Stellar Populations and Nearby Galaxies with the LSST

A. Saha (NOAO), K. Olsen (NOAO), D.G. Monet (USNO) and the LSST Stellar Populations Science Collaboration

The LSST will produce a multi-color map and photometric object catalog of half the sky to g~27.5 (5σ). Strategically cadenced time-space sampling of each field spanning ten years will allow variability, proper motion and parallax measurements for objects brighter than g~25. Accurate multi-band photometry will permit photometric parallaxes, chemical abundances and a handle on ages via colors at turn-off for main-sequence stars at all distances within the Galaxy, permitting a comprehensive study of star formation histories (SFH) and chemical evolution for field stars in the Galaxy. With a geometric parallax accuracy of 1 milli-arc-sec, the LSST will produce a robust complete sample of the solar neighborhood stars. While delivering parallax accuracy can stellar astrophysics. Cepheids, Miras and LPVs will be detected and measured in galaxies up to ~ 5 Mpc in chemical abundances and a handle

Data from LSST:

- Depth of combined images in main survey: g ~ 27.5 mag at 5σ
- Depth of single epoch image: g ~ 25.0 mag at 5σ
- 10 percent error at 1 mas
- Photometric parallax accuracy of 1 milli-arc-sec

Timescales sampled by cadence:
- 1 hr to several years
- Time sequences will be patterned to period aliasing given operational constraints

Photometry:
- Accuracy requirements:
  - 6 bands: u'g'r'i'z'Y
  - 0.005 mag relative to local objects
  - 0.01 mag over all sky on native system
  - 0.02 mag on Sloan u'g'r'i'z' system

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 parallax distances, 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 systematic 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 structure of the outer Milky Way (Ivezic et al. 2004). The number density multiplied by the cube of the galacticcentric radius for 523 BSSS candidate RR Lyrae stars within 10 kpc from the Sm dwarf tidal stream plane. The triangle marks the position of the Sm dwarf core. The clump at (X,Y) of (20,-35) and (-20,25) is definitely associated with the tidal stream, as is discernible from the distribution of 2MASS M giants (Majewski et al. 2003), shown as the white dots. Other clumps, while consistent with being part of the stream, could also be unrelated Super-Planckian fluctuations, such as those suggested by Bullock et al. (2001). LSST will extend such mapping to about 50 times larger volume.

Simulations of the stellar populations detectable by LSST within 100 pc of the Sun. Stars with parallax errors <5% and photometric errors < 0.1 magnitudes are plotted in this image representation of a color-magnitude diagram, where warm colors denote increasingly high densities of stars. The simulation draws from the Galactic disk star formation history of Bertelli & Nasi (2001), and the SFH is calibrated with the tidal stream, as is discernible from the distribution of 2MASS M giants (Majewski et al. 2003), shown as the white dots. Other clumps, while consistent with being part of the stream, could also be unrelated Super-Planckian fluctuations, such as those suggested by Bullock et al. (2001). LSST will extend such mapping to about 50 times larger volume.

Deep Synoptic Survey Telescope

References


- Rich et al. (2000), and the Baraffe et al. (2003) calculations using the Girardi et al. (2000) magnitudes for the 1.1x10^6 objects were calculated using the Girardi et al. (2000) standard luminosities, the white dwarf models of Fischer et al. (2000), and the Benneke et al. (2003) techniques for sub-stellar masses. It is assumed that all stars are uniformly distributed within the volume.

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. CMDs furnish ages and chemical compositions. Proper motions (to ~50 kms^-1 per star) reveal kinematic behavior: disk or halo or tidal stream? Photometric parallaxes (colors and magnitudes) show the stars from the Milky Way halo that are spatially interspersed with stars from the Clouds. Combined with proper motions, they reveal how these components have interacted. A more select search for metal poor and old stars in the extremities of the Clouds come from the discovery of RR Lyraes in this extended region of sky.

Examples of Unique Science Opportunities:

- Detect 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.
- Homegrown (unpredicted) time sampled data for Long Period Variables LPV/CEP
- Find Cepheids in all galaxies with young stars out to 10 Mpc.

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 deciphering chemical composition and age distributions.

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 star 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 independently, the 5σ band data can be used to self-consistently solve for extinction and SFH. This is more complicated if distances are not known independently, such objects within the Galaxy, but even then, along lines of sight with low extinction, the SFH can be derived using very select types of stars.

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