The Pan-STARRS1 view of the Hyades cluster

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Outline

- Pan-STARRS1, the most ambitious optical survey of the decade
  - Instrument(s)
  - Surveys
- The Hyades cluster:
  - search for VLM members at large cluster radius
  - PS1 parallax search for nearby BD members
• 1.8-m dedicated telescope in Haleakala
• 7-sq.deg. FoV and 1.4 Gpix
• 13-sec overheads
• ~80% filling factor
• 3.5-year duration
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Surveys

- **3\pi survey (60%)**:  
  30,000 sq.deg., 5 filters x 12 exposures  
  see posters by Kim Aller & Will Best

- **Medium Deep Fields (23%)**:  
  70 sq.deg., 5 filters ~daily

- **Smaller surveys**:  
  - transit survey for exoplanets: few fields with high cadence  
  - asteroids: broad w filter on the ecliptic plane  
  - Andromeda: microlensing, variable stars,…
3π survey

Image quality

Single exposure depth

arcsec

AB mag
3π survey

Image quality

All exposures

<table>
<thead>
<tr>
<th></th>
<th>g</th>
<th>r</th>
<th>i</th>
<th>z</th>
<th>y</th>
<th>w</th>
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<tbody>
<tr>
<td>FWHM Median</td>
<td>1.29</td>
<td>1.17</td>
<td>1.10</td>
<td>1.06</td>
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arcsec

Single exposure depth

AB mag
### 3π survey

#### Image quality

**All exposures**

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**arcsec**

#### Single exposure depth

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<td>50%</td>
<td>21.95</td>
<td>21.77</td>
<td>21.48</td>
<td>20.77</td>
<td>19.74</td>
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**AB mag**
Stack depth

$10\sigma$

over $20\times20\text{arcmin}^2$

$z$ band PS1 vs. SDSS

Plot by E. Morganson (MPIA)
Stack depth

- SDSS slightly deeper in $g$ (by 0.11 mag)
- PS1 deeper in $r$ (0.21), $i$ (0.44) and $z$ (1.28 mag)
- PS1 has a wider distribution of magnitudes
  - We observe photometrically in all weather/lunation
  - Stacks contain 4-12 images
Photometric calibration

- Über-calibration à la SDSS
- Schlafly et al. (CfA/MPIA)
Photometric calibration

- Über-calibration à la SDSS
- Schlafly et al. (CfA/MPIA)

Maps of the difference between the color-corrected SDSS magnitudes of stars and the internally-calibrated Pan-STARRS1 photometry, while the rms of the map is indicated in the lower rectangles in right ascension and declination. The rms of each map is about 10 mmag. Narrow stripes in right ascension and declination are symptomatic of problems with the SDSS photometric calibration. The filter used for each map is indicated in the right margin.
• Über-calibration à la SDSS
• Schlafly et al. (CfA/MPIA)

Photometric calibration

PS1–SDSS
Cluster mass functions & evolution

• Mass function: slope(s), universality
• Evolution of clusters: how do they dissolve into the field
• Stellar evolution
  see Taisiya Kopytova’s talk
• Binarity
Cluster mass functions & evolution

- Mass function: slope(s), universality
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Figure 3: The derived present day mass function of a sample of young star-forming regions. The shaded region shows the standard deviation from the mean characteristic mass in each panel.

Bastian+, ARA&A, 2010
Cluster mass functions & evolution

- Mass function: slope(s), universality
- Evolution of clusters: how do they dissolve into the field
- Stellar evolution
  see Taisiya Kopytova’s talk
- Binarity
The Hyades survey

- Nearby cluster (47pc)
  - brown dwarfs (Ls at the centre, closest Ts) visible in PS1
  - study the spatial structure & dynamics
- Intermediate age of 625 Myr
- Large spatial velocity $U,V,W = -41,-19,-1$ km/s
- PM selection to remove field contaminants
Candidate selection

- Kinematic selection:
  - convergent point method: $|V_\perp| < 2$ km/s & 7 deg
  - proper motion from PPMXL
  - small PM errors < 20 mas/yr
  - 2MASS ‘A’ flag in $J$ and $K_s$

- Photometry from PanSTARRS1

- Hunt for various problems:
  - erroneously large PMs
Photometric selection

good: $|v_\perp| < 1 \text{ km/s}$
other kinematic candidates

Goldman et al. (submitted to A&A)
Photometric selection

Saturation

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$M_g$ vs. $g - K_{2\text{MASS}}$

- R11 candidates
- g|r|i candidates

Goldman et al. (submitted to A&A)
Photometric selection

R11 candidates
rejected in other band

Goldman et al. (submitted to A&A)
Photometric selection

Goldman et al. (submitted to A&A)
Photometric selection

Reddening

Padova

Dusty

$M_g$

$g - K_{2\text{MASS}}$

R11 candidates

gri candidates

AGSS2009 CIFIST2011

Goldman et al. (submitted to A&A)
Contamination
Previous studies

- Double the numbers of candidates with $m < 0.15 M_\odot$
- Refine Röser et al (2011) sample:
  refine poor CMC photometry or PPMXL PMs
- Confirms 13 candidates of Bouvier et al. (2008),
  rejects five (kinematic)
- Not sensitive to Hogan et al. L dwarfs (depth)
- 2MASS J0230155+270406 L0: Cruz et al (2007)
Mass functions

Simulation by Ernst et al (ARI)

all

$3.1 \ll 9 \text{pc}$

$18 \ll 30 \text{pc}$

$9 \ll 18 \text{pc}$

$0 \ll 3.1 \text{pc}$
Spatial distribution
Spatial distribution
Going Deeper with PS1 proper motions
PS1-only PMs: 1st optical candidate

- 2MASS J04482244+2051433 M6V
  Luhman (2006) as Taurus candidate??
- PS1 PMs: $+92 \pm 6$, $-36 \pm 5$ mas/yr
  [no good match in PPMXL, USNO-B1, NOMAD]
- PS1 parallax: $19 \pm 7$ mas
  vs. kinematic: $22 \pm 1$ mas
PS1-only PMs: 2nd optical candidate

- LP 155-252
- PS1 PMs: $+121 \pm 7, -75 \pm 7$ mas/yr vs. $+113, -66$ mas/yr*
- PS1 parallax: $21 \pm 5$ mas vs. kinematic: $18 \pm 1$ mas

* Lépine & Shara (2005)
PS1 parallaxes of kinematic candidates

- Require baseline > 1.5 years, 8+ detections, good PM, $\pi$
  - 50% of the sample after two seasons
- $1.5 \times 10^5$ objects with large PMs
- 400 kin. candidates
- 160 candidates based on PS1 parallax
- Still requires photometric parallax confirmation
PS1 parallaxes of kinematic candidates

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- 50% of the sample after two seasons.
- $1.5 \times 10^5$ objects with large PMs.
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Conclusions

- Derived the MF to 0.1M\textsubscript{\odot} to larger cluster radii
  - double the numbers of candidates with \( m < 0.15 \text{M}_{\odot} \)
  - depletion of VLM stars in the centre
- Cluster simulations provide a roughly good picture
  - but room for improvements
- Multi-band coverage and astrometry improve purity
  - soon parallaxes to allow search for nearby BD members