A transit survey at Antarctica Dome A

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Topics

• Why we chose Dome A?
• Recent progress and results.
• Plan in the coming future.
Why Dome A—transit survey
Transit is one of the most effective way to detect exoplanet
- High photometric precision: stable, clean, instrument
- Continuous observation: site, weather, instrument

\[ f \sim \left( \frac{R_p}{R_*} \right)^2 \]
Dome A is a very good photometric observation site

High elevation, low temperature, shallow turbulence layer
- stable
- Low extinction

Sky brightness in $i$ band

<table>
<thead>
<tr>
<th></th>
<th>Dome A</th>
<th>20.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>La Palm</td>
<td>20.10</td>
<td>Cerro Tololo</td>
</tr>
<tr>
<td>Paranal</td>
<td>19.93</td>
<td>Calar Alto</td>
</tr>
</tbody>
</table>
Total valid time

Polar night ~ 40 days (hours / day > 18) ~70 days (hours / day > 12) ~112 days
observable hours/yr

Dome A

Xinglong, Beijing
Detection Probability: 1yr’s continues observe

Dome A

Xinglong, Beijing
Chinese Small Telescope Array

• CSTAR (2008)
  - aperture: 4x10cm, Schmidt Telescopes
  - FOV: 4.5 x 4.5 sq. degree
  - bands: open, g, r, i
  - Fully automatic, fixed to point the south-pole
Use CSTAR 2008 catalog

- SDSS $i$-band
- Whole Antarctic winter
- 20-30s
- $<14m_i$
- 300,000 frames
- 10,000 light curves
- rms 2%~3%

### TABLE 1

**PHOTOMETRY OF SEVERAL SOURCES IN THREE DIFFERENT APERTURES**

<table>
<thead>
<tr>
<th>Number</th>
<th>R.A. (J2000)</th>
<th>Declination (J2000)</th>
<th>M1 (r = 3 pixel)</th>
<th>$\sigma_1$</th>
<th>M2 (r = 4 pixels)</th>
<th>$\sigma_2$</th>
<th>M3 (r = 5 pixels)</th>
<th>$\sigma_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>277 .....</td>
<td>23:23:46.274</td>
<td>$-89:25:17.81$</td>
<td>11.095</td>
<td>0.022</td>
<td>11.011</td>
<td>0.022</td>
<td>10.838</td>
<td>0.025</td>
</tr>
<tr>
<td>278 .....</td>
<td>10:43:24.023</td>
<td>$-88:42:00.78$</td>
<td>11.099</td>
<td>0.026</td>
<td>11.048</td>
<td>0.022</td>
<td>11.013</td>
<td>0.022</td>
</tr>
<tr>
<td>279 .....</td>
<td>16:13:39.187</td>
<td>$-87:44:30.11$</td>
<td>11.100</td>
<td>0.026</td>
<td>11.030</td>
<td>0.022</td>
<td>11.014</td>
<td>0.022</td>
</tr>
<tr>
<td>280 .....</td>
<td>14:09:08.706</td>
<td>$-89:07:12.63$</td>
<td>11.100</td>
<td>0.026</td>
<td>11.035</td>
<td>0.022</td>
<td>10.987</td>
<td>0.022</td>
</tr>
<tr>
<td>281 .....</td>
<td>13:46:15.127</td>
<td>$-88:26:01.94$</td>
<td>11.100</td>
<td>0.026</td>
<td>11.013</td>
<td>0.022</td>
<td>10.885</td>
<td>0.025</td>
</tr>
<tr>
<td>282 .....</td>
<td>17:54:27.175</td>
<td>$-89:42:21.70$</td>
<td>11.103</td>
<td>0.026</td>
<td>11.065</td>
<td>0.022</td>
<td>11.032</td>
<td>0.022</td>
</tr>
</tbody>
</table>

**NOTE.**—Catalog header parameters are decoded as: CCD temperature ($^\circ$C), date, exposure time (in seconds), the number of sources detected in the image, day of the year during 2008. The catalogs can be downloaded from National Astronomical Observatories Science Data Center, Chinese Academy of Science at [http://archive.bao.ac.cn/en/cstar](http://archive.bao.ac.cn/en/cstar).

**Zhou X. et al. 2010**
1. Correction for the inhomogeneous extinction (Wang et al. 2012)

2. Correction for the ghost images (Meng et al. 2013)
3. Correction of the movement of stars within the FOV (Wang et al. 2014)

After corrections, we achieve 0.4% at the bright end
• We found six exoplanet candidates
• We found 45 eclipse binaries
  19 detached, 6 semi-detached, 20 contacted. ETV analysis show 2 systems may have companions. Yang et al. 2014, in preparation
• So, what’s Next?
Antarctic Schmidt Telescopes (AST3)

- 50cm, 10Kx10K CCD
- Ia SNe & dark matter
- Exoplanet
- Variable stars
- Stellar seismology
Overview of the south sky

Open cluster: 1051
Exoplanet: 374; Dec > South 60 → only 60 exoplanets
Hot Jupiter: 53; Dec > South 60 → only 9 hot Jupiters

AST3 exoplanet survey can help to fill this deficit.

High accuracy photometry survey on high latitude southern hemisphere is needed.
1. Transiting candidates expected by AST3

According to Kepler’s results:

<table>
<thead>
<tr>
<th>Photometric accuracy</th>
<th>Frequency of Exoplanet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>0.047%</td>
</tr>
<tr>
<td>0.5%</td>
<td>0.085%</td>
</tr>
<tr>
<td>0.1%</td>
<td>0.28%</td>
</tr>
</tbody>
</table>

Exoplanet searching area: cover 900,000 objects (8m - 14.5m)

With a single 30s exposure, AST3 can achieve 1% accuracy for $V<14.5\,\text{m}$ and 0.1% for $V<11\,\text{m}$

Total candidates expected: 90 days/year, 5-10 years

<table>
<thead>
<tr>
<th>Planet size</th>
<th>Expected number</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;Jupiter</td>
<td>&gt; 400</td>
</tr>
<tr>
<td>Neptune - Jupiter</td>
<td>~ 250</td>
</tr>
<tr>
<td>Neptune</td>
<td>~ 150</td>
</tr>
<tr>
<td>Total</td>
<td>&gt; 750</td>
</tr>
</tbody>
</table>
Microlensing

Free floating planets

The observed light curve of the OGLE-2005-BLG-390 microlensing event
• **AST3-I (2012)**

- aperture: 50/68cm modified Schmidt Telescopes
- FOV: 4.2 sq. degree
- bands: 400nm-900nm, g, r, i filters
- remote control, tracking
AST3-I 2012 raw data

- SDSS $i$-band
- 2012/03/15 ~ 2012/05/08
  - SN template
  - LMC & SMC
  - Transit search
    (04/25~05/01)
  - Variables
- 30s
- < 18m$_i$
- 1900 frames
- pipeline
- 30,000 light curves
For crowded star field $\langle 11-13m_i \rangle \sim 0.6\%$

For normal star field $\langle 11-12m_i \rangle \sim 0.3\%$

(by Zhang H.)
- Eclipse binaries and variables > 200
• Found 1 exoplanet candidate

depth: 3%
period: ~4 days
duration: ~1 hour

(by Zhang H.)
Coming soon…

- **AST3-II (G-band)**
  Set up in 2015, update 2013, test observation at Mohe

- **AST3-III (NIR)**
  Set up in 2017
• So, what’s next after next?
We are marinating that….

KDUST
(Kunlun Dark Universe Survey Telescope)
aperture: 2.5 m
(optical & Infrared)

Chinese Polar Astronomy Center
PI: Lifang Wang
- Weak lensing
- Galaxy and black holes
- High $Z$ super Nova, gamma-ray
- Exoplanet characterization
Conclusions:

1. Dome A is one of the best sites for time-domain astronomy, especially for exoplanet transiting survey, micro-lensing...

2. However, as now it is fully ‘automatic’ site, we are still facing many challenges to make it work.

3. A successful transit survey on Dome A can complemental to some ground projects (e.g. WASP, HAT, NGTS, etc,) and space projects (TESS, PLATO) .
Thank you!