Large Synoptic Survey Telescope

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Stellar Population Science with LSST

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The LSST will produce a multi-color photometric catalog of half the sky to r=27.5 (AB mag; 5σ). Multi-epoch observations over the survey's ten year baseline will allow variability, proper motion and parallax measurements for objects brighter than r=24.5. These capabilities allow LSST to identify and characterize resolved stellar populations in unprecedented breadth and detail, enabling a more comprehensive and nuanced understanding of the star formation history of the Milky Way and nearby galaxies. We describe below only a brief selection of the stellar populations science LSST will enable; a more complete description is given in the Stellar Populations chapter of the recently published LSST science book.

The Milky Way White Dwarf Population

The SDSS has dramatically increased the known population of white dwarfs by over an order of magnitude (Eisenstein et al. 2006). This sample provided a more accurate white dwarf luminosity function for the Galactic disk (Harris et al. 2006), improved our knowledge of post-main sequence chemical evolution, and uncovered exotic systems such as highly magnetized white dwarfs. LSST's sensitivity and wide areal coverage, however, is expected to yield over 13 million white dwarfs with r < 24.5. LSST will completely sample the brightest white dwarfs in our Galaxy (with M_V~11) to beyond 20 kpc, and provide sensitivity to the thousands of dark halo white dwarfs predicted by MACHO results, identifying whether these stars represent an appreciable fraction of the Galactic dark matter (Alcock et al. 2000). LSST's photometry will also be more than three times as precise as SDSS photometry, particularly in the u band. Matching observed and predicted colors at the 1% level will enable completely photometric estimates of white dwarf temperatures, gravities, and spectral types (see Figure 1).

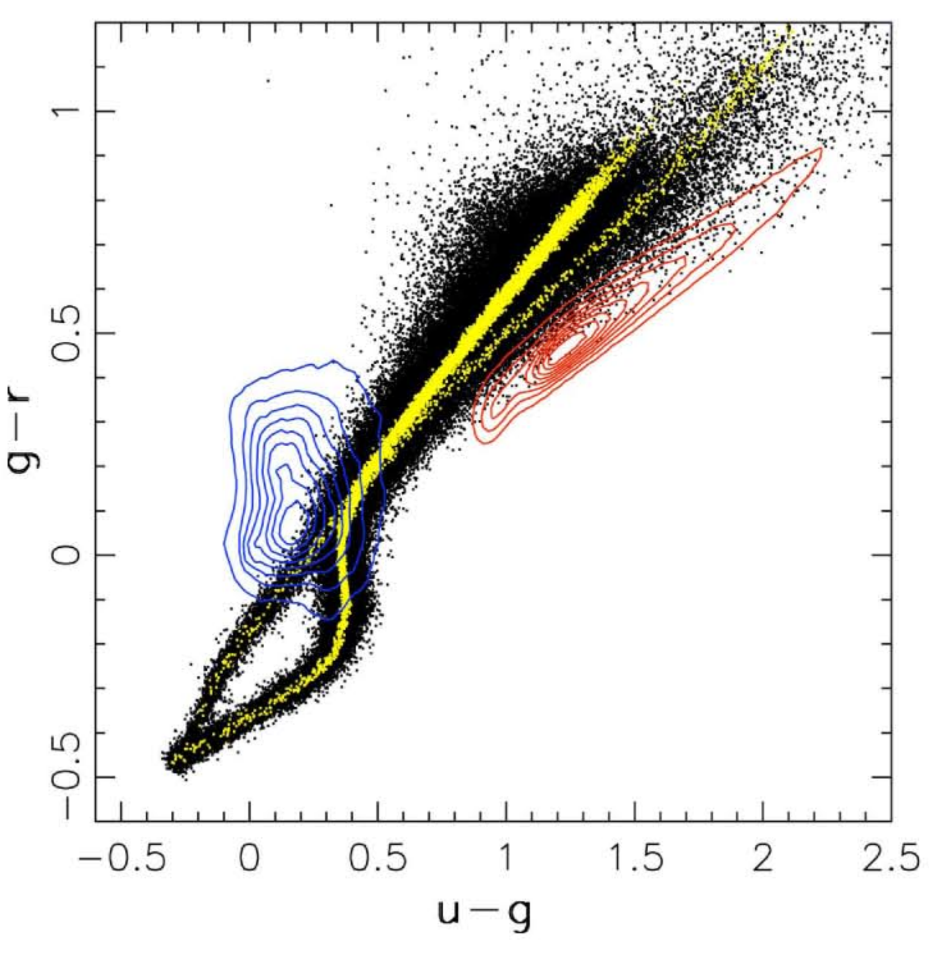


Figure 1 -- Simulated white dwarfs in $g - r$ vs. $u - g$ color-color space. Black points show objects with r < 24.5 and b > 60°. Yellow points show brighter sources for which LSST will provide 10σ or better trigonometric parallax measurements. The two sequences correspond to He and H white dwarfs. LSST photometry will be sufficiently accurate to separate hydrogen from helium white dwarfs, not only to separate white dwarfs from low-redshift quasars (z < 2.2; blue contours) and main sequence stars (mainly F and G stars; red contours).

Decoding the Star Formation History of the Milky Way via Gyrochronology

Over the past decade, calibrations of the mass–dependent relationship between stellar rotation and age have been derived (Barnes 2003; Meibom et al. 2008; Mamajek & Hillenbrand 2008). Kepler photometry will extend these `gyrochronology' relations to older and lower-mass stars in the near future. Measuring stellar rotation periods for numerous Milky Way field stars (see Figure 2), LSST will produce gyrochronology maps of the Galaxy's star formation history over the past 1-5 Gyrs. Simulations indicate that LSST will measure rotation periods of 250 Myr old solar analogs from 1-20 kpc, 5 Gyr old solar analogs from 1-8 kpc, and M dwarfs out to 500 pc.

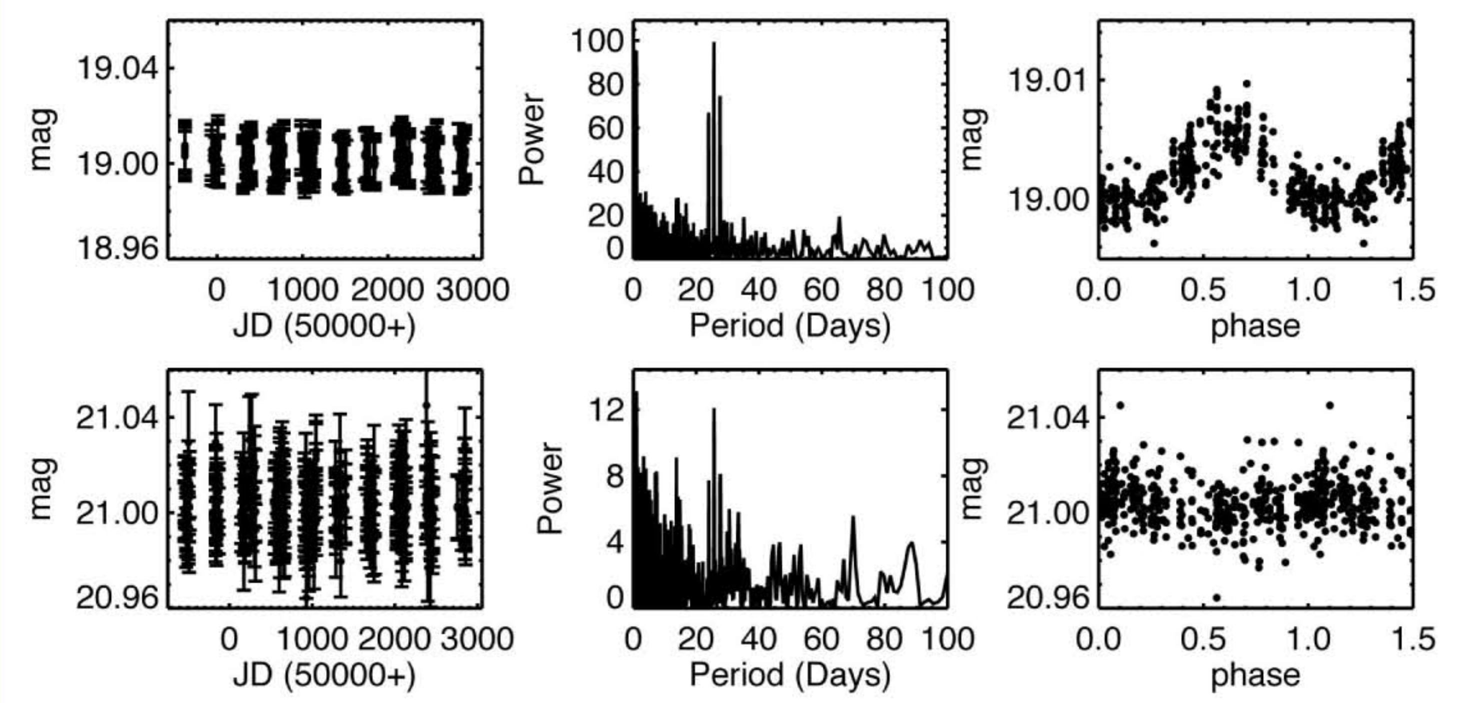


Figure 2 -- Unfolded simulated LSST light curves (*left*), Lomb-Scargle periodograms (*center*), and folded light curves (*right*) for a 2.5 Gyr K2 dwarf with r = 19 (*top row*) and 21 magnitudes (*bottom row*). The star's rotation period is easily recovered at the bright end; the efficiency decreases at the faint end, particularly for older stars with small amplitudes. If spots are long-lived, LSST can recover rotation periods for young (t < few Gyrs) G to early–M type stars with r < 21. Newer simulations are underway to determine how various LSST cadences could improve our sensitivity to short-lived star spots.

Star Formation Histories in the Local Group

Individual bright stars in nearby galaxies can be identified with ground-based observations and used to diagnose a galaxy's star formation history over the last 2-8 Gyrs (see Figure 3). Single epoch LSST images will resolve individual Red Giant Branch stars in galaxies within ~ 4 Mpc, while LSST's "stacked" photometry of Local Group galaxies will reach below the Horizontal Branch also allow the detection of RR Lyrae stars. This will give LSST a unique opportunity to (1) cover extended structures, and compare how populations change with location in the galaxies – important clues to how galaxies were formed, and (2) identify the brighter variables in each galaxy, such as RR Lyraes, Cepheids, and the brightest eclipsing binaries.

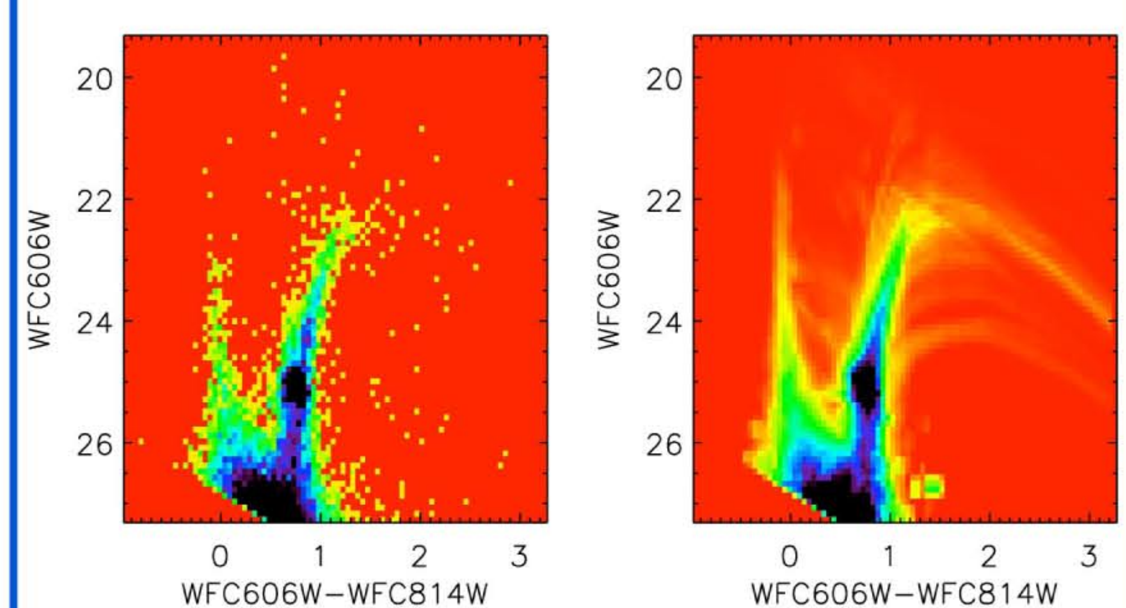


Figure 3 -- A CMD reaching depths comparable to that expected for LSST's co-added frames, from an archival Hubble Space Telescope Advanced Camera for Surveys field in M33. *Left*: The observed CMD. *Right*: The best-fitting model CMD using stellar evolution models.

A Systematic Survey of Star Clusters in the Southern Hemisphere

Despite their importance as stellar evolution laboratories and tracers of the Milky Way's star formation history, most rich star clusters have been relatively poorly surveyed due to the difficulty of observing targets at large distances or with large angular sizes. LSST will provide homogeneous, high quality photometry of all nearby star clusters in the southern hemisphere (where no survey of star clusters has ever been undertaken). The LSST footprint contains 419 currently known clusters; of these, 179 are within 1 kpc, and several are key benchmark clusters for testing stellar evolution models. Only 15 of the clusters in the LSST footprint, however, have more than 100 known members in the WEBDA database, demonstrating the relative paucity of information known about these objects. LSST's deep, homogeneous, wide-field photometry (comparable to that shown in Figure 4) will reveal new, previously unknown clusters and provide a more complete characterization of the properties and membership of known clusters.

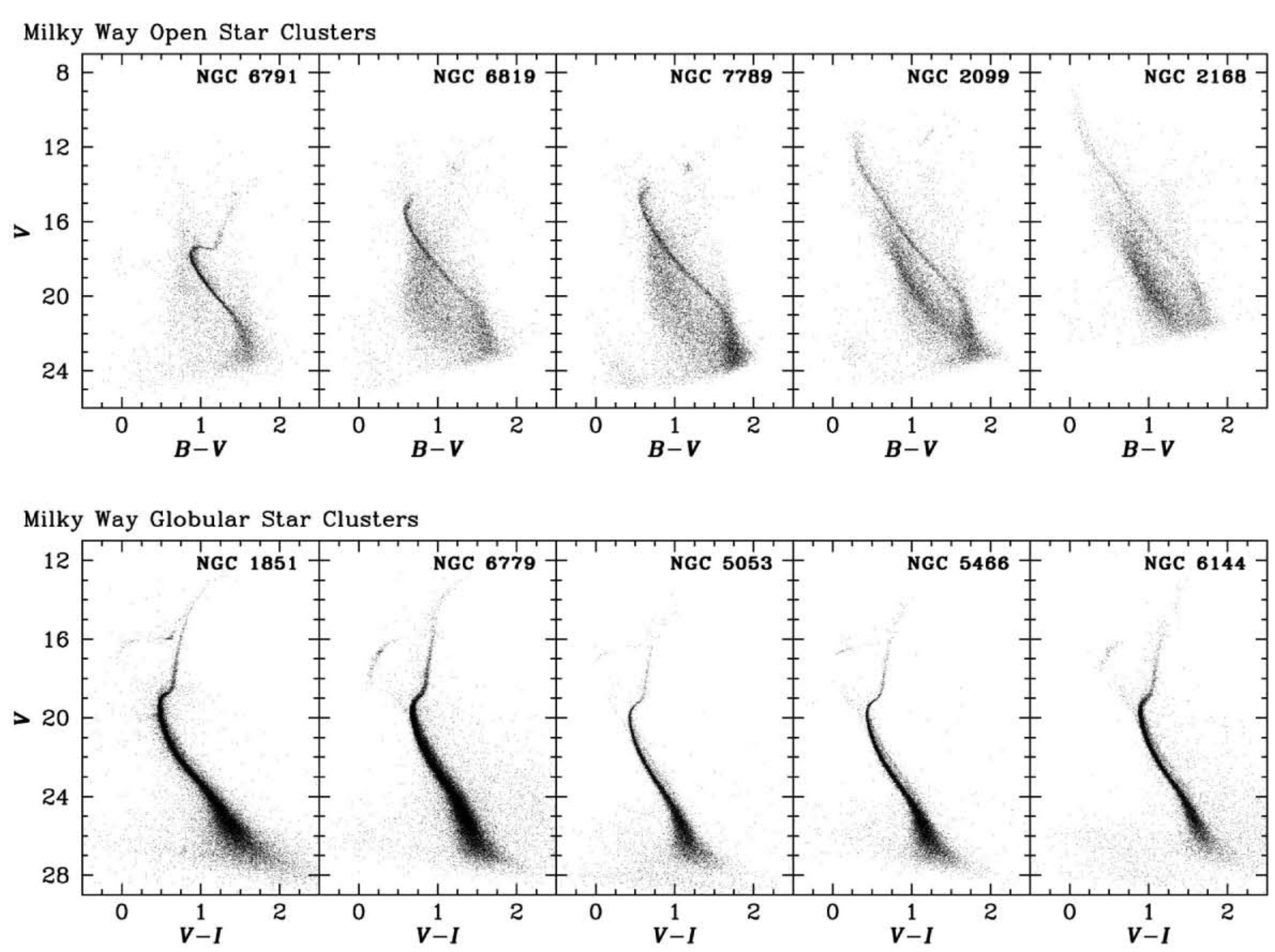
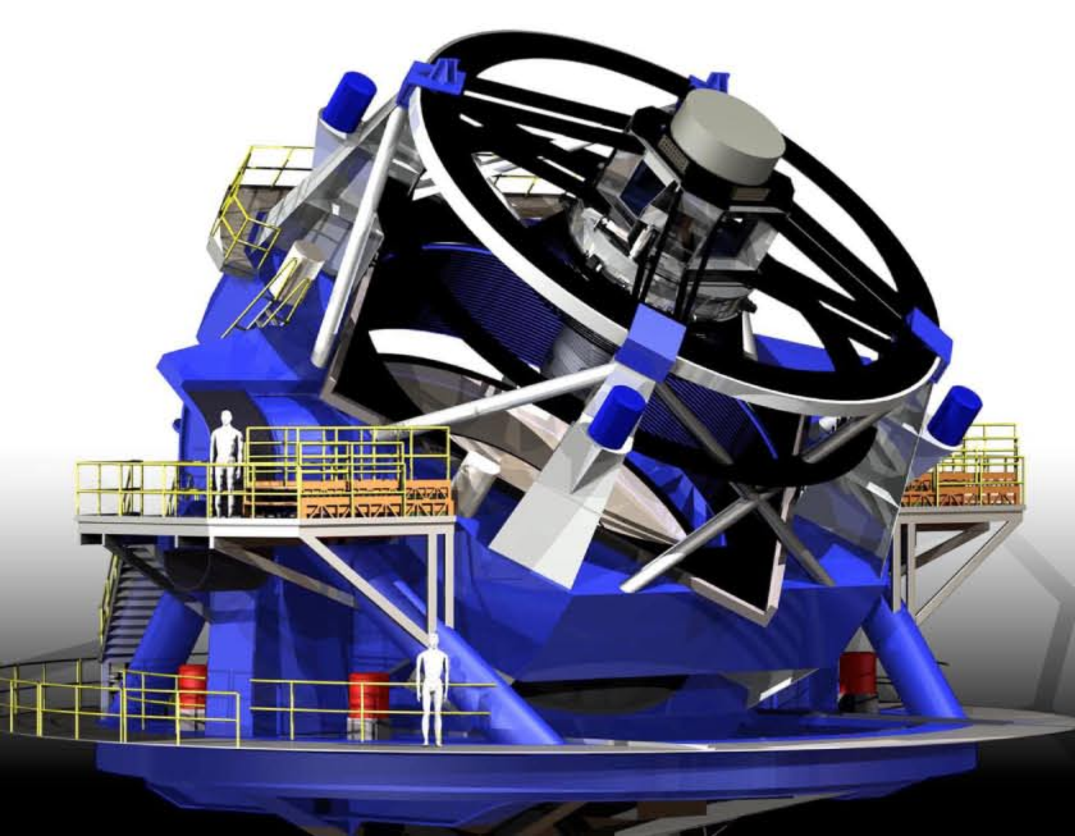


Figure 4 -- Color-magnitude diagrams of rich open star clusters from the Canada-France-Hawaii Telescope Open Star Cluster Survey (*top row:* Kalirai et al. 2001a) and globular clusters observed in the ACS treasury survey (*bottom row:* Sarajedini et al. 2007; Kalirai et al. 2009). The clusters are arranged from youngest in the top-right corner (100 Myr) to the oldest in the bottom-right corner (8 Gyr). LSST astrometry and photometry will allow the construction of deep, proper motion cleaned cluster CMDs for numerous poorly characterized Southern clusters.



January 2010

LSST is a public-private partnership. Design and development activity is supported in part by the National Science Foundation. Additional funding comes from private gifts, grants to universities, and in-kind support at Department of Energy laboratories and other LSSTC Institutional Members.