Stellar Populations and Nearby Galaxies with the LSST

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The LSST will produce a multi-color map and photometric object catalog of half the sky to r=27.6 (AB mag; 5-sigma). Time-space sampling of each field spanning ten years will allow variability, proper motion and parallax measurements for objects brighter than r=24.7. As part of providing an unprecedented map of the Galaxy, the accurate multi-band photometry will permit photometric parallaxes, chemical abundances and a handle on ages via colors at turn-off for main-sequence (MS) stars at all distances within the Galaxy as well as in the Magellanic Clouds, and dwarf satellites of the Milky Way. This will support comprehensive studies of star formation histories and chemical evolution for field stars. The structures of the Clouds and dwarf spheroidals will be traced with the MS stars, to equivalent surface densities fainter than 35 mag/square arc-second. With geometric parallax accuracy of 1 milli-arc-sec, comparable to HIPPARCOS but reaching more than 10 magnitudes fainter, a robust complete sample of solar neighborhood stars will be obtained. The LSST time sampling will identify and characterize variable stars of all types, from time scales of ~1 hr to several years, a feast for variable star astrophysics. The combination of wide coverage, multi-band photometry, time sampling and parallax taken together will address several key problems: e.g. fine tuning the extragalactic distance scale by examining properties of RR Lyraes and Cepheids as a function of parent populations, extending the faint end of the galaxy luminosity function by discovering them using star count density enhancements on degree scales, and identifying inter-galactic stars through nova and Long Period Variables.

Characteristics of Data from LSST:

- Depth of combined images in main survey:
- Depth of single epoch image:
- Attainable parallax over whole survey period:
- Attainable proper motion over whole survey period:
- Timescales sampled by cadence:
- Photometry:
  - Accuracy requirements:

Derivatives from Proper Motions and Parallaxes (HIPPARCOS accuracy to V ~ 25):

1) Complete sample of all objects as faint as hydrogen burning limit within 500pc
2) Proper motions commensurate with radial velocities throughout the Galaxy (20 kpc) for stars brighter that M_v ~ 8.
   a) Space velocities for stars with radial velocities - parsing populations kinematically, statistical parallaxes, etc.
   b) Two components of velocity vector for stars without radial velocities
3) Proper motions of stars in nearby galaxies, e.g. LMC, SMC, and systemic motions of dwarf spheroidals
4) Detection of low-mass binary companions from "wiggles" in proper motion
5) Cluster memberships and census of low mass "escaped" stars

The LSST limit for RR Lyrae: 400 Mpc

Examples of Unique Science Opportunities:

- Derivatives from Proper Motions and Parallaxes:
  - Photometric parallaxes for main sequence (MS) stars within Galaxy. For external systems (where individual stars are resolved and lend themselves to population analysis) distances derived from, independent methods, e.g. variable stars.
  - Wide spectral range (u' through Y) provides good handle on considering and extinction, both Galactic and within a target galaxy
  - Methods of deriving star formation histories (SFH) (the distribution of star formation rate as a function of time and chemical composition) from Hess diagrams given photometry and/or counts in 2 or more bands (and comparing with synthetic models) is adequately developed, e.g. Dolphin (2002).
  - For extragalactic systems and in the solar neighborhood, where distances are known to high precision and, the SFH can be derived using some select types of stars.
  - Multi-band photometry in the Magellanic Clouds will reach well into the main sequence, and will be identified with ease.
  - These stars are:
    - unbiased tracers of extended structure
    - color-magnitude diagrams (especially given u' passband) very effective for discovering chemical composition and age distributions

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- Derivatives from Time Sampling:
  - Detection and characterization of variable stars of all kinds. Especially good for serendipitously discovering rare, and perhaps currently unknown kinds of objects that vary, whether periodic, irregular, or transient.
  - Distribution of various classes of variables with structural components of the Milky Way.
  - Identify RR Lyraes to 400 kpc: delineate the stellar halo of the Galaxy, and trace it past the equi-potential surface with M31. Trace the stellar halos and tidal debris of the Magellanic Clouds.

- Find Cepheids in all galaxies with young stars out to 10 Mpc.
  - characterize any systematic variations with properties of parent population
  - Homogeneous (unprecedented) time sampled data for Long Period Variables

Survey 1000 square degrees around the LMC and SMC. Photometry (both magnitudes and multiple colors) identify main sequence stars related to these objects in their outer extremities.

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