Physics 224 **Origin and Evolution of the Universe** Spring 2014

Examples of Term Projects

These examples are just meant as suggestions to get you started thinking about a term project, to be presented as an oral report during the Final Exam week. Projects will all start with reading some relevant papers, but might include – or lead to – some original research. A few term projects in previous years have led to published papers. Please do some further thinking about your project, and plan to meet with me soon to discuss it further. I'll try to help you choose a topic and find suitable articles to get you started.

Examples of topics to summarize from the literature:

- Clues to the nature of dark matter from small scale issues: cusps, satellites, …
- Dwarf galaxies, and the galaxy luminosity function
- Tidal streams and implications, including shapes of dark matter halos
- Feedback effects in galaxy formation
- Outflows from galaxies
- Black holes in galactic centers – origins, correlations, and effects

Alternatives to the Standard ΛCDM Ω_m=0.3 Cosmology, for example

- Warm Dark Matter, Interacting Dark Matter, Decay-product Dark Matter
- Modified Newtonian Dynamics (MOND) and other alternatives to GR

Big bang nucleosynthesis and implications of possible ^{7}Li and ^{6}Li discrepancies

How to test Eternal Inflation theory, multiverses, or string/brane cosmology

Primordial black hole formation in the early universe and observational implications

CMB polarization measurements and implications for the nature of Cosmic Inflation

Redshift Surveys and Implications –

- Broad Redshift Surveys: SDSS, Dark Energy Survey, and SkyMapper
- Deep Redshift Surveys, such as DEEP, COSMOS, etc.

Structure of ΛCDM Dark Matter Halos (might involve analyzing simulations)

- Smallest scale CDM fluctuations and "boost" factor in WIMP annihilation
- Centers of dark halos – implications of observations for dark matter
- Phase-space properties of substructure
- Halo shapes – triaxiality, velocity anisotropy, radial dependence, implications
- Angular momentum distribution
- Formation of the Local Group in the standard ΛCDM cosmology

Constraints on Cosmology from Weak and Strong Gravitational Lensing

Detection of WIMP Dark Matter
- Cryogenic Detectors (e.g. CDMS, EDELWEISS, CRESST)
- Liquid Noble Gas Detectors (e.g., LUX, Xenon1000, Panda-X)
- Directional Detectors, Dependence on Halo Shape and **v**-Distribution
- Are Dark Matter Caustics Important? (Sikivie vs. Moore)
- Indirect Detection, e.g. of dark matter annihilation in galaxy centers
  - using Atmospheric Cherenkov Telescopes, Fermi, IceCube
- Using DarkSUSY www.physto.se/~edsjo/darksusy or MicrOMEGAS
  - lappweb.in2p3.fr/lapth/micromegas/ WIMP particle astrophysics software

Semi-Analytic Modeling of galaxy formation – e.g.
- Formation and evolution of low-mass galaxies, origin of scaling relations
- Understanding the growing data on damped Lyman alpha systems
- Formation and evolution of massive galaxies
- Extremely Red Objects
- Understanding the origin of galaxy color bimodality

Hydrodynamic simulations of galaxy formation and evolution
- Formation of galaxies
- The first stars
- "Dark Stars" and possible effects of dark matter annihilation on the first stars
- The first quasars
- Formation of galactic spheroids: mergers vs. disk instabilities
- Evolution of galaxy populations
- Correlations of galaxies and of galaxy properties

Applying galaxy morphology statistics
- Parametric galaxy morphology statistics – e.g., radius, axis ratio, Sersic index
- Nonparametric galaxy morphology statistics – e.g., Gini/M_{20}, shapelets
- Comparing galaxy simulations (e.g., AGORA) and observational data sets
- Correlations with other galaxy properties

Extragalactic Background Light and implications, including Spitzer & Herschel data
- EBL lower limits by integrating the luminosity function
- EBL upper limits and detections from gamma rays
- To what extent is the 850 micron EBL accounted for by known sources?

How to determine the nature of dark energy
- Figures of merit for current and proposed dark energy experiments
- Satellite experiments, including Euclid and WFIRST