NEAT workshop

Science Case #3
Diversity of exoplanets : the case of young stars

Incidence and properties of young planets

Many critical questions concerning the formation and early evolution of gas and ice giant planets suffer from a near-total lack of data about the properties of planets orbiting young stars.

- What processes affect the formation and dynamical evolution of planets?
- When and where do planets form?
- What is the initial mass distribution of planetary systems around young stars?
- How might planets be destroyed?
- What is the origin of the eccentricity of planetary orbits?
- What is the origin of the apparent dearth of brown dwarf companions to mature stars?
- What accretion mechanisms might explain the apparent gap between the critical core mass and planets of Jupiter-Saturn mass?
- How might the formation and migration of gas-giant planets affect the formation of terrestrial planets?
- How do the observable properties of a planet change with its mass and evolve with time?
Requirements in terms of astrometry

Astrometric surveys of young stars will probe the critical region between 1-5 AU where gas giants are thought to form, but where imaging techniques are hardest pressed to detect objects of <5 MJup.

<table>
<thead>
<tr>
<th></th>
<th>1 M Star</th>
<th>0.15 M Star</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance, pc</td>
<td>Distance, pc</td>
</tr>
<tr>
<td></td>
<td>Orbit, AU</td>
<td>Orbit, AU</td>
</tr>
<tr>
<td></td>
<td>30 pc</td>
<td>140 pc</td>
</tr>
<tr>
<td>Planet</td>
<td>1</td>
<td>5.2</td>
</tr>
<tr>
<td>Jupiter, 1 MJup</td>
<td>32</td>
<td>170</td>
</tr>
<tr>
<td>Saturn, 0.28 MJup</td>
<td>9</td>
<td>47</td>
</tr>
<tr>
<td>Uranus, 0.023 MJup</td>
<td>0.7</td>
<td>4</td>
</tr>
</tbody>
</table>
Parameter space

Sensitivity of different techniques to planets in the mass–semi-major axis plane for young 1Msun stars (<5 Myr) at a distance of 140 pc. A representative population of planets seen around nearby mature stars is shown to indicate what we might find when looking at young stars. SIM Lite sensitivity estimates are given for worst-case and best-case scenarios for starspot noise (Beichman et al. 2009)
Star spots on young stars?

Using a simple model for the effect of starspots on the stellar photocenter (Beichman 2001; Tanner et al. 2007), the astrometric jitter for a typical T Tauri star at 140 pc is less than 3 μas (1σ) for R-band variability less than 0.05 mag.

Thus, the search for Jovian planets is plausible for young stars less variable than ~0.05 mag in the visible. If stellar jitter follows the t^{-0.5} dependence seen for calcium plage activity (Skumanich 1972) then a 40-Myr-old, 0.15 Msun star at a distance of 30 pc would have an astrometric jitter at <0.5 μas making planets of super-Earth to Uranus masses detectable over the semi-major axis range of 1 to 5 AU.
Potential Targets for Young Star Survey

![Chart showing distribution of targets by distance and age categories.]

- BetaPic (12 Myr, 35 pc)
- ABDor (50 Myr, 30 pc)
- Young (<10 Myr)

+ Hyades cluster