Galactic Science with the LSST

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Haverford College

Thanks to: Dana Casetti, Kevin Covey, Marla Geha, Zeljko Ivezic, Lynne Jones, Jason Kalirai, Nitya K, Dave Monet, Keivan Stassun
Two Science Collaborations

Imaging billions of southern hemisphere stars with wide-field, deep, multi-color, time-series photometry will revolutionize our understanding of stellar populations.

Stellar Populations
56 members

co-chairs:
Kevin Covey (Cornell)
Knut Olsen (NOAO)

These stellar populations will be the foundation of multi-dimensional maps of the Milky Way (MW) galaxy and its neighbors.

Milky Way and Local Volume Structure
34 members

co-chairs:
Marla Geha (Yale)
Beth Willman (Haverford College)
LSST Galactic Science: Case 1

Fundamental Stellar Parameters with Eclipsing Binaries
LSST Galactic Science: Case 1

Fundamental Stellar Parameters with Eclipsing Binaries

Combination of:

Half of sky and six filters (ugrizy)

- **time domain:** entire visible sky every 3 nights for 10 years

- **deep:** $5\sigma$ limits

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Case 1: Eclipsing Binaries

**LSST will observe:**

16 million EBs to $r \sim 22$ with
$S/N > 10$ per data point

1.6 million EBs with
photometric precision
sufficient for detailed
modeling
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16 million EBs to $r \sim 22$ with $S/N > 10$ per data point

1.6 million EBs with photometric precision sufficient for detailed modeling

10,000 simulated EBs sampled with LSST cadence and sensitivity. Prsa, Pepper, & Stassun (in preparation)
LSST Galactic Science: Case 2

10 billion main sequence stars

*Spatial-([Fe/H]) map of the Milky Way and beyond*

*High fidelity maps of tangential velocity field to at least 10 kpc (at 10 km s\(^{-1}\) precision) and as far as 25 kpc (at 60 km s\(^{-1}\) precision).*
Case 2: 3D Spatial-[Fe/H]-v$_{\text{tan}}$ Maps

*Combination of:*

**Half of sky and six filters (ugrizy)**

- **time domain:** entire visible sky every 3 nights for 10 years

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- **precision photometry:**
  
  0.01 mag precision in $u$ yields [Fe/H] to 0.1 dex

- **precision astrometry:**
  
  0.2 mas/yr at $r = 21$
  1.0 mas/yr at $r = 24$
Case 2: 3D Spatial-[Fe/H]-v\textsubscript{tan} Maps

Many stellar tracers of structure, hierarchical formation, and star formation history of the Milky Way, e.g.

low-mass stars and brown dwarfs (e.g. detect L0 to 2 kpc and parallaxes to 200? pc, detect T0 to 100 pc)
F- and G- main-sequence turnoff stars
RR Lyrae stars (> 400 kpc)
bright red giant branch stars (6 Mpc)
Case 2: 3D Spatial-[Fe/H]-\(v_{\text{tan}}\) Maps

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Case 2: 3D Spatial-[Fe/H]-$v_{\text{tan}}$ Maps

![Graph showing 3D Spatial-[Fe/H]-$v_{\text{tan}}$ Maps]

- PS1
- DES
- SM
- DR7
- RCS2
- Stripe82

MW Volume Fraction vs MSTO Detection Dist (kpc)
Case 2: 3D Spatial-\([\text{Fe/H}]-v_{\text{tan}}\) Maps

![Graph showing MW Volume Fraction vs. MSTO Detection Dist (kpc)]
Case 2: 3D Spatial-[Fe/H]-v_{tan} Maps

MSTO stars detectable to 300 kpc
Census of ultra-faint dwarfs to virial radius
Case 2: 3D Spatial-[Fe/H]-v_{tan} Maps

- Old, metal-poor MSTO stars detected to 300 kpc.
- Photometric [Fe/H] as precise as 0.1 - 0.2 dex for 200 million stars to 100 kpc.
- Tangential velocity field to >10 kpc (at 10 km s^{-1} precision) and as far as 25 kpc (at 60 km s^{-1} precision).

inset: SDSS map to d_{limit} = 10 kpc
Case 2: 3D Spatial-[Fe/H]-v\textsubscript{tan} Maps

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Tangential velocity field to >10 kpc (at 10 km s\textsuperscript{-1} precision) and as far as 25 kpc (at 60 km s\textsuperscript{-1} precision).
Current Work: Stars vs. Galaxies

At faint magnitudes, most point sources are galaxies

Data from COSMOS catalog of Ilbert et al (2009)

work in progress by Fadely, Hogg & Willman
Current Work: Stars vs. Galaxies

A simple $ugriz$ spectral template $\chi^2$ calculation helps, but...

Data from COSMOS catalog of Ilbert et al (2009)  
work in progress by Fadely, Hogg & Willman
Current Work: Short Exposure Astrometry

Series of observations on Subaru, MMT/Megacam

Investigate atmospheric effects on short exposures

work in progress by Dana Casetti, Terry Girard, Nitya Kallivayalil (Yale)
Summary

• Time domain, deep+precise photometry, precise astrometry *uniquely combine* to enable definitive measures of fundamental stellar parameters and a multi-dimensional map of the Milky Way and beyond

• Wide range of work in progress by many collaboration members - geared to LSST but making resolved stellar science better *now* (e.g. using Operations/Image simulations to develop algorithms, separating stars and galaxies, short exposure astrometry)

• Lots more to do!