Galaxy Evolution with LSST

The key goal of the LSST Galaxies Working Group is to measure the multivariate properties of the galaxy population including trends with redshift and environment. This includes observed galaxy properties (luminosities, colors, sizes, and morphologies) as well as derived galaxy properties (stellar masses, ages, and star formation rates) and how the joint distribution of these galaxy properties depends on redshift and environment as measured on a wide range of scales. Galaxy formation is inherently stochastic, but is fundamentally governed by the statistical properties of the underlying dark-matter density field. Determining how the evolving multivariate galaxy properties and scaling relations depend on this density field, and on the distribution and evolution of dark matter halos, will connect the results of large surveys to theoretical models of structure formation and galaxy evolution.

Galaxy Statistics: LSST Volume, Limits, Numbers

- full-depth LSST 5σ point source detection limits
- >10^7 galaxies detected to z ~ 6
- 10^8 galaxies detected at z ~ 2
- structural measurements and ugrizy photometry for 4x10^7 galaxies at z < 1.5
- dwarf galaxies detected to 4 Mpc at M_V ~ -14; to 128 Mpc at M_V ~ -14
- L* galaxies (M_z ~ -21) detected to z ~5 over 10^13 Mpc^3 co-moving volume (Fig. 1)
- deep drilling fields’ will be ~10x deeper than standard LSST over ~10 LSST pointings with 50 pc point source limits ugriz ~26.0, y ~26.6

Galaxies and their Dark Matter Halos

- Measuring the spatial clustering of dark matter halos hosting galaxies over wide range of cosmic time will allow us to trace the evolution of galaxy populations from one epoch to another by identifying their progenitor/descendent relationships.

Large Data Analysis Challenges and Multivariate Studies

- The vast amount of LSST data will require novel data analysis techniques. Key to galaxy studies will be:
  - Deblending: reconstructing galaxies when either well resolved or blended with other sources.
  - Multivariate analysis: constructing luminosity functions, n-point correlation functions, etc. and their dependence on environment and redshift (or, conversely, bias as a function of redshift and galaxy properties, see Fig. 4).
  - Cross-survey correlation: Combining LSST survey data, at least in limited areas such as the deep drilling fields, with radio, IR and X-ray surveys will allow improved determination of parameters such as star-formation rate, dust temperature and mass, and AGN accretion rate. X-ray data in particular will be important for determining the AGN fraction (and correspondingly helping to remove obscured AGN as a source of outliers in these analyses). The planned mission eRosita and proposed mission WFXT would detect ~10^3 and 10^4 normal galaxies and ~10^4 and 10^6 AGN, respectively. XMM-Newton and Chandra are spending an increasing fraction of their time on very large projects and surveying LSST deep drilling fields will likely be proposed and could reach detection limits corresponding to NGC 6240 (a ULIRG/merger with a binary AGN) at z ~ 2.

To address these challenges the LSST galaxies team will be proceeding by:
  - Analyzing mock catalogs from end-to-end simulations based on the Millenium galaxy simulation and models of the LSST telescope and operations (see Krughoff poster)
  - Consultation with the LSST Astroinformatics collaboration on the use of advanced statistical techniques, e.g., data mining techniques for dimensionality reduction and outlier detection/rejection, and the use of Virtual Observatory tools for cross-survey correlations (see Borne et al. poster).
  - After the start of operations, using deep drilling fields as a “primer” for the analysis of the shallower survey data
  - Community-based computing strategies, such as the “Galaxy Zoo” to allow the public to help classify sources and identify mergers and irregular galaxies that will be problematic for deblending algorithms.

References: