PLAnetary Transits
and Oscillations of stars

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on behalf of the PLATO Consortium

http://www.oact.inaf.it/plato/PPLC/Home.html
What is PLATO?

- planet transit experiment + seismic analysis (stellar oscillations) of host stars

- ultra-high precision, long, uninterrupted photometric monitoring of very large samples of bright stars: CoRoT - Kepler heritage

- medium-class candidate mission to the ESA Cosmic Vision programme

- currently under assessment study:
  2 concurrent industrial studies of full mission
  + 1 payload study by PLATO consortium
PLATO Objective #1

- detect and characterize exoplanets of all kinds, including telluric planets in the habitable zone
- combine transit and radial velocity observations = essential for planet characterization

- photometric transits: orbit, radius, inclination
- radial velocity follow-up: confirmation, mass

region becoming accessible to both space photometry (transits) and RV follow-up = goal of PLATO

transiting planets

CoRoT-7b

radial velocity surveys

planet density, internal structure
PLATO Objective #2

precise and reliable characterization of the host stars via seismic analysis

→ star radius, mass, age  →  planet radius, mass, age

stellar masses and ages are not determined well enough with classical methods

now entering a new era:

Gaia + GB spectro → radii to within 2% (\( L = 4\pi R^2 \sigma T^4 \))
PLATO seismology → masses to within 2% (model independent)
→ ages to within 10%
Why we need to focus on bright stars

1. need to detect transits from small planets:
   - ultra-high S/N photometry

2. need for high precision RV follow-up:
   - high res, high S/N, high stability spectroscopy

3. need for precise characterization of host stars:
   - radius, mass, age: asteroseismology
   - chemical composition, rotation, activity:
     - high res, high S/N spectroscopy

4. further observations of detected systems:
   - on-off transit spectroscopy
   - secondary transits
   - reflected light analysis
   - ...
The PLATO star samples

main point of PLATO: focus on bright stars !!

basic science requirements

> 20,000 bright ($m_V \leq 11$)

cool dwarfs/subgiants ($\geq$F5V&IV):

- exoplanet transits
- AND
- seismic analysis of their host stars
- AND
- ultra-high precision RV follow-up

noise < 2.7 \times 10^{-5} in 1hr

for 3 years

> 1,000 very bright ($m_V \leq 8$)

cool dwarfs/subgiants for 3 years

> 250,000 cool dwarfs/subgiants ($\sim m_V \leq 13$)

exoplanet transits

+ RV follow-up

noise < 8 \times 10^{-5} in 1hr

for 3 years

> 3,000 very bright ($m_V \leq 8$)

cool dwarfs/subgiants

for > 5 months

exoplanets

around bright and nearby stars

> 250,000 cool dwarfs/subgiants ($\sim m_V \leq 13$)

exoplanet transits

+ RV follow-up

noise < 8 \times 10^{-5} in 1hr

for 3 years
The PLATO Payload Consortium concept
(= one of three different concepts)

the challenge:
very wide field-of-view
AND large collecting area

multi-telescope concept

Basic concept
- 40+2 telescopes
- overlapping line-of-sight

four subsets of 10 telescopes
• 4 different lines of sight,
• 3 different zones:
  ➢ 200°² seen by 40 telescopes
  ➢ 800°² seen by 20 telescopes
  ➢ 800°² seen by 10 telescopes

Optimizes both number
and brightness of targets

- 2 long pointings (3 + 2 yrs)
  very small planets, long orbits

- 1 yr step & stare
  flexibility: very wide survey
  2nd visits

(11,000 deg² = 25% of whole sky!)
PPLC Payload

40+2 telescopes

fully dioptric design
12cm pupil, 28°x28° field

75 cm equivalent

3.66 m

FPA: 4 CCDs 3584², 18µ

25 sec cycle
8-13 mag

2.5 sec cycle
4-8 mag

X 40

X 2

40+2 telescopes

fully dioptric design
12cm pupil, 28°x28° field

75 cm equivalent
Performances (1/2)

highest priority targets

all sources of noise (incl. confusion)

80 ppm/hr

27 ppm/hr

photon noise only
Performances (2/2)

<table>
<thead>
<tr>
<th>noise level ($10^{-5}$/hr)</th>
<th>PLATO industry 1 3600 deg$^2$</th>
<th>PLATO industry 2 1250 deg$^2$</th>
<th>PLATO PPLC 3600 deg$^2$</th>
<th>Kepler 100 deg$^2$</th>
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<tr>
<td>2.7</td>
<td>cool dwarfs mag /subgiants lim</td>
<td>cool dwarfs mag /subgiants lim</td>
<td>cool dwarfs mag /subgiants lim</td>
<td>cool dwarfs mag /subgiants lim</td>
</tr>
<tr>
<td>24,000</td>
<td>10.4</td>
<td>21,000</td>
<td>23,000</td>
<td>1,300</td>
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<tr>
<td>374,000</td>
<td>12.7</td>
<td>257,000</td>
<td>316,000</td>
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<th>magnitude</th>
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<td>1,350</td>
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<td>1,320</td>
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<td>370</td>
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<tr>
<td>11</td>
<td>11</td>
<td>16,800</td>
<td>1,300</td>
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</table>

numbers of cool dwarfs and subgiants observable by PLATO and Kepler, for various photometric noise levels and various magnitudes
Science impact

estimated numbers of detected transiting planets for PLATO and Kepler:
- using star counts in PLATO «template» field
- assuming each star has one and only one planet
- planet characteristics (mass, radius, orbit) are assumed equiprobable (no model)
- planet is assumed detected if transit signal AND radial velocity signal can be measured
- stellar intrinsic «noise» taken into account

The lower right corner of the (orbit, mass) plane, not covered by Kepler, will be explored by PLATO thanks to its priority on bright stars.
Further science impact

Examples:

Stellar reflected light  Planet secondary transits

characterize planet surface/atmosphere

Astrometric detection of giant exoplanets

Identify/study exoplanets around nearby stars = privileged targets for further investigation, e.g. with JWST, e-ELT, etc.
Summary & Conclusion

Building on CoRoT and Kepler experience,

- **PLATO** is a next generation planet finder and characterizer
- its focus will be mainly on bright and nearby targets
- it will detect and characterize significant numbers of telluric planets in the habitable zone
- **PLATO** will represent a major step forward after the pioneering CoRoT and Kepler missions

The importance of being bright: >60% of papers on transiting planets involve the brightest two objects!
PLATO: overview

PLATO objectives:
- search for planetary transits in front of large samples of bright stars:
  > 20,000 cool dwarfs/subgiants brighter than $m_V=11$
- perform seismic analysis of their host stars

PLATO concept:
- ultra-high precision, long (up to 3 years), uninterrupted photometric monitoring
- very wide surveyed area: 3600 deg$^2$ monitored for up to 3 years
  up to 11,000 deg$^2$ monitored for a few months
- large collecting area (~75cm equivalent)
- multi-telescope concept

PLATO performances:
- noise level $< 2.7 \times 10^{-5}$ / hr down to $m_V = 10-11$, > 20,000 cool dwarfs/subgiants
- noise level $< 8.0 \times 10^{-5}$ / hr down to $m_V = 12-13$, > 300,000 cool dwarfs/subgiants
- 1,350 cool dwarfs/subgiants with $m_V \leq 8$
- 13,000 cool dwarfs/subgiants with $m_V \leq 10$
- 48,000 cool dwarfs/subgiants with $m_V \leq 11$

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