Large Synoptic Survey Telescope

Mapping the Milky Way and Intergalactic Space with LSST

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The LSST will produce an accurate multi-color digital map of half the sky down to V~26.5, while time-spaced sampling of each field will provide variability, proper motions, and parallax measurements for objects brighter than V~24. These photometric, astrometric, and variability data will enable the construction of a detailed and robust map of the Milky Way, allowing exploration of its star formation, chemical enrichment, and accretion histories on a grand scale. For example, the parallax data will allow a complete census of all the stars above the hydrogen-burning limit that are closer than 500 pc, and RR Lyrae stars will be detectable through their variability to a distance limit of 400 kpc. Accurate colors will allow the estimate of photometric distance, and hence the three-dimensional number density distribution, for over a billion main-sequence stars to a distance limit of 100 kpc, and proper motion measurements will provide strong constraints on their kinematics. The LSST will also be able to detect novae out to the Virgo and Fornax clusters, providing an abundant stellar tracer of intergalactic space out to large distances. The LSST Milky Way and nova maps will revolutionize our understanding of the Milky Way and of intergalactic space, and in turn will have a significant impact on the theories of galaxy formation and evolution.

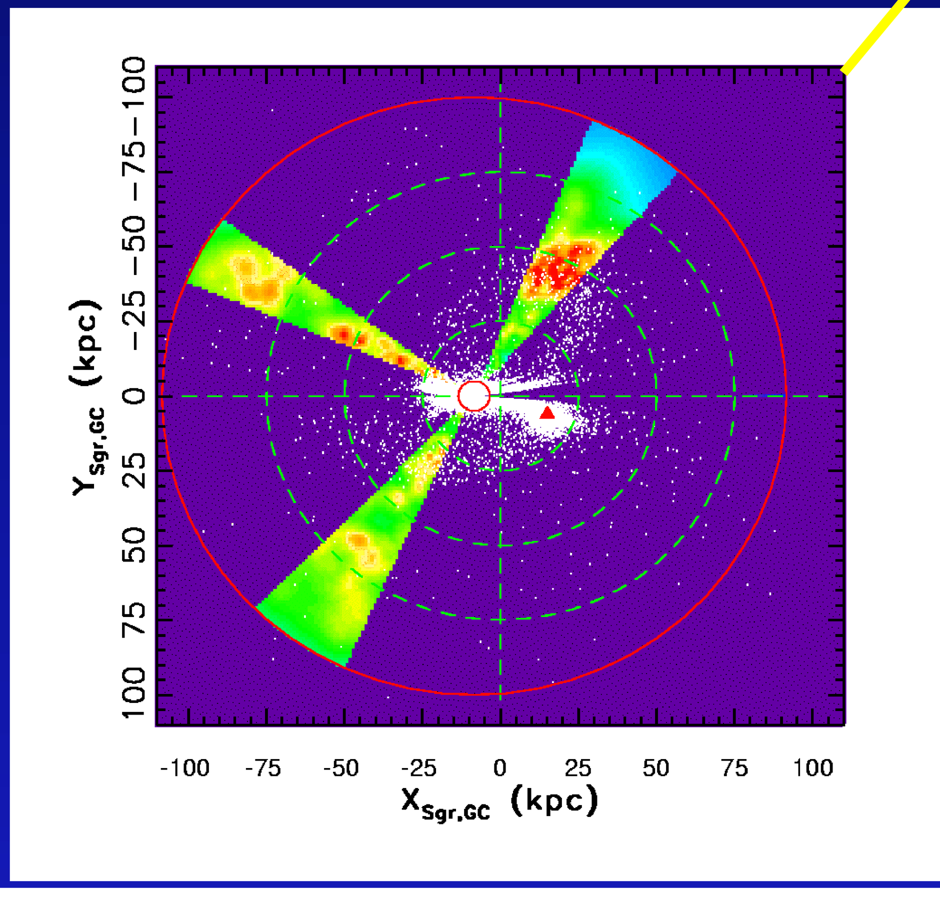
What is the structure and accretion history of the Milky Way?

Tools:

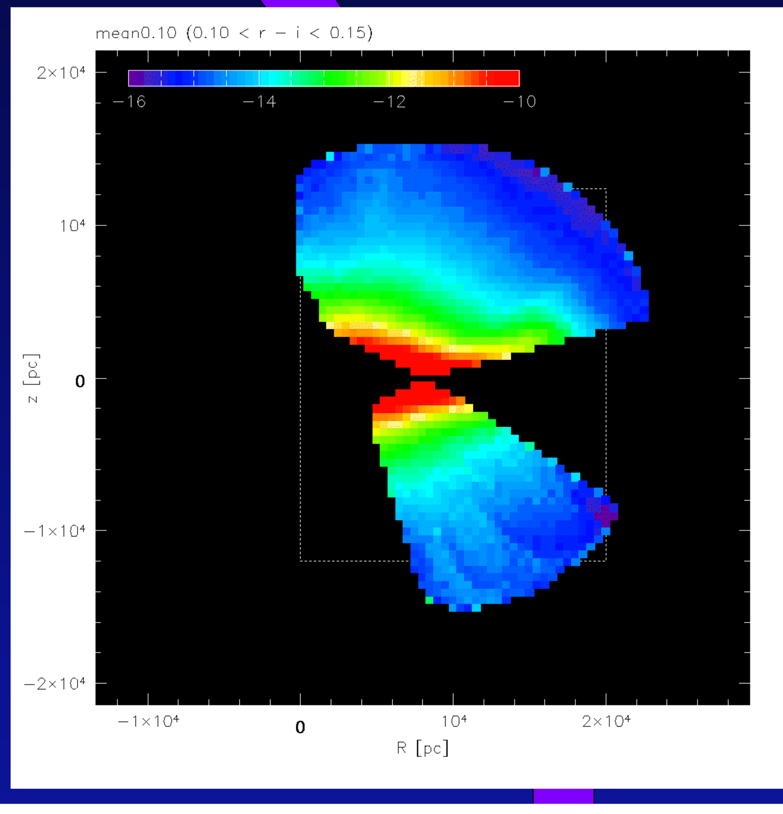
- **Variability**
  - **RR Lyrae to d~400 kpc**
- **Color selection of populations**
  - **Main sequence stars to *m-M*=21 - 22**
- **Proper motions**

$\sigma_v = 170 \times (\mathrm{FWHM}/0.''5)(d/100\ \mathrm{kpc})^{2.65} \times (N/100)^{-1/2}(t/10\ \mathrm{yrs})\ \mathrm{km\ s^{-1}}$

LSST limit for RR Lyrae: 400 kpc



The structure of the outer Milky Way (Ivezic et al. 2003). The number density multiplied by the cube of the galactocentric radius for 923 SDSS candidate RR Lyrae stars within 10º from the Sgr dwarf tidal stream plane. The solid circles show the sample distance limits (5 kpc and 100 kpc). The dashed circles are centered on (X=0,Y=0), and have radii of 25, 50, and 75 kpc. The triangle marks the position of the Sgr dwarf core.The clumps at (X,Y) of (20,-35) and (-20,25) are definitely associated with thetidal 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-Poissonian fluctuations, such as those suggested by Bullock et al. (2001). LSST will extend such mapping to about 50 times larger volume.

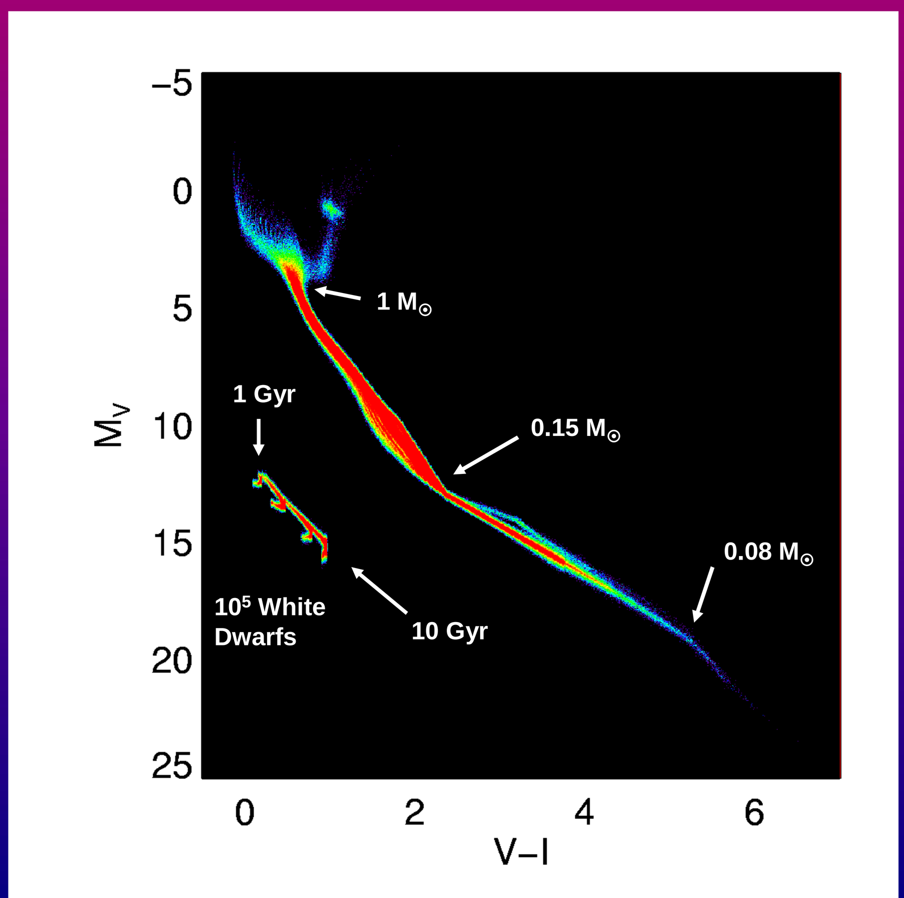


The structure of the inner Milky Way (Juric et al. 2005). The space density of Galactic main sequence stars detected by SDSS, selected by the criterion 0.10 < *r' - i'* < 0.15, is displayed logarithmically in this edge-on view of the Milky Way. The center of the galaxy is at R=0, z=0; while the Sun is at R=8.5x10^3 pc. The shapes of the thin and thick disks are clearly seen, while the outer edges of the thick disk appear disturbed, perhaps marking the transition to the halo. LSST will produce a similar map out to distances of 100 kpc, a volume currently only available to the much less numerous RR Lyrae stars in SDSS and M giants in 2MASS.

What are the fundamental properties of all stars within 200 pc of the Sun?

Astrometric tools:

- **Parallax: 2 - 4 mas positional accuracy per observation will yield 10% distances out to 250 - 500 pc by end of survey for stars near the H-burning limit**
- **Sensitivity to wiggles: binary orbits will be measured in systems with orbital periods up to 40 years, allowing clear separation of binary sequence**



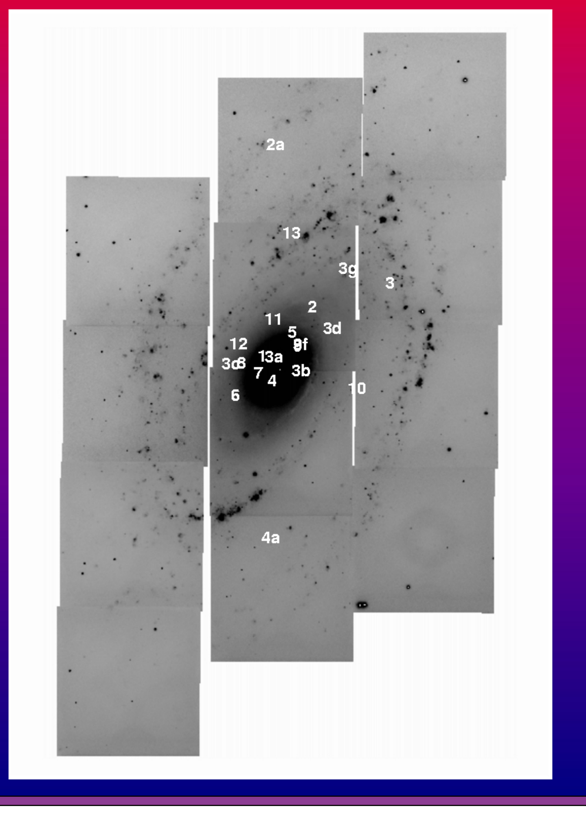
Simulation of the stellar populations detectable by LSST within 200 pc of the Sun. Stars with parallax errors <10% and photometric errors < 0.1 magnitudes are plotted in this image representation of a color-magnitude diagram, where warm colors denote increasingly high densities of stars. The simulation follows the Galactic disk star formation history of Bertelli & Nasi (2001), and incorporates the stellar IMF measured by Reid, Gizis, & Hawley (2002) and the substellar IMF of Burgasser (2004). V and I magnitudes for the 1.1x10^6 objects were calculated using the Girardi et al. (2000) stellar isochrones, the white dwarf models of Richer et al. (2000), and the Baraffe et al. (2003) isochrones for substellar masses. The simulation assumes that all stars are uniformly distributed within the volume.

What is the history of galactic cannibalism?

Tools:

- **Novae as tracers of stripped material**

Expect ~2000 intergalactic novae to be detected by LSST out to distance of Virgo; these trace the older stellar populations that have been torn out in interactions



The distribution of classical novae in M81. 19 novae discovered by Neill & Shara (2004) are shown in this image. The majority of the novae are concentrated towards the bulge, indicating that the novae are tracers of older populations. There also appears to be an asymmetry in the distribution along the major axis of the galaxy.

References

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