Large Synoptic Survey Telescope

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Mapping Milky Way and Local Volume Structure

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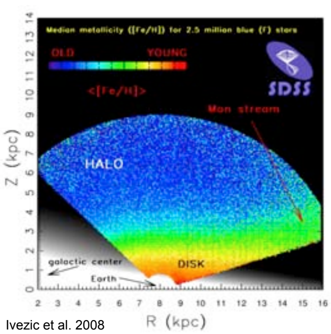
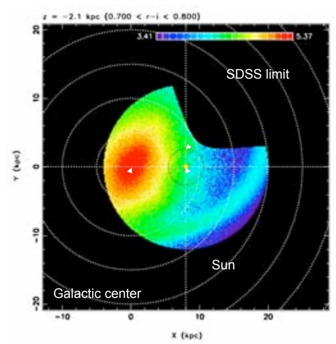
The last decade has seen a renaissance in the study of our own and other galaxies in the Local Volume, based in large part on multi-dimensional maps of the vast numbers of stars cataloged by surveys such as 2MASS and SDSS. This renaissance revolutionized our view of the Milky Way (MW) by facilitating tomographic studies of its global structure and by revealing a vast menagerie of substructures, including a new population of satellite galaxies with a millionth the luminosity of the MW and a halo replete with lumps and streams that betray the formation history of the MW. With LSST's planned 1000 epochs over 6 bands and a final limiting magnitude of r=27.5 (AB mag; 5σ), 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 anticipated to catalog 10 billion stars, including photometric abundances for the 200 million F/G stars within 100 kpc and proper motion/parallax measurements for stars brighter than r=24 mag. Specific related science to be enabled by LSST includes: mapping the 3D distribution of dust in the MW's disk, including variations in R_V; 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.

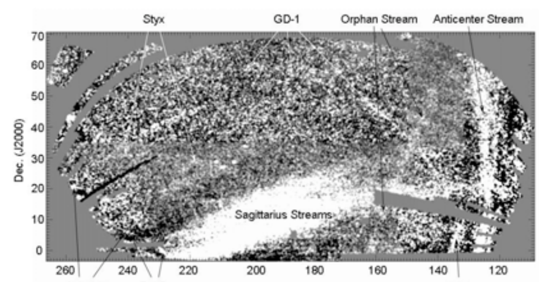
Unprecedented Maps of the Milky Way: Metallicity and Density



Ivezic et al. 2008



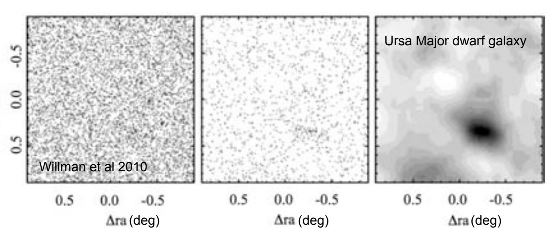
(Left panel) SDSS DR6 median photometric metallicity map for 2.5 million Milky Way disk stars shown in cylindrical Galactic coordinates R and Z . The gradient of the median metallicity is approximately parallel to the Z axis, except in the Monoceros stream region, as marked. This suggests that the Monoceros 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. 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 the 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.**

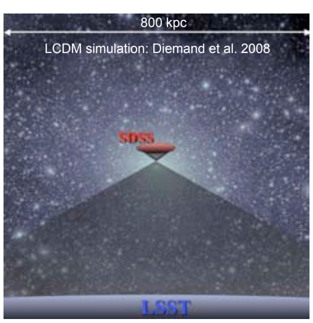


Rau et al 2009

Signatures of Hierarchical Formation Throughout the Local Volume

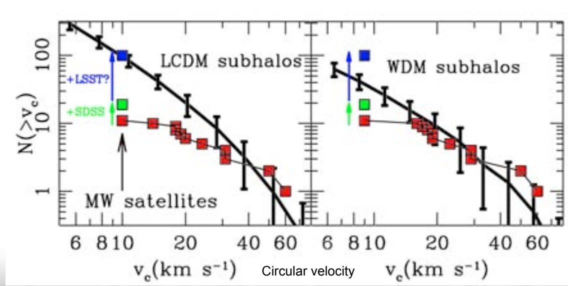
(Above) A composite, filtered surface density map of stars in SDSS DR 5. Lighter shades indicate enhanced surface density. Distances to the streams range from 4 kpc for Acheron, to 9 kpc for GD-1 and the Anticenter Stream, to ~50 kpc for Sagittarius and Styx. To reveal these streams, stars were filtered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





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 can only be discovered within ~50 kpc of the Sun in SDSS-depth data (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 (see figure to left; Koposov et al. 2008; Walsh et al. 2009). The current satellite count (green + red in the figure below) is close to the Warm Dark Matter prediction. New discoveries from LSST may potentially rule out Warm Dark Matter models (figure from Zentner & Bullock 2003). **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).**



References

Belokurov, V. et al. 2007, ApJ, 654, 897
Diemand et al. 2008, Nature, 454, 735
Grillmair, C. J. 2009, ApJ, 693, 1118
Ivezic, Z. et al. 2008, ApJ, 684, 287
Koposov, S. et al. 2008, ApJ, 686, 279
Rau, A. et al. 2009, PASP, in press
Tollerud et al., 2008, ApJ, 688, 277
Walsh, S. et al., 2009, AJ, 137, 450
Willman, B. et al. 2005, ApJ, 626, L85
Willman, B. et al. 2010, Adv in Astron, Article ID 28545
Zentner, A. R. & Bullock, J. S. 2003, ApJ, 598, 49

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.