Large Synoptic Survey Telescope

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Mapping Milky Way And Local Volume Structure With LSST

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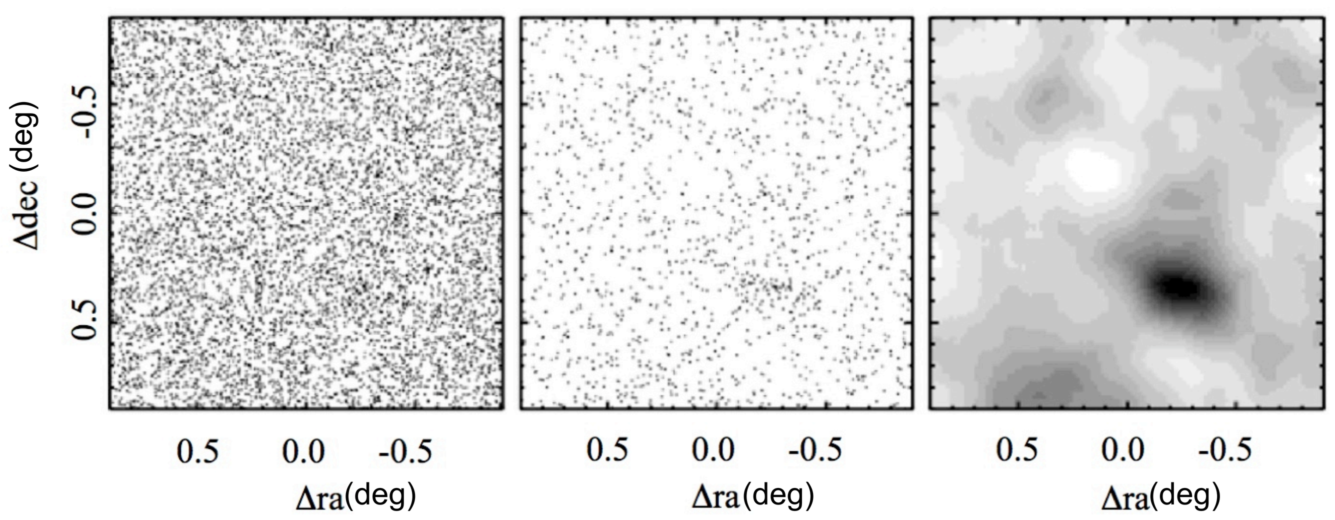
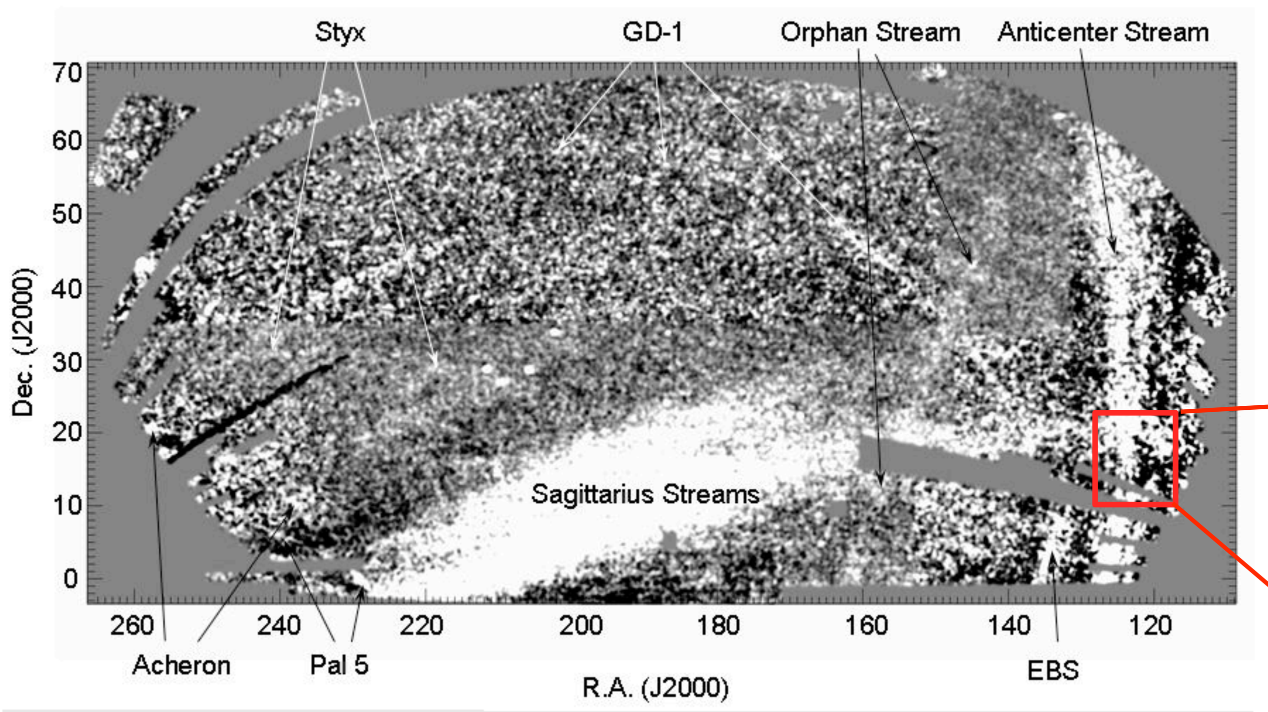
The LSST will yield revolutionary, multi-dimensional maps of the Milky Way (MW) galaxy and its neighbors. With its planned ~1000 epochs over 6 bands and a final limiting magnitude of r=27.5 (AB mag; 5-sigma), it will provide an excellent resource for mapping the structure and accretion history of the MW and beyond in a way that the present generation of surveys can only hint at. LSST is expected to catalog 10 billion stars, including photometric metallicities for the 200 million F/G stars within 100 kpc and map the tangential velocity field of stars brighter than r=24 mag to at least 10 kpc (at 10 km/s precision) and as far as 25 kpc (at 60 km/s precision). Specific related science to be enabled by LSST includes: mapping the 3D distribution of dust in the MW's disk, including variations in RV; understanding the smooth distribution of stars in the MW and other nearby galaxies; understanding large-scale chemical gradients in the MW; discovering lumps and streams in metallicity and phase space; inferring the mass distribution in the MW; discovering ultra-faint galaxies throughout the Local Volume.

Milky Way Satellite Census and the Nature of Dark Matter



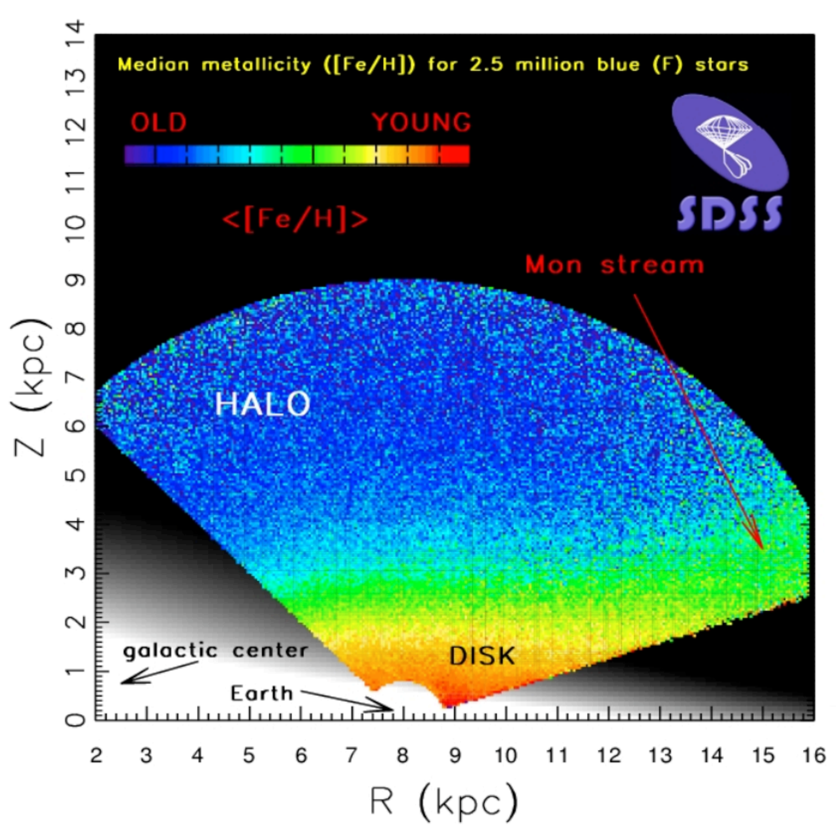
The SDSS has revealed a population of ultrafaint, L~10^3 L_{sun}, dwarf galaxies that in SDSS-depth data can be discovered only within ~50 kpc of the Sun (Willman et al. 2005; Belokurov et al. 2007). These objects may signal a much larger population of faint galaxies at larger distances, that may populate the numerous clumps of dark matter predicted to orbit the Milky Way. (Left panel) The spatial distribution of all SDSS stars near a diffuse object; (center) stars passing a color-magnitude filter, (right) the spatially smoothed number density map (Koposov et al. 2008; Walsh et al. 2009). LSST will detect these objects out ~400 kpc distances over half of the sky (Tollerud et al. 2008), and thus will elucidate the nature of the 'Missing Satellites' problem facing Lambda + Cold Dark Matter theory (LCDM).

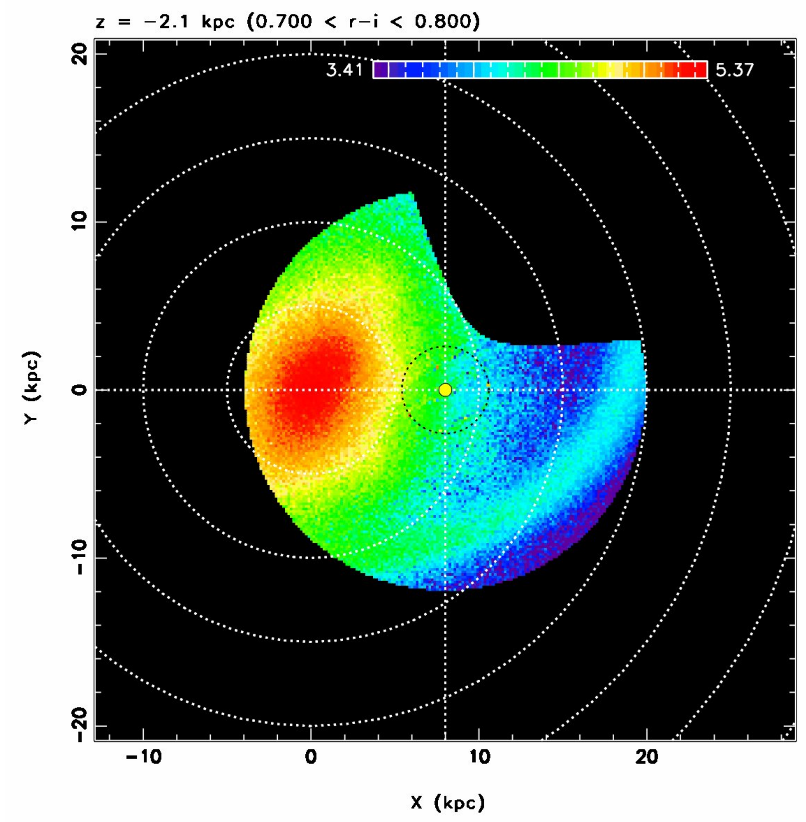
Signatures of Hierarchical Formation Throughout the Local Volume



(Above) A composite, filtered surface density map of stars in SDSS DR 5. Lighter shades indicate enhanced surface density. Distances to the streams range from 4 kpc for Acheron, to 9 kpc for GD-1 and the Anticenter Stream, to ~50 kpc for Sagittarius and Styx. To reveal these streams, stars were filtered to select stellar populations at different distances with color-magnitude sequences similar to that of the globular cluster M 13 (Grillmair 2009). Similar techniques applied to the LSST dataset will enable studies of streams, outer disks and halos out to 5 Mpc.

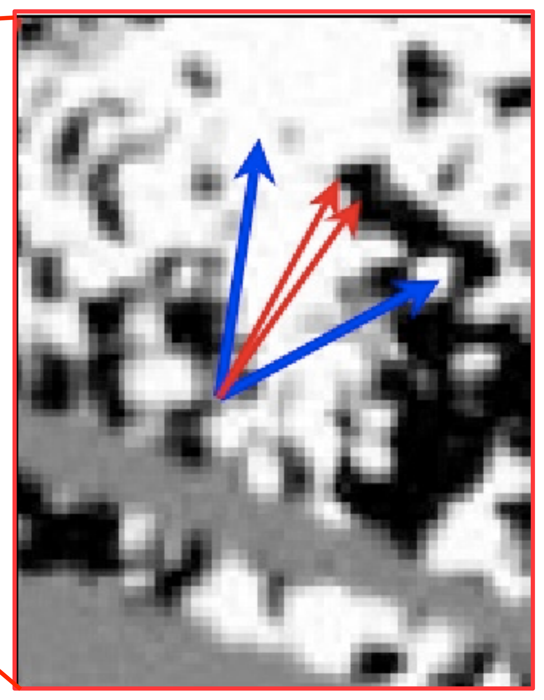
Unprecedented Maps of the Milky Way: Metallicity and Density





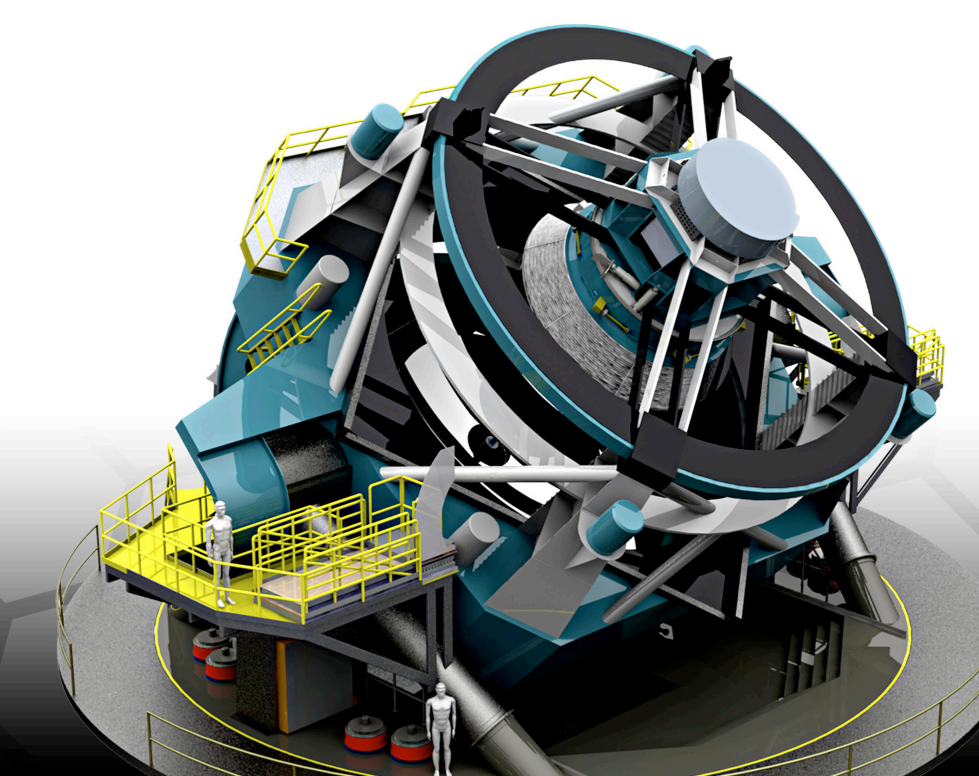
(Above left panel) SDSS DR6 median photometric metallicity map for 2.5 million Milky Way disk stars shown in cylindrical Galactic coordinates R and Z . The gradient of the median metallicity is approximately parallel to the Z axis, except in the Monoceros stream region, as marked. This suggests that the Monoceros stream is a disk feature as opposed to an accreted satellite stream. LSST will extend these maps to ~100 kpc distances and open new windows on the assembly of the Milky Way. (Right panel) A plane-parallel slice through a simulated three-dimensional map of stellar number density (stars kpc^{-3}, log scale) taken at Z=−2.1 kpc as observed by LSST. Stars are distributed according to the Juric et al. (2008) density law, with the addition of an inner triaxial halo/bulge/bar component, and a nearly plane-parallel Monoceros-like tidal stream in the outer regions. Only data at Galactic latitudes |b|>10° are shown. The missing piece in the first quadrant is due to the δ < 34.5° limit of LSST survey. Plotted within the small black circle are the actual SDSS data. Neither the outer stream nor the triaxiality of the inner halo/bulge were detected by the SDSS. LSST will easily detect and characterize both.

Proper Motions in the Galactic Halo



LSST will produce proper motion measurements for individual stars in the Galactic halo, nearby satellite dwarf galaxies, globular clusters and stellar streams. Over the 10-year LSST baseline, proper motion accuracy is expected to be 0.2 mas yr^{-1} for objects as bright as r = 21 and 1 mas yr^{-1} for objects down to r = 24. LSST will smoothly extend Gaia's error vs. magnitude curves (for trigonometric parallax, proper motion and photometry) 4 magnitudes fainter than Gaia's r=20 magnitude limit. Combined with radial velocities, this will allow LSST to map 3D velocities out to 10 kpc (at 10 km/s precision) and as far as 25 kpc (at 60 km/s precision).

(Left) A comparison of current proper motion measurement errors in the Anticenter stream region, compared to errors expected from an LSST-based measurement. The blue arrows indicate the current 3-σ proper-motion error-cone as determined from photographic proper motion measurements (1-σ = 0.35 mas yr^{-1}; Carlin et al. 2010, Casetti-Dinescu et al. 2006). The red arrows represent the expected 3-σ error-cone for an LSST determination in an area equal to that of the Carlin et al. measurement (40'x60'). LSST proper-motion errors are expected to be a factor of 12 better than the current measurements and will pinpoint the orbit of the Anticenter Stream, providing improved constraints on the Galactic potential.



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