Southern Sky Survey and the Milky Way Halo

Stefan Keller
Mt. Stromlo Observatory

Brian Schmidt, Mike Bessell and Patrick Tisserand
Southern Sky Survey

SkyMapper

- 1.35m telescope with a 5.7 sq. degree field of view
- Located at Siding Spring Observatory, NSW
- To conduct the Southern Sky Survey:
  - Five year
  - Multi-colour (6 filters)
  - Multi-epoch (6 exposures, each filter)
  - $2\pi$ steradians
  - Limiting mag. g~23
- First light October 2007
The Rapid Imaging Survey Era

| Name               | Aperture (m) | FOV (sq deg) | Filter Set | Areal Coverage | Hemisphere | First Light |
|--------------------|--------------|--------------|------------|----------------|------------|-------------|
| SDSS               | 2.5          | Drift scan   | ugriz      | $\pi$ of 3/2$\pi$ | N          | Operating   |
| CFHT MegaCam       | 3.6          | 1            | ugriz      | <1000          | N          | Operating   |
| SkyMapper          | 1.35         | 5.7          | uvgriz     | 2$\pi$         | S          | 2007        |
| PanStarrs          | 1.8 (+3x)    | 7            | grizY      | 3$\pi$         | N          | 2008        |
| VISTA              | 4            | 1.65         | zYJHK      | 2$\pi$         | S          | 2008        |
| VST                | 2.6          | 1            | ugriz      | ~5000          | S          | 2008        |
| Discovery Chn      | 4            | 2            | ?          | ?              | N          | 2009?       |
| Dark Energy        | 4            | 2            | ?          | 5000           | S          | 2009?       |
| LSST               | 8.4          | 10           | ugrizY     | 3$\pi$         | S          | 2013        |

- We aim to fill the gap in the coverage of the Southern sky, matched to SDSS but with significant improvements:
  - sky + temporal coverage; sensitivity to stellar parameters (BUT no concurrent spectroscopy...)
Telescope Optics

- 0.69m secondary
- 0.6m fused silica asphere
- 1.35m primary
- 2 x 0.45m fused silica spherics

Telescope – Focal length & f/ ratio:
- 16224.75mm
- f/4.78
The SkyMapper CCDs

- 32 E2V CCD44-82 devices:
  - 2048x4096 15 micron pixel CCDs
  - Broadband coated
  - 40 micron (thick) deep depletion devices
    - Reduced fringing, inc. red response
- 16384x16384 0.5” pixels
- Using new Pan Starrs controllers ([http://www.stargrasp.org/](http://www.stargrasp.org/))
- Readout in ~12 seconds
- Readnoise ~5e- @ 12 seconds
The Southern Sky Survey

- $2\pi$ coverage: 4096 fields observed in six filters, six times per filter
- Cadence: hours, days, weeks, months, years
- Star/galaxy photometry to 3% globally ($g<18$)
- Astrometry to 50 milliarcsec (absolute)
  - 36 images of each object over 5 years
    ⇒ proper motions to ±2 mas/yr. (i.e. $\sigma_{vtan}=25\text{km/s at 2.5kpc}$)
    ⇒ parallax ±5 mas (i.e. 20pc $\sigma_d=10\%$) [David Monet priv. comm.]
- Survey complete in 5 years
**SkyMapper Filter Set**

Design filter set - optimal sensitivity to Teff, logg, [Fe/H]

Addition of intermediate v filter (DDO38-like)

Black = SDSS

Additional all-sky imaging in DDO51 (MgH) & Hα
## Expected Survey Limits

|       | $u$  | $v$  | $g$  | $r$  | $i$  | $z$  |
|-------|------|------|------|------|------|------|
| 1 epoch | 21.5 | 21.3 | 21.9 | 21.6 | 21.0 | 20.6 |
| 6 epochs | 22.9 | 22.7 | 22.9 | 22.6 | 22.0 | 21.5 |
| Sloan Digital Sky Survey comparison | 22.0 | n/a  | 22.2 | 22.2 | 21.3 | 20.5 |

AB mag. for signal-to-noise = 5 from 110s exposures
Key Science

- What is the distribution of large Solar-System objects beyond Neptune?
- What is the history of the youngest stars in the Solar neighbourhood?
- How far does the dark matter halo of our galaxy extend and what is its shape?
- Gravity and metallicity for on order of 100 million stars ⇒ the assembly and chemical enrichment history of the bulge, thin/thick disk and halo?
- Extremely metal poor stars
- dSph satellites of the MW
- Nearby SNe and GRBs
- bright z>6 QSOs
SkyMapper Filter Set
optimised for stellar astrophysics

1-sigma uncertainty in logg as a function of logg, T_{eff}
Blue Horizontal Branch Stars

-4<[Fe/H]<0

u-v measures H^− continuum opacity which increases with logg

logg=2  
logg=5

Teff: 10000K  6000K

u-v: surface gravity sensitive
Southern Sky Survey

Blue Horizontal Branch Stars

- MS+BS
- logg=5
- logg=2
- ZAHB

Teff: 10000K 6000K

HBA RRL

Taking us out to distances >100kpc with low contamination

5% contamination and 90% completeness

Halo turn-off Teff
Blue Horizontal Branch Stars

The SDSS view
Use a set of colour and spectroscopic indices to isolate BHBs
Extend to 60kpc

The SkyMapper View
Photometric BHB selection to 130kpc with 5% contamination
+ RRLs obtained from time series

From Sirko et al. 2004
AJ, 127, 914
Extremely Metal-poor Stars in the Halo

- Goal: find the first stars to have formed in the Universe: tell us about the assembly and chemical enrichment of the Galaxy.
- \( v-g \) is dependent on the level of metal line blanketing in the blue continuum.
- ✓ not perturbed dramatically by C-enhancement, chromospheric emission as affects objective-prism surveys.
Better still in 5-dimensional colour space.
From the 5-d colour space: $[\text{Fe/H}]=-4 \Rightarrow \pm 0.7 \text{dex}$
Extremely Metal-poor Stars in the Halo

Select a sample with photometrically derived [Fe/H]<-4 and g<18 returns this sample of spectroscopic [Fe/H]

~130 [Fe/H]<-5

Scale HES numbers for increased area, depth
Dwarf Galaxy Satellites of the MW

The Stromlo Missing Satellite Program
PI: Helmut Jerjen

SDSS has almost doubled the number of known MW satellites

Walsh et al. (2007 in prep.) present 14 more candidates!
Dwarf Galaxy Satellites of the MW

The Stromlo Missing Satellite Program
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We can expect similar limits from the Southern Sky Survey

from Walsh et al. 2007 astro-ph/07051378 - discovery of Boo II dSph
Dwarf Galaxy Satellites of the MW

- The frequency of new dSph ⇒ many more to be found
- Will the Great Disk stand? More interesting discussion!

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Southern Sky Survey

MWHalo Bonn 2007
Summary

- SkyMapper and the Southern Sky Survey - a valuable resource for the southern sky
- with a filter set specifically designed for stellar astrophysics
- Provide accurate photometry and astrometry for 8 to 23rd magnitudes in multiple epochs
- First light in October this year
- Can be used for countless science programs - ask us, get involved

http://www.mso.anu.edu.au/skymapper
astro-ph:0702511 Project Overview