Astrometry & the Yale/WIYN ODI Survey
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Potential astrometric projects

- **Local luminosity function** *(van Altena, et al.)*
  - obtain $\sigma/\pi \leq 0.10$ parallaxes to 150 pc for $i \leq 22$, combine w/ proper motions & RVs for subset of stars
  - $\rightarrow$ matter balance in solar neighborhood

- **Milky Way structure, satellites, streams & star systems** *(Casetti, Girard & van Altena)*
  - absolute proper motions (orbits!) of cold systems, + kinematic structure of major components

- **Wobbles in nearby white/red/brown dwarfs** *(Henry)*

- **Deep Astrometric Standard fields** *(Platais)*

- **Open cluster proper-motion studies** *(WOCS)*

- **Solar system objects** *(Rabinowitz)*
  - search for distant small bodies
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Expected astrometric precision

Assume 2 mas single-measure precision (see OPTIC results),
26 visits over 6-month period in one year,
5-exposure visit 2 years later
then...
parallaxes to +/- 0.66 mas
proper motions to +/- 0.54 mas/yr

At the survey limit, expect several dozen QSO’s per field, thus
zero-point accuracy < 0.1 mas, and < 0.1 mas/yr

Note 1: This assumes a detailed set of observations is made early on to allow a full astrometric calibration of the FOV. (In each filter?)

Note 2: Such a calibration will benefit other (non-astrometric) ODI projects, e.g., those requiring precise image stacking.
Observations of open cluster NGC 188 in 2003 and 2007

The 2003 data
8 x 300sec I band
seeing: 0.6” - 0.9”
OTA engaged

The 2007 data
3 x 300sec I band
seeing: 1.0” - 1.3”
OTA not engaged

2.0 mas per single measurement of a well-measured star (to S/N ~ 40).

0.45 mas/yr per single measurement of a well-measured star.
OPTIC & WIYN: An astrometric feasibility test

At $V \sim 20$, S/N $\sim 40$:

$\sigma_x = 2$ mas

$\sigma_\mu = 0.45$ mas/yr (4-yr baseline)

Systemic-motion Uncertainty for GCs and dSphs

$\sim 0.03 - 0.05$ mas/yr $\Rightarrow$ 7 to 12 km/s at 50 kpc

Photometry:

<table>
<thead>
<tr>
<th>$V$</th>
<th>$\sigma_V$</th>
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<tbody>
<tr>
<td>20.0</td>
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<tr>
<td>21.0</td>
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With $\sigma_\pi = 0.66 \rightarrow 10 \sigma$ parallaxes out to 150 pc, down to $i = 22$. This corresponds to $M_V \sim 20$. Note that the main-sequence minimum mass range is $\sim$ at $M_V$ of 17 - 19.

We expect on the order of 50 stars with $d<150$ pc per ODI field. Over the 36 sq deg of the survey, we will be able to obtain a stellar census to within $\pm 2.3\%$.

*The improved image centering precision provided by OT CCDs enables up to probe 3 times more deeply in parallax (and proper motion) space for a given exposure.*

Henry 2004 (ASP Conf. Series 318)
MW Structure, Streams, Satellites & Star Systems

**Milky Way dwarf spheroidals:**
“missing” satellite problem → subhalo mass distribution → tidal effects on mass determinations → accurate orbits → accurate absolute proper motions

origin → cosmological substructures or tidal dwarf galaxies? → distribution of orbital angular momentum → orbits → accurate absolute proper motions

*targets: 9 satellites within 90 kpc (δ >-15°)*

**Milky Way globular clusters:**
formation of the MW globular cluster (GC) system → accretion vs dissipational collapse? →
chemical & kinematic signature → orbits → accurate absolute proper motions

nature of most massive, multiple-population GCs → nuclei of disrupted satellites? → kinematic signature → orbits → accurate absolute proper motions

*targets: 30 candidate GCs (δ >-15°)*

www.sdss.org

*Freeman 2007, Dinescu et al. 1999*
MW Structure, Streams, Satellites & Star Systems

**Tidal streams:**
shape of the Galactic potential & satellite disruption processes → 3D velocities of stars in tidal streams → accurate absolute proper motions

*targets: Sgr stream, Mon stream, Virgo Overdensity, possibly a few others*

**Main Milky-Way components (thin, thick disks and halo):**
formation in a cosmological context → mean velocities and velocity dispersions as a function of distance from the Galactic plane and center → accurate absolute proper motions

*targets: 3 main fields, plus along the lines of sight to streams, globular clusters and satellites*

*Keller et al. 2008*
MW Structure, Streams, Satellites & Star Systems

Target Fields
Astrometry & the Yale/WIYN ODI Survey

Deep Astrometric Standard fields


Goal: construct four (seasonal) fields, 10 sq deg each, spanning $10 < V < 25$, with 5-10 mas positional accuracy and 2 mas/yr proper motion accuracy for subsequent calibration of large FOV, deep instruments/surveys, e.g., LSST.

Originally proposed 10-s, 120-s, 900-s exposures with 4-m telescope and Mosaic Imager → ~100 hrs/field

Might the Yale/WIYN ODI Survey provide three such fields as windfall?

(What about the bright end?)

Fig 7 of Platais et al.: a) 10-sec exposure with Subaru Suprime-Cam. Largest residual vector is 50 mas. b) 30-sec exposure.
Wobbly Dwarfs  \textit{(T. Henry)}

\textbf{Perturbation search of nearby white/red/brown dwarfs}

There are $\sim 5000$ red dwarf systems within 25 pc
$\rightarrow$ 1 per 8 sq deg

Targeted fields of known dwarfs
Monitor for 3 yrs min, $\geq$ 5 yrs “gets really interesting”
\textit{r, i, or z} filter (the redder the better)
5 dithers (or not) per visit
5 visits per field (i.e, per star)
Search for Distant Solar-System Objects:
Finding the next Sedna  (*D. Rabinowitz*)

Small-Body Searches to Date

<table>
<thead>
<tr>
<th>Area (sq deg)</th>
<th>Depth (R mag)</th>
<th>Telescope</th>
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<tbody>
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<td>20.5</td>
<td>Palomar 1.2m - QUEST</td>
</tr>
<tr>
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</tbody>
</table>

**Strategy**: 5-min exposures (*R*=24), 3 per field, separated by ~ 2 hrs
- Extremely interesting survey: ~1000 sq deg to find more Sednas
- Still interesting: 100 sq deg, with ≤ 50% chance of another Sedna but would help characterize the high-inclination population (Note: would require follow-up observations on 2-3 m class telescope)
Questions to ponder:

1. What is the optimum observing cadence for the main survey?

2. What projects (add-ons) can be combined to bring a “science multiplier” to the overall survey(s)?

3. Are there complementary observations that can be made or gleaned from existing archives that will provide immediate return once the ODI survey begins? Will we be ready?

4. What astrometry-specific reduction tools are available/needed for working with ODI datasets? Will we be ready?