The PLATO space mission and the quest for habitable worlds

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PLATO mission status

- Selected in February 2014 as the M3 “medium-class” mission in the ESA Cosmic Vision Programme
- Definition phase completed in 2016
- Adoption by the ESA Science Programme Committee on 20 June 2017, with a target launch in 2026
- The implementation phase has started
- ESA provides:
  - Satellite platform, payload CCDs
  - Mission and Science operations centres
- The Mission Consortium provides:
  - Payload
  - Contribution to Science operations
Planets are very diverse

We need accurate planetary radii and masses to understand exoplanet diversity.
Need to observe bright stars
Known small exoplanets and the HZ

1< \( M_{\text{planet}} \leq 10 M_E \)

\( R_{\text{planet}} \leq 2 R_E \)
Bulk characterised super-Earths

LHS 1140b: RV mass
TRAPPIST-1 planets: TTV masses

1 < M_{planet} ≤ 10M_E
R_{planet} ≤ 2 R_E
Bulk characterized super-Earths - PLATO

PLATO will detect and characterise planets up to the habitable zone of solar-like stars.
PLATO Methods

Transit method

Orbit parameters
Orbital inclination, $i$
Planet-to-star radius ratio

Filtering of false positives (ground-based observations)

Orbit parameters
Orbital inclination, $i$
Planet $R, M$

Asteroseismology

Precise stellar $R, M, age$

Orbit parameters
Minimum planet mass, $M \sin i$

Stellar $R, M$ from catalogues (e.g. Gaia)

Radial velocity (ground based observations)

Orbit parameters

Orbit Parameters
Planet $R, M, age$
Diversity of Super-Earths

PLATO will determine:

- radii (3% accuracy)
- masses (10% accuracy)
- ages (10% accuracy)

for Earth-like planets orbiting G stars with $V < 10$

Buchhave et al. (2016)
Additional science

Other topics in planetary science:
- Circumbinary planets
- Exomoons
- Rings/comets
- Misaligned planets
- Planets around young and evolved stars

Complementary science (e.g.):
- Stellar and Galactic evolution: Gaia synergy
  - Gaia: radius, distance, proper motion, luminosity, Teff, log g
  - PLATO: stellar masses, ages
- Accretion physics near compact objects
Exomoons can be detected with transit time variations, transit duration variations, or orbital sampling effect in the phase-folded transit light curve (OSE, e.g. Heller et al. 2016)

OSE simulation for PLATO

G dwarf star ($m_V = 8$) transited by a Jupiter-sized planet ($P = 45$ d) with a $0.7 \, R_E$-sized moon
Observing strategy

• Long uninterrupted photometric monitoring of bright stars in the visible band
  • Core sample: ~15,000 sun-like stars of $m_V < 11$
    
    *to be complemented with radial velocity ground-based observations*
  • Statistical sample: >245,000 stars of $m_V < 13(16)$

• Mission nominal science operations: 4 years
  ➢ Baseline strategy:
    2 long pointings, duration 2 years each
    *(will be fixed two years before launch)*
  ➢ Satellite/instrument designed to last with full performance for 6.5 years
  ➢ Consumables will last 8 years

Credit: V. Nascimbeni
PLATO satellite

Launch in 2026 into orbit around L2 Earth-Sun Lagrangian point

Multi-telescope approach

- Large FOV (large number of bright stars)
- Large total collecting area (high sensitivity)
- Redundancy
- 24 «normal» cameras, cadence 25 sec
- 2 «fast» cameras, cadence 2.5 sec, 2 colours

Airbus

OHB
PLATO cameras

Dynamical range: $4 \leq m_V \leq 11$ (16)

Focal plane: 104 CCDs (4 CCDs per camera) with $4510 \times 4510$ 18 $\mu$m pixels

Instantaneous field of view $\sim 2250$ deg$^2$

One of the 24 “normal cameras”
A new era of planetary sciences

PLATO will detect transit signals of thousands of planets which are bright enough for radial velocity spectroscopy to determine their masses

PLATO will provide:
• A sample of well characterised Earth-Sun analogues
• Characterised terrestrial planets in the HZ
  ➢ high accuracy in radius, mass, age
• Enough accuracy to study small-planet diversity – how unique is Earth?
• Planets at all ages, understand planet evolution
• Accurate knowledge of the host stars, including its activity
• A target list for atmosphere spectroscopy