Observational Astronomy II - Suggested Final Project Schemas
ASTR 412 - Spring 2017

1. Exploring Quasars Across Cosmic Time

Background / Motivation:

Due to their extreme luminosities, quasars can be observed from great distances and provide a tool for mapping structure in the early/distant universe. Unfortunately, quasars can be difficult to find in the first place, since in imaging surveys quasars are often hard to distinguish from stars; both quasars and stars appear as point sources and can have similar colors and magnitudes. In regions of color-space where quasar identification is particularly difficult, other indicators, such as optical variability and/or radio emission, can help us to pick them out from the much more numerous stars.

Spectroscopic follow-up is always required in order to definitively identify a quasar and determine its redshift. Quasar spectra are distinguished by their strong and broad emission lines (produced by the energetic accretion disk). At different redshifts, these emission lines fall in different photometric filter ranges, causing quasar colors to be redshift-dependent. This results in color selection of quasars becoming more difficult (and their targeting less efficient) at certain redshifts.

Suggested Project Objectives:

- Explore ways of identifying quasars in color imaging surveys
  - For different ranges in redshift, visualize the colors of quasars in comparison to stars in the Milky Way.
    - Recommended magnitude range: $14 < r < 19$
    - Recommended color-color axes: (g-r) vs. (u-g)
- Explore the spectra of quasars, and how the appearance of quasar spectra change with increasing redshift, brightness, spectral slope, or radio emission
- Examine the redshift distribution of SDSS quasars, and explore whether the shape may be correlated with the color-dependent target selection.
- Explore where quasars with broad absorption lines are found in color-magnitude space

Resources:

SDSS spectral line table for galaxies and quasars:
http://classic.sdss.org/dr6/algorithms/linestable.html

The SDSS DR7 quasar catalog:
http://www.astroml.org/user_guide/datasets.html#sdss-dr7-quasar-catalog

Comparing the colors of stars and quasars:
http://www.astroml.org/examples/datasets/plot_sdss_galaxy_colors.html

The color-selection of quasars from the SDSS Legacy survey:
http://adsabs.harvard.edu/abs/2002AJ....123.2945R
http://www.sdss.org/dr12/algorithms/legacy_target_selection/#Quasars

Visualizing the SDSS imaging filter curves:
http://ogrisel.github.io/scikit-learn.org/sklearn-tutorial/auto_examples/tutorial/plot_sdss_filters.html

2. Galaxy Evolution: Bimodality and the "Green Valley"

Background / Motivation:

One of the first major results of the SDSS was the finding that galaxies in the modern universe fall into two primary regions in a color-magnitude diagram: a "blue cloud" of lower-luminosity blue spiral galaxies, and a "red sequence" of luminous, massive, old ellipticals. Astronomers have recently been examining how galaxies might evolve rapidly through the "green valley", the region in color-magnitude space separating the blue cloud and the red sequence.

Suggested Project Objectives:

- Use the SDSS spectroscopic galaxy sample to plot the color-magnitude distribution of galaxies with low redshift ($z<0.1$)
- Consider which magnitude measurements you've used. Does the distribution of galaxies in the color-magnitude diagram change if you use different types of magnitude measurements available in the SDSS database? If so, can you speculate why?
- Identify the two major populations of galaxies, defined by color and magnitude
- Does the color-magnitude distribution of galaxies evolve with redshift?
- The amplitude of the calcium (a.k.a. D4000) break in galaxy spectra is an indicator of galaxy age. Does this amplitude correlate with location in the color-magnitude diagram?
- Examine the galaxies that fall in the "green valley"; Is there anything particular about their morphologies (shapes) or spectra of these galaxies, compared to their counterparts in the blue cloud or red sequence?

Suggested Resources:

The color bimodality of galaxies in SDSS
http://adsabs.harvard.edu/abs/2001AJ....122.1861S

http://www.galaxyzooforum.org/index.php?topic=1923.0

The color bimodality of galaxies at higher redshift:
https://arxiv.org/abs/0910.2227

Origins of the galaxy bimodality
http://www.physics.utah.edu/~vdbosch/SC09.pdf

3. Clustering and the environmental-dependence of galaxy properties

Background / Motivation:

Over the past 13.7 Billion years gravity has shaped the Universe into a vast cosmic web. One of the primary aims of the Sloan Digital Sky Survey was to map out the shape of the nearby cosmic web. The survey also set out to explore the ways in which different types of galaxies cluster on large scales, and whether galaxy properties may be related to their environments.

Suggested Project Objectives:

- Make a "pie-slice" diagram of galaxy clustering in the SDSS, and experiment with other ways of visualizing the large-scale structure of the Universe, using SDSS observations
- Explore various methods of measuring structure in the Universe
- Quantify the clustering of galaxies in the SDSS
- Explore the relationship between galaxy color and clustering
- Investigate how a galaxy's environment relates to its other properties (e.g., color, shape, mass, star formation rate)

Suggested Resources:

An introduction to galaxy clusters, superclusters, and voids in the Universe:
http://skyserver.sdss.org/dr1/en/astro/structures/structures.asp
http://skyserver.sdss.org/dr1/en/astro/cosmology/cosmology.asp

Descriptions and tools for measuring large-scale clustering:
http://voyages.sdss.org/wp-content/uploads/2015/08/BAO_activity-2015.pdf
http://www.astroml.org/book_figures/chapter6/fig_correlation_function.html
http://www.astroml.org/user_guide/correlation_functions.html

Selecting a random subset of the SDSS data:
http://www.sdss.org/dr12/tutorials/random/

Catalogs of galaxies, according to their environment (isolated, paired, clustered):
http://www.aanda.org/articles/aa/full_html/2015/06/aa26016-15/aa26016-15.html