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STEP Mission: Search for Terrestrial Exo-Planets

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Abstract

Search for Terrestrial Exo-Planest (hereafter STEP) mission is a latest advanced research project in Chinese Strategic Pioneer Program (SPP) on Space Science. STEP aims at the nearby earth-alike planets detection, comprehensive research on the planetary system and some astrometry research with 0.5 uas precision in the space, which will get the fruitful achievements in the exo-planetary and astrometry research fields. STEP will take the Space Astrometry technique in the optical band. The FOV is 0.44 degree, based on 1.2m primary and focus length is 50m. The special metrology technique will be taken to reach 0.5 uas astrometry precision, which will be idea for terrestrial exo-planets detection. The mission will take the L2 orbit.

1. Introduction

With the present state of exo-planet detection techniques, none of the rocky planets of the Solar System would be detected and indeed their presence is a very strong constraint on the scenarios of the formation of planetary systems. By measuring the reflex effect of planets on their central host stars, astrometry can lead us to the mass of planets and to their orbit determination. This technique is used frequently and is very successful to determine the masses and the orbits of binary stars. However it is necessary to go to space to reach the precision required to detect all planets down to the telluric regime. We proposed STEP to Chinese Strategic Pioneer Program (SPP) on Space Science and just approved to be the advanced research project. The objective is to use differential astrometry to complete the measurements obtained by other techniques in order to lower the threshold of detection and characterization down to the level of an Earth mass in the habitable zone of each system. We want to explore in a systematic manner all solar-type stars (FGK spectral type) up to 20 pc from the Sun.

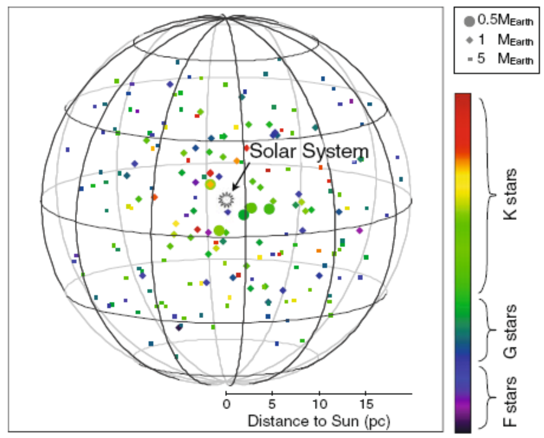

Figure 1: STEP targets in 3-D sphere of Sun neighbourhood

2. Technique

One of the fundamental aspects of the STEP mission is the extremely high precision required to detect exo-Earths in habitable zone by astrometry. The amplitude of the astrometric signal that a planet leaves on its host star is given by the following formula:

$$A = 3\left(\frac{M_P}{MEarth}\right)\left(\frac{a}{1\,\mathrm{AU}}\right)\left(\frac{M_*}{\mathrm{M}_\odot}\right)^{-1}\left(\frac{D}{1pc}\right)^{-1}[\mu\mathrm{as}]$$

For an Earth in the habitable zone located at 10 pc from the sun, the astrometric signal is 0.3 micro arc-seconds This is smaller than the precision announced for the Gaia mission which should be 6 µas, in optimal conditions. With a focal length of 50 meters, and taking into account a required signal to noise ratio of 6 and the required number of measurements per target, the 0.3 µas requirement to detect an Earth at 10 pc translates into a need to calibrate the pixelation error to 5×10^{-6} pixels for each integration.

High-precision astrometry technique is ideal for the terrestrial exo-planets detection. The long-focus around 50m design can make ultra precise < 1 uas (microarcsec) astrometry measurements of nearby stars in a ~ 2hr observation. Four major error sources prevent normal space telescopes from obtaining accuracies close to 1 uas. Even with a small dish telescope, photon noise is usually not a problem for the bright nearby target stars. But in general, the reference stars are much fainter. Typically a field of view of ~0.5 deg dia is needed to obtain enough bright reference stars. The STEP concept uses a very simple but unusual design to avoid optically induced astrometric errors. The third source of error is the accuracy and stability of the focal plane. A 1uas error over a ~2000 arcsec field of view implies the focal plane is accurate or at least stable to 5 parts in 1000 over the lifetime of the mission (~5yrs).

3. STEP Configuration

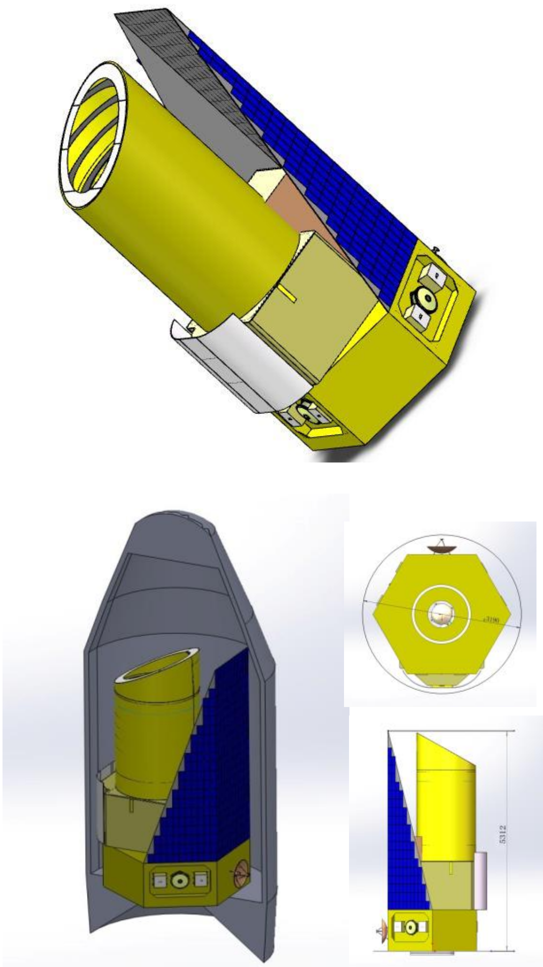

Figure 2: STEP Spacecraft Configuration.

4. STEP Mission Profile

1	**Aperture of Primary**	**1.2m**
2	**Focal length**	**50m**
3	**FOV**	**0.44^0**
4	**Focal plane**	**400mmX400mm**
5	**Designed precision**	**0.5uas**
6	**Orbit**	**L2 Halo**

5. Science Operation

STEP science operations will consist for 70% of the time in a survey of our closest F, G and K neighbors (main program) and for 30% to pointed observations in predefined domains (additional programs). It requires some preparatory work, and the data reduction-without being exactly the same as Gaia - will benefit from its developed structures. The data rate will reach 65Gb/day requiring the use of a 64-m antenna for 1.8 h each day. The final data processing work will last one year after the mission completion, but we expect to deliver intermediate solutions during the observations.

6. Perspectives

Currently STEP is selected as the advanced research project in Chinese Strategic Pioneer Program (SPP) on Space Science, hopefully it will be approved to enter phase B in two years and then wait for launch in 2020. International collaborations are welcome!

References

[1] Zhai, C., Shao, M., Goullioud, R., Nemati, B.:Micro-pixel accuracy centroid displacement estimation and detector calibration. Proc. R. Soc. A, 2011.

[2] F. Malbet, A. Legar, M. Shao, et. al..: High presicion astrometry mission for the detection and characterization of nearby habitable planetary systems NEAT, Exp Astron, 2012.