Searching for habitable planets

Bright Star Survey Telescopes (BSST)

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2014.2.25, Chengdu, China
Finding habitable exoplanets is one of the most important goals in Human history.

- With radial velocity method, there are > 800 exoplanets confirmed (exoplanets.org)
- None of them are confirmed to habitable.
Achievement of Kepler Mission

Kepler’s Planet Candidates
22 Months: May 2009 - Mar 2011

- Kepler Mission detected > 3600 candidates;
- Most of them are around dim stars, so only 246 are confirmed.
- It only searched for 105° of sky.

Credit: NASA Kepler team

Search for HP with a photometry of 0.01%, it can only achieved by Space Missions.
There are similar projects proposed after Kepler:


TESS: a full sky survey, aiming at mostly short period orbits
Location: Earth lunar 2:1 resonance orbits

Credit: PLATO team

Planed at: 2020-2022

Orbit: Solar-Earth L2
In its nominal science operation phase, PLATO 2.0’s current baseline observing strategy combines:

- **Long-duration Observation Phases**, consisting of continuous observations for two sky pointings, lasting a minimum of 2 years with a maximum of 3 years for the first pointing, and 2 years coverage for the second pointing.

- **Step-and-Stare Operation Phases**, consisting of shorter-period observations of several sky fields which will last 1-2 years total, depending on the duration of the long duration phases. Sky fields in this phase will be observed for at least 2 months, up to a maximum of 5 months.
BSST (Bright Stars Survey Telescopes)

- **Main Payload**: 10cm x 10 Telescopes, FOV $15^\circ \times 15^\circ \times 4 = 1350^\circ$
- **Orbit**: NEO $>200$km
BSST Satellite

FOV: 15° x 15° x 6 = 90°

Orbit Height: 500 km
Orbit Period: 90 min

Total FOV: 15° x 90° x 6 = 8100 Square Degree

Turning Angle: 105°

Tracking Interval: 7 min each
Pointing Interval: 3 min each
Sky Coverage: $1350^\circ \times 6 \times 2 = 16200^\circ$

**Figure 2:** The observed regions (~16,200 square degrees, top and bottom bright area) of BSST as compared with the 3-year observation area of PLATO 2.0 (two pink squares) and Kepler.
Table 1: Predicted No. of planet candidates detected by BSST.

<table>
<thead>
<tr>
<th>Vmag</th>
<th>Nstar</th>
<th>Nstar (G,K,M)</th>
<th>Precision</th>
<th>Predicted No. of planet candidates by BSST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;1.25Re</td>
</tr>
<tr>
<td>6.5-8.0</td>
<td>14,000</td>
<td>7,600</td>
<td>0.01%</td>
<td>48</td>
</tr>
<tr>
<td>8.0-10.0</td>
<td>108,000</td>
<td>56,000</td>
<td>0.05%</td>
<td>0</td>
</tr>
<tr>
<td>10.0-12.0</td>
<td>680,000</td>
<td>&gt;28,000</td>
<td>0.5%</td>
<td>0</td>
</tr>
<tr>
<td>Totally</td>
<td>800,000</td>
<td>90,000</td>
<td>-</td>
<td>48</td>
</tr>
</tbody>
</table>
## A comparison of TESS, PLATO, BSST

<table>
<thead>
<tr>
<th></th>
<th>TESS (Long)</th>
<th>TESS (Short)</th>
<th>PLATO (Long)</th>
<th>PLATO (Short)</th>
<th>BSST (Long)</th>
<th>BSST (短模式)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sky coverage</td>
<td>3280°</td>
<td>38,000°</td>
<td>4500°</td>
<td>15750°</td>
<td>16200°</td>
<td></td>
</tr>
<tr>
<td>Orbit period</td>
<td>&lt;2/3 year</td>
<td>month</td>
<td>1 year</td>
<td>1 month</td>
<td>1 year</td>
<td></td>
</tr>
<tr>
<td>0.01% Precision</td>
<td>4.0-7.5 Mag</td>
<td>4.0-7.5 Mag</td>
<td>4.0-11.0 Mag</td>
<td>4.0-11.0 Mag</td>
<td>6.5-8.0 Mag</td>
<td></td>
</tr>
<tr>
<td>0.1% Precision</td>
<td>7.5-12 Mag</td>
<td>7.5-12 Mag</td>
<td>11.0-16.0 Mag</td>
<td>11.0-16.0 mag</td>
<td>8.0-12 Mag</td>
<td></td>
</tr>
<tr>
<td>Expected Terrestrial Planets</td>
<td>20 (may be &lt;2/3yr)</td>
<td>Total 60</td>
<td></td>
<td></td>
<td>48（mostly HP） (10 times less expensive)</td>
<td></td>
</tr>
<tr>
<td>Launch time/Life time</td>
<td>2017 (USA)</td>
<td>4 years</td>
<td>2020-2022 (ESA)</td>
<td>6-8 years</td>
<td>2020? (China+ESA?)</td>
<td>3 years</td>
</tr>
</tbody>
</table>
Scientific aim of BSST

1. Searching for exoplanet candidates: to searching for >10,000 candidates, ~48 Terrestrial plants, mostly in Habitable zone, and understanding planets system with precise stellar parameters;

2. Stellar seismology: >800,000 star’s 3 year continues high-precision light curves; Variable stars;

3. Transient sources: Gammy Ray busts, supernova, …
Heritage from previous studies

- NIATO has constructed 10cmx4 CSTAR, put in Dome A, Antarctic, and it worked > 4 years—Ground techniques are OK.

Wang et al. 2014
Possible collaborators:

- **Techniques**: for space telescopes,
- **Budget**: RMB ~10M is enough for Payload.
- **Possible collaborators in Europe**: PLATO 2.0 group & Dome C exoplanet team
- **Near Infrared Camera**: Hot Jupiter’s 2\textsuperscript{nd} transit: Temperature $\Rightarrow$ composition----Unique Mission!

![Graph](image)

**Emission spectroscopy (day side, secondary transit)**
Thank you!

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