Search and characterization of young planets with GAPS

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Protoplanetary disks
Osservatorio Astronomico di Roma, Monte Porzio Catone (RM), Italy
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GAPS: Global Architecture of Planetary Systems

- Collaboration among ~80 Italian scientists (+ external collaborators) in the exoplanets field since 2012
- Long-term radial velocities survey with HARPS-N@TNG
- Search and Characterization of the architectural properties of planetary systems

Objectives:
- **Frequency** of exoplanets around M stars, metal poor stars, stars in open clusters
- Search for **additional low mass companions**
- **Characterization** through Rossiter-McLaughlin effect and Asteroseismology/SPK (star-planet interaction) and orbital refinement of known systems
A coordinated and solid Italian community for the Exoplanets study

- 17 “GAPS” papers
- 12 papers from collaboration (HADES, H-N GTO, ...)
- Many others in preparation
- Results in line with previous RV surveys
5 years of GAPS observations: Quick look to the results

- 1st binary with both stars hosting planets
- 1st planetary system in OC star
- 3 long period giant planets with close companion (HJ or SE)
- Super Earth system around M dwarf
- Giant companion around giant star (GIARPS ante litteram)
- SE with one temperate Saturn + cold Jupiter mass companions
- 3 giant planets in open clusters
- Long period planet around metal poor star
- ...

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<th>Planet frequency</th>
<th>Field G dwarfs</th>
<th>Stars with planets</th>
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<td>P&lt;50d M&lt;30M_E</td>
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To be updated!!
Planets migration: hot Jupiters

Smooth disc migration
- small eccentricities
- spin-orbit alignments

High-eccentricity migration
- circular orbits + short periods/
  eccentric orbits + long periods
- spin-orbit (mis)alignments

Adapted from Dawson & Asher Johnson 2018
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1-10 Myr

Adapted from Dawson & Asher Johnson 2018

YOU MUST SEARCH FOR YOUNG PLANETS!
The opportunity of GAPS

**Planet detection**

Young stars are very active: Simultaneous VIS-NIR observations allow to disentangle between RV “jitter” and Keplerian RV modulations.

**Characterization of planets atmosphere**

Huge spectral range to search for the molecular compound of hot giant planets.

**Observables:**

- Planet frequency around young stars + Orbital parameters to understand **how** do the planet migrated.
- Atmospheric composition to understand **where** do the planets formed.
The opportunity of

**Observables:**
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**GAPS2 WPs:**
- Young Objects (YO)
- Atmospheres (AT)
- Super Earths in the Habitable Zone of M-dwarfs

**Planet detection**
Young stars are very active: Simultaneous VIS-NIR with RV

**Characterization of planets atmosphere**
Huge spectral range to search for the molecular compound of hot giant planets
GAPS2 Young Objects program
Objectives and strategy

- Monitoring young (< 20 Myr) and intermediate age (< 700 Myr) stars to search for **hot Jupiters (HJ) in formation** or at the early stage of their **evolution** within the timescales of migration.
- Confirm/Retract the apparent higher **frequency** of HJ around very young stars (age < 10 Myr, Donati+2016, Yu+2017).
- At least **50 epochs** for each target to retrieve Keplerian signals up to 5-10 times lower than the stellar activity jitter (possible with Gaussian processes).
1. Planet candidates program

2. Discovery program
   - Intermediate age: robust data treatment
   - Young: exploration of strategy and techniques
     - RV archives
     - known rotation period
     - “Small” vsini < 20 km/s

3. TESS Candidates (>2019)

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<tr>
<th>Stars</th>
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<tr>
<td>Taurus</td>
</tr>
<tr>
<td>Cepheus</td>
</tr>
<tr>
<td>Hyades</td>
</tr>
<tr>
<td>Coma</td>
</tr>
<tr>
<td>Upper Sco</td>
</tr>
<tr>
<td>Leonis</td>
</tr>
<tr>
<td>Ursa Major</td>
</tr>
<tr>
<td>AB Doradus</td>
</tr>
</tbody>
</table>
The Young sample

<table>
<thead>
<tr>
<th>Star</th>
<th>mag</th>
<th>Mass $M_\odot$</th>
<th>age</th>
<th>vsini [km/s]</th>
<th>$P_{\text{rot}}$ [d]</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>YO01</strong> M0 WTTS Taurus</td>
<td>V12.1 H8.6</td>
<td>1</td>
<td>2 Myr</td>
<td>30</td>
<td>2.7</td>
<td>Giant Planet claimed</td>
</tr>
<tr>
<td><strong>YO15</strong> K0 CTTS Upper Sco</td>
<td>V12.6 H6.7</td>
<td>0.9</td>
<td>3 Myr</td>
<td>11</td>
<td>6.8</td>
<td>Giant Planet claimed</td>
</tr>
<tr>
<td><strong>YO16</strong> K3 WTTS Upper Sco</td>
<td>V12.1 H8.5</td>
<td>0.78</td>
<td>5-10 Myr</td>
<td>10</td>
<td>5.5</td>
<td></td>
</tr>
</tbody>
</table>

very preliminary results...
YO01: Planet candidate in Taurus

Not optimal sampling

Not enough for a clear detection of the planet signal

New observations foreseen in the next season

HARPS-N RV scatter: ~400 m/s
GIANO-B RV scatter: ~950 m/s
YO15: strong indication of accretion (Upper Sco)

High variability of the main accreting diagnostics in ~ one week

\[ \Delta \log M_{\text{acc}} = 0.3 \text{ dex for } 1 \, M_\odot \]

Consistent with the variations in the CTTS (see discussion with J. Alcala’ + talk L. Venuti)
YO15: discarded for planet search

YO15
vsini = 15 km/s
SpT = K0

No photospheric lines:
- No parameters
- No lines useful for RV determination

BD+20 1790
vsini = 10 km/s
SpT = K5

CTTS are not suitable targets for RV search (talk by V. D’Orazi)
YO16 (WTTS in Upper Sco)

No accretion features detected

HARPS-N:
- RV scatter: 236.2 m/s
- RV mean error: 4.4 m/s

GIANO-B:
- RV scatter: 130.9 m/s
- RV mean error: 89.8 m/s

amplitude ratio:
- VIS/NIR = 1.8

Too few and sparse RV data to search for rotation period

HARPS-N RV scatter from residuals: 24 m/s
Comparison with YSO in Lupus

Adapted from Alcala’ et al. 2017

\[ \log(L_{acc}) \text{ (lines)} \]
After 3 semesters (1 with a “short” Pilot program + 2 as large program) GAPS2 will report to INAF to confirm the LP status (4 more years)

- More data are needed to enrich our time series
- ESO LP with HARPS submitted to complement YO
- Sinergy with GAIA DR2 (stellar parameters, membership)
- Future collaboration with the community working on protoplanetary disks??
Thank you!