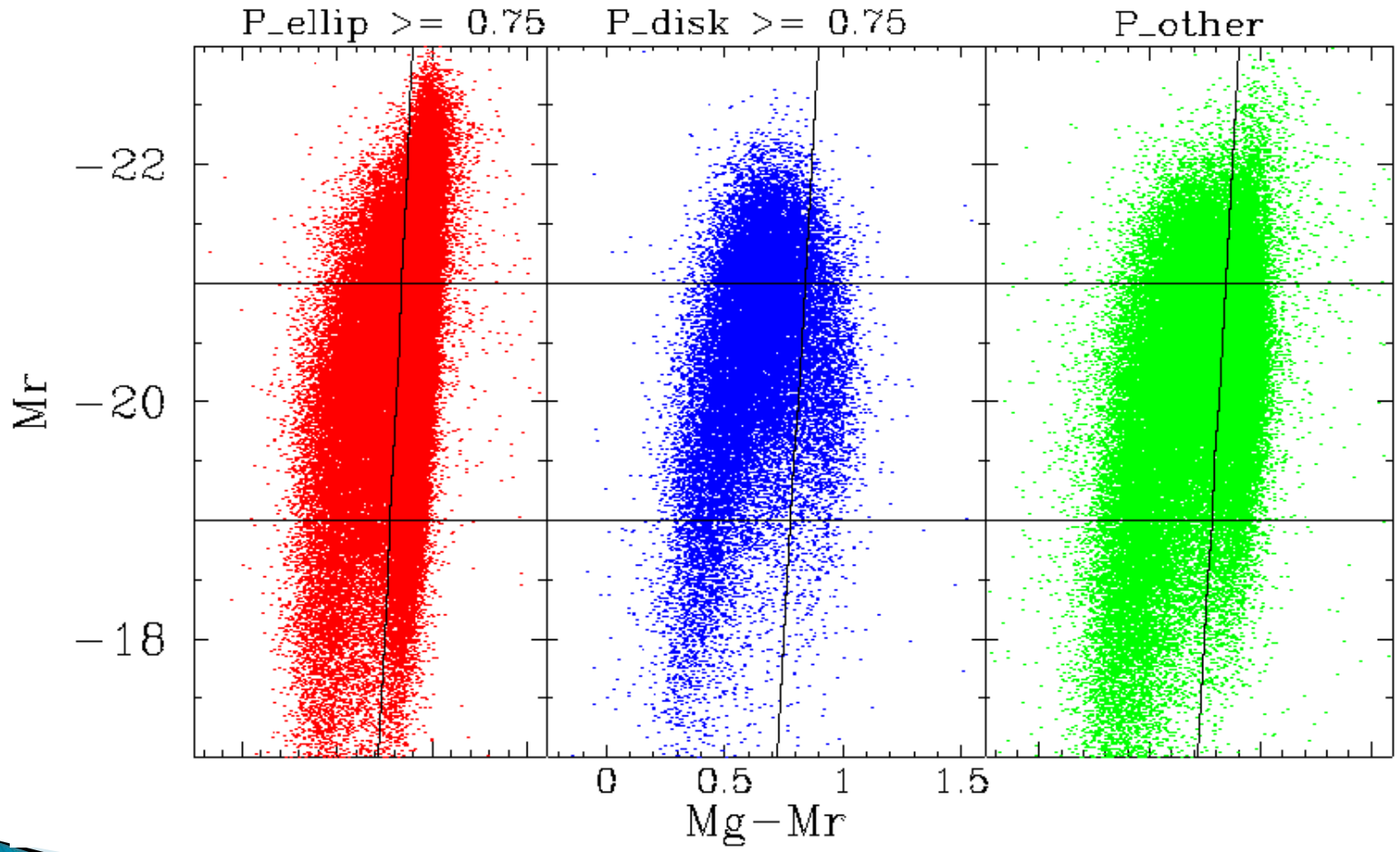


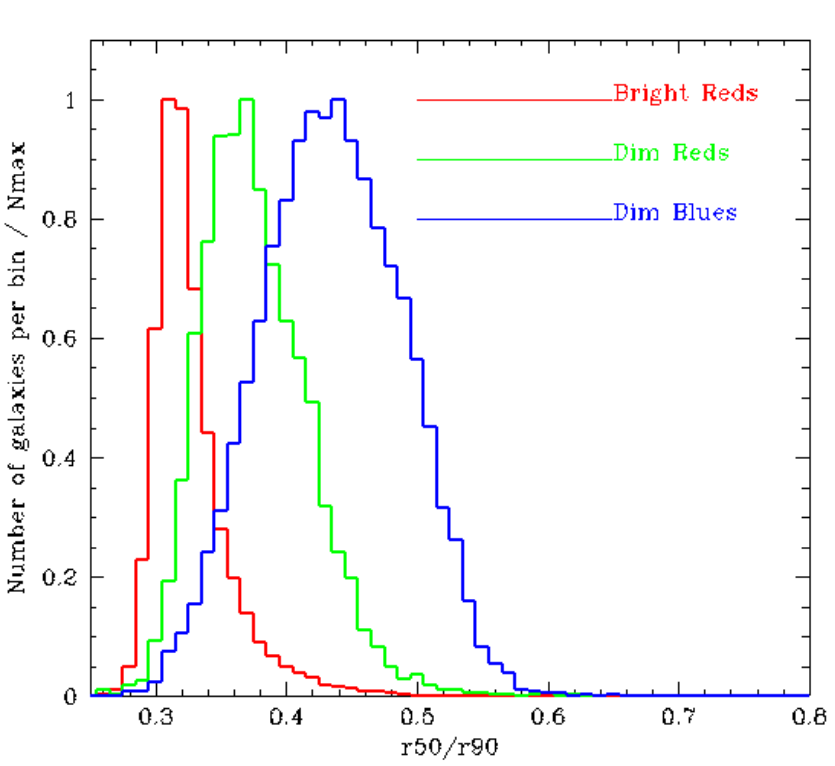
Color-Magnitude Diagram of SDSS sample



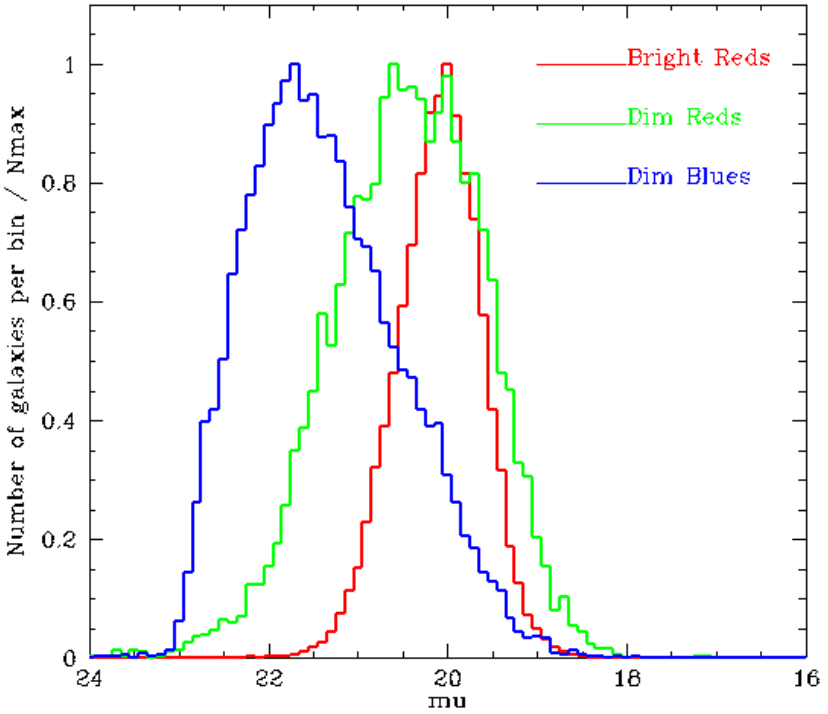
Bottom panel: Distribution of surface brightness for our dim red (red line), dim blue (blue line), Bright red (magenta) and red L (green) samples. Middle panel: Distribution of Sersic index for the same samples. Top panel: Concentration distribution of galaxy's b/a radii .*

Results

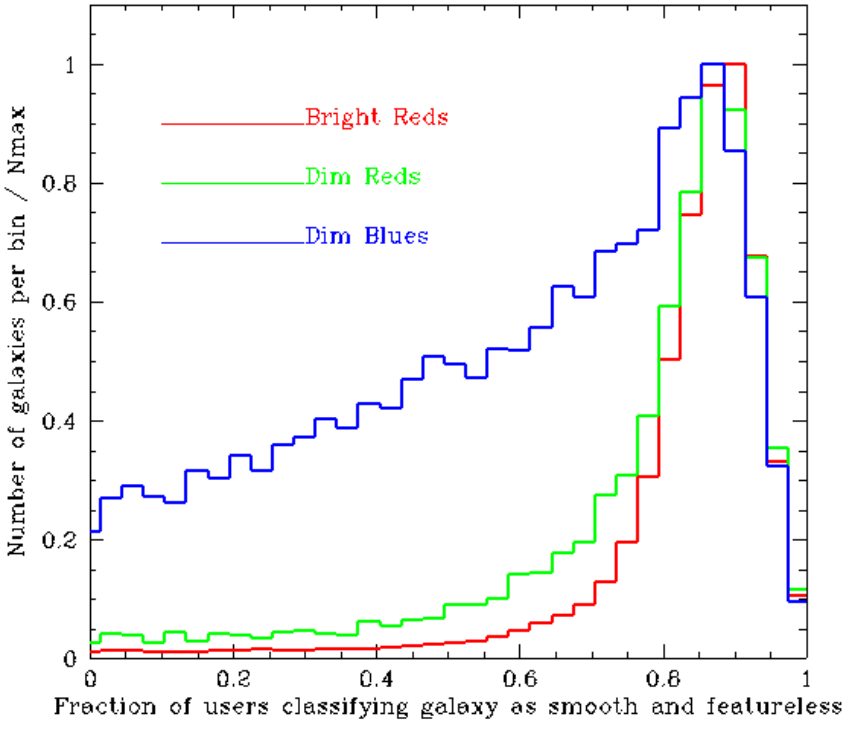


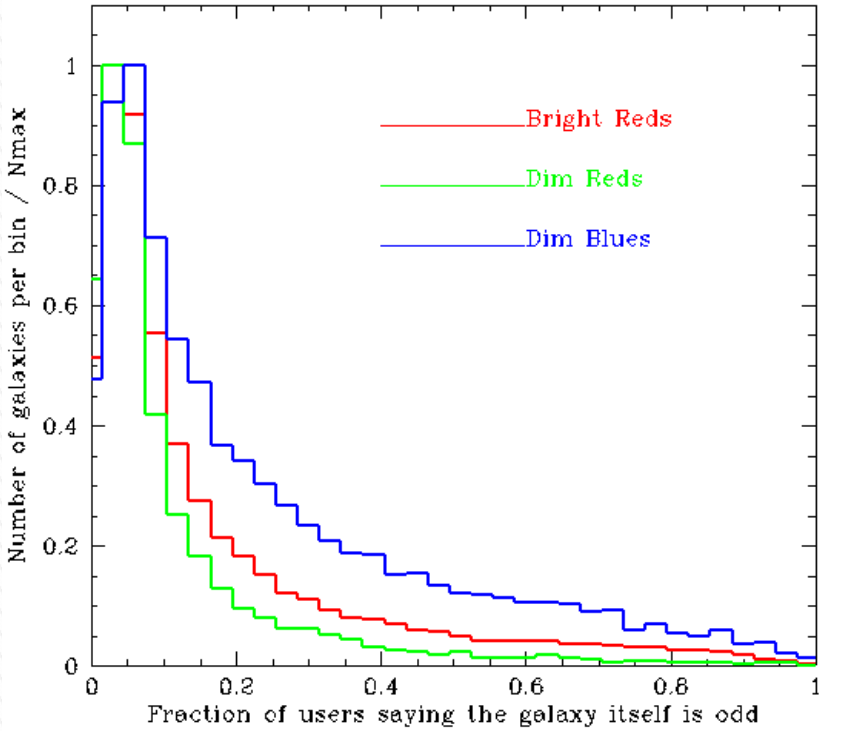


Distribution of the ratio of radii enclosing 50% and 90% of the light for each of the populations



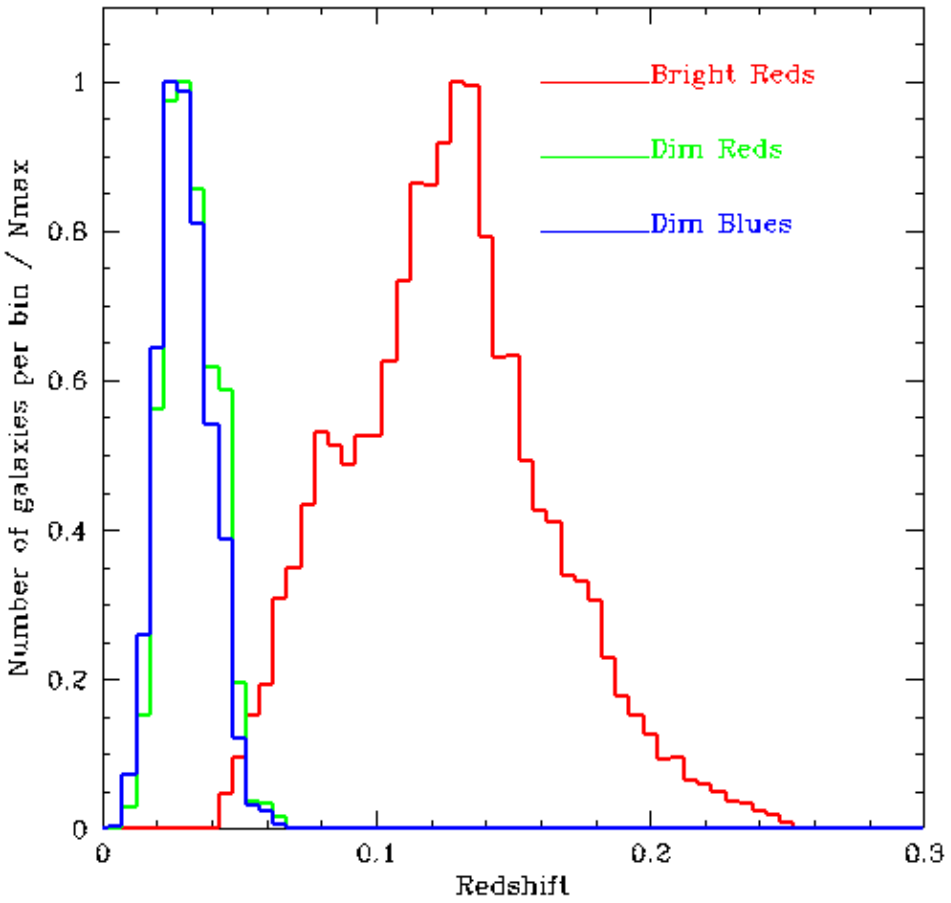
Distribution of surface brightness mu{50} for each of the populations





Fraction of users saying the galaxy is smooth and featureless (elliptical)

Fraction of users saying there is something odd or they are otherwise unable to classify the galaxy

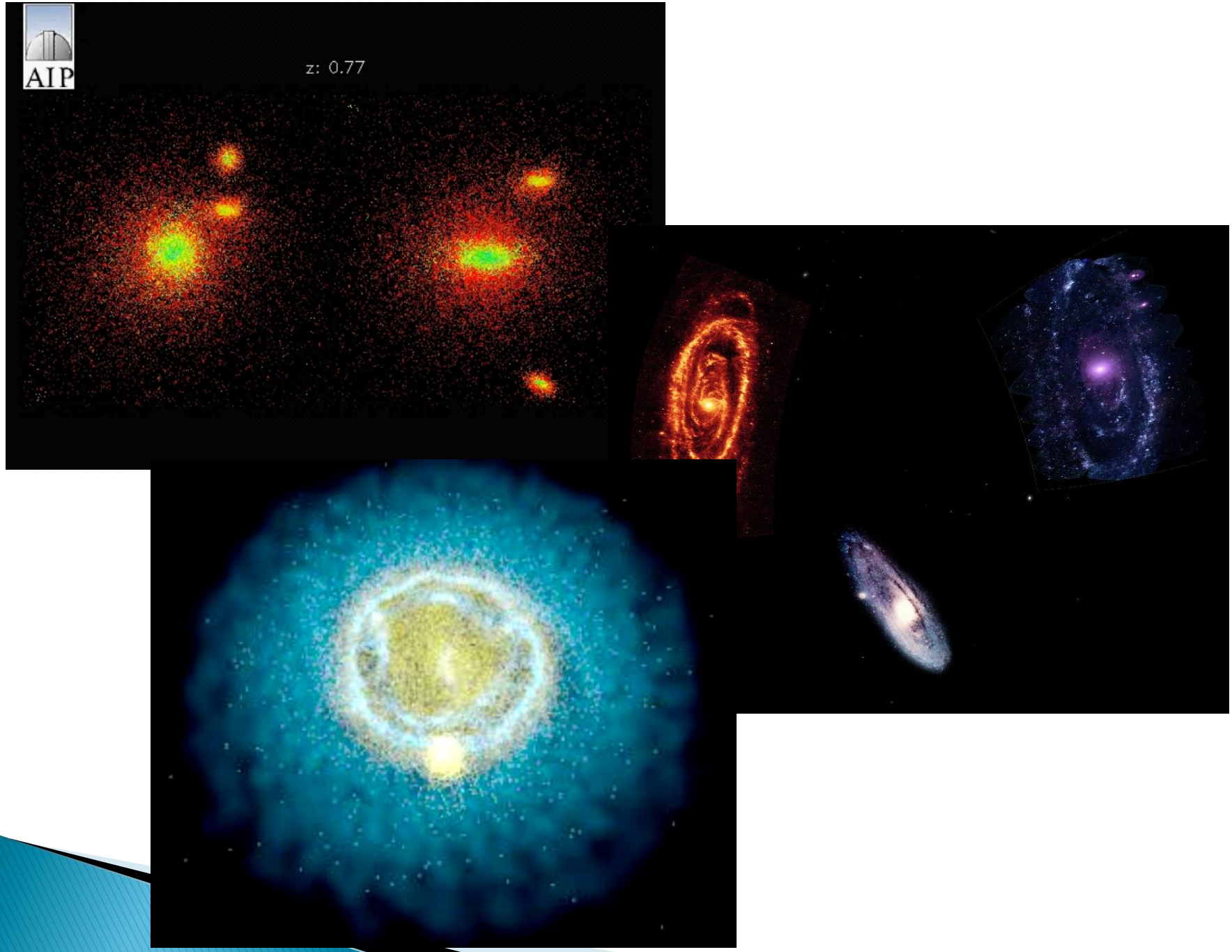

Bright Reds
Dim Reds
Dim Blues
Number of galaxies per bin / Nmax
Redshift
0
0.2
0.4
0.6
0.8
1
0
0.1
0.2
0.3

Conclusions

- We know these galaxies have intermediate features, but they are being lumped into the elliptical bin
- The classification results might be skewed in favor of elliptical classifications, due to the public's inexperience with the system and features becoming much harder to discern in faint galaxies.
- While we can say more about our sample after this, more work is necessary to determine whether anything meaningful can be extracted even with the skewed classifications

Part 3

Taking Galaxy Zoo Public


AIP
z: 0.77

Available to Everyone

- Sdss.org
- Go to: Data, Datasets
- What would you like to try? Some suggestions:
  - Navigate
  - Criteria SQL search
  - Casjobs – for the whole shebang! Must create an account in order to access
- SQL search and Casjobs both require inputs using Structured Query Language. Tutorials are available on the website.

Try an Example – Cluster 1689

- SQL:

```
SELECT
ra, dec, z, dered_g, dered_r

FROM dr12.SpecPhotoAll
INTO mydb.cluster1689

WHERE (
  (z <= 0.25)
    AND (z >= 0.16)
    AND (ra >= 196.5)
    AND (ra <= 198.5)
  AND (dec <= 5.9)
    AND (dec >= 5.5)
)
```

Try an Example – Cluster 1689

- One of your 23 results will have
  - RA: 198.05678
  - Dec: 5.778229

  - Pop those in Navigate, you can see image of cluster and it will take you to information about that individual galaxy as well.

Another Example

- RA: 114.932625
- Dec: 37.983145

- In Navigate, what does it look like?
- Go to Quick View, classification type is missing but redshift is 2!
- Go to Explore, and the spectra is included and it is correctly classified as a quasar.

» Questions?

Acknowledgements

- Adviser: Idit Zehavi
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- Building on previous work by Steven Janoweicki (CWRU 2006)

References

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