

Astro 512

Extragalactic Astronomy

During this quarter, you will become an expert in an extragalactic topic of your choice. You will do so by:

- Carrying out a sustained program in reading the academic literature, including older foundational papers in the literature and newer papers on astro-ph.
- Reproducing a calculation from a theoretical paper on your topic, as one of your assignments later in the quarter
- Writing a research justification for an accepted space-observatory program with a public abstract that addresses a current issue in your chosen field, as one of your assignments later in the quarter. In other words, re-engineer a compelling proposal about a project that already exists.

At a minimum of once every two weeks, you should get together with me to discuss the papers you've been reading, and possible choices about other directions to explore. If the reading is proving challenging, feel free to drop by more often, and if you're in a good rhythm and getting a lot out of your reading, feel free to stay at a once every 2 week pace.

Tips for Learning to Read Articles

Professional scientists read the literature consistently, but only a fraction of their reading involves reading an entire paper from beginning to end. Instead, as researchers gain knowledge, they are better able to dive in and out of papers, gathering the knowledge that is most of use to them, and being selective about which papers to devote more attention.

As a junior scientist, this pattern of reading is more difficult, because you likely haven't yet mastered enough of the vocabulary and techniques to immediately see the landscape and isolate what is new to you, because often *everything* is new to you. The first papers you read on your topic will probably be a slog, because of the large amount of new information. By the end of the quarter, however, you will likely be finding that it's much easier to skim introductions and some subsections, because you'll already be familiar with some of the arguments, techniques, and referenced literature. You'll be able to "read" more papers, more easily.

The links below offer some useful tips for how to approach reading papers. There is no right way other than "what works for you", but hopefully some of these could help you find that right way.

<https://astrobites.org/2011/04/19/journal-articles-in-astronomy/>

<https://www.sciencemag.org/careers/2016/03/how-seriously-read-scientific-paper>

<https://www.elsevier.com/connect/infographic-how-to-read-a-scientific-paper>

A Non-Exhaustive List of Possible Specialization Topics

Before you embark on your choice of topics, you may want to search astro-ph for papers with “Astro2020” in the title. These are white papers that people have submitted to the Decadal Survey, discussing their aspirations for the future of the field. Some of the papers will be quite narrow, but others will discuss some of the larger themes they see for future research. Skimming a few of these white papers may either excite or dim your level of interest in a particular topic. Feel free to discuss your choice with me if you are having a hard time deciding on a direction.

The Internal Properties of Galaxies

- Dust in galaxies
- Stellar populations in galaxies
- Cold gas in galaxies
- Star formation in galaxies
- Bulges of spiral galaxies
- Extraplanar gas in disk galaxies
- Models of the formation of disk galaxies
- Models of the formation of elliptical galaxies
- Chemical enrichment of galaxies

The Galaxy Population

- The distribution of galaxy properties (luminosity function, surface brightnesses, etc) at $z = 0$ and through cosmic time
- The structural parameters of disk galaxies
- Differences between satellite and central galaxies
- Bars in galaxies
- The origin of the color bimodality in galaxies
- The metallicity of galaxies
- The fundamental plane of elliptical galaxies
- The Tully-Fisher relation
- Properties of central black holes (correlations with galaxy properties, evolution with z)
- The mass evolution of galaxies and their halos

Special Galaxies

- Ultra-luminous starburst galaxies (ULIRGs)
- Compact “red-nugget” galaxies
- The origin of ultra-faint and dSph galaxies
- Low surface brightness (LSB) galaxies

Galaxy Evolution

- High redshift galaxies
- The star formation rate over cosmic time
- The evolution of the galaxy merging rate
- The buildup of the red sequence of elliptical galaxies

- Large-scale winds & outflows from galaxies
- Circumgalactic gas
- How do galaxies get their gas?

Groups & Clusters of Galaxies

- Hot X-ray emitting gas in clusters of galaxies
- Galaxy groups
- The dependence of galaxy populations on environment
- Cluster gravitational lensing
- Evolution of galaxy clusters

Active Galaxies & Their Absorption Lines

- AGN-driven winds
- Models of AGN
- The evolution of QSO's
- The Lyman-alpha forest
- Damped-Lyman alpha absorbers

Cosmology

- Quantifying large scale structure
- The value of the Hubble Constant (i.e. the extragalactic distance scale)
- Reionization of the universe
- Density profiles of dark matter halos
- The overabundance of low mass galaxies in CDM