μAstrometry

Exploring planets in the solar neighbourhood

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A mission to detect planets around the **200 nearest** solar-like stars by ultra-high precision astrometry (~μarcsec)

*Fig. 1*: A 3D representation of the F, G, K stars within 15 pc from us.
Astrometric signal
Why nearby systems?

- Best opportunities for high-S/N studies of planets
- Prime targets for direct detection and future *spectroscopic* missions (e.g. TPF, Darwin)
- Strongest astrometric signals for given planets:
  \[ A \sim 3\mu\text{as} \left( \frac{M_p}{M_{\text{Earth}}} \right) \left( \frac{a}{\text{AU}} \right) \left( \frac{D}{\text{pc}} \right)^{-1} \]
Why astrometry?

• Transits searches will not find the nearest planets because of required geometry

• Radial velocity most sensitive to shorter period planets around “nice” stars

• The astrometric sensitivity increases with orbital period, up to the mission duration – ideal for planets in the “Habitable Zone”

• GAIA will find thousands of massive planets, but will saturate for nearby stars (V<6 mag)
Primary objectives

• Exhaustively detect *all* gas giants planets in the *Habitable Zone*, i.e. jupiters, saturns (down to 50 $M_{\text{Earth}}$), around our 200 nearest solar-like stars

• Down to 10 $M_{\text{Earth}}$ around the nearest 25 stars

• For $\alpha$ Cen A & B, sensitivity down to Earth-mass!

• Complete characterisation of orbits (inclination, eccentricity, semi-major axis, planet mass)
μAstrometry

Detector spacecraft

Focal plane array (FOV~0.6°, Ø~15cm)

Young’s interference fringes

Focal length (~12m)

Telescope spacecraft

Sun shades

Telescope axis beam

Metrology

Off-axis parabolic mirror (D~30cm)
Characteristics

- Mirror module and focal plane array module
- Spacecraft separation 12m
- Precision formation flying (< 1 cm)
- 30 cm mirror with tip-tilt at 50 Hz
- Precision focal plane array metrology (<4×10⁻⁵ pix)
- L2 orbit, 3 year mission
Cost-effective: space-proven formation-flying with off-the-shelf hardware. Estimated cost for platform with modifications to suit μAstrometry: 20 M€
Precision metrology

- 3×3 array of CCDs developed for EUCLID
- Position accuracy of metrology system achieved in lab: <4×10^{-5} pixel
FOV~0.6°, Ø ~ 15cm

4096x4096 Euclid CCD

Moving Young’s Interference fringes

Science target
Telescope axis beam
Reference stars

Focal Plane
• \(\mu\)Astrometry has unique science capabilities not found in existing and planned exoplanet missions

• \(\mu\)Astrometry is proposed to build upon the existing and proven formation-flying platform PRISMA, providing a very cost-efficient solution

• The required metrology precision has been proven in the lab
Target star: HIP 27072

- Tycho2 reference star ID (Vmag)
- Best Tycho2 reference star per quadrant
Science questions

- How frequent are planetary systems in the HZ?
- What is the architecture of planetary systems in the HZ?
Figure 9: Control error observed by RF nav, GPS nav, and POD during the 1st session

$\sigma = 4 \text{ cm}$
Simulation \( (50 \, M_{\text{Earth}}, 1.5 \, \text{AU}, 10 \, \text{pc}) \)
Targets distance distribution

- F stars
- G stars
- K stars

Number of stars vs. Distance to Sun (pc)