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Eye-Sat, a triple Cubesat to monitor the zodiacal light intensity and polarization

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Abstract

Eye-Sat is a small telescope in a triple Cubesat, under development by students, mostly working at CNES. It should, in 2016-2017, provide a survey of the intensity and polarization of the light scattered by interplanetary dust cloud, leading to a better understanding of the properties and origin of its particles.

1. Introduction

CNES, the French Space Agency, has developed since 2012 the JANUS project, helping students to build their own nanosatellite. In this context, the triple Cubesat Eye-Sat is being developed by students of French engineering schools working at CNES as interns and students from the IUT (University Institute of Technology) of Cachan, France [1]. Eye-Sat purpose is not only to provide the opportunity for technological demonstrations, but also to study from Earth's orbit the intensity and polarization of the solar light scattered by interplanetary dust particles.

2. Scientific objectives

2.1 Context in planetary sciences

The interplanetary dust cloud extends from the Sun to at least the asteroid belt, with a symmetry plane slightly inclined on the ecliptic plane. Studying, from Earth's orbit, the intensity and linear polarization of the solar light scattered by interplanetary dust, the so-called zodiacal light, is of interest for two reasons. Firstly, the zodiacal light, as a faint glow that extends all over the sky, constitutes a foreground which needs to be corrected for in the observation of faint extended astronomical sources (e.g., circumstellar disks, galaxies), all the more since it varies with the revolution of the Earth around the Sun [2,3]. Secondly, analysis of its polarization provides information on the local properties of the dust particles, such as their spatial density, morphology, composition and albedo. Previous observations, mostly from the Earth and with a resolution in the 5°-15° range, have been used to infer that the local polarization at 90° phase angle increases with increasing solar distance, at least up to 1.5 au in the ecliptic, while the local albedo decreases [2,3]. Simulations of the polarimetric behavior of interplanetary dust particles have suggested that, in the inner solar system, they may consist of a mixture of absorbing and less absorbing materials, that radial changes could originate in a decrease of organic materials with decreasing solar distance (probably due to alteration processes), and that a significant fraction of the interplanetary dust is of cometary origin [4,5].

2.2 Purpose of Eye-Sat observations

Eye-Sat is dedicated to the study, during its nominal one-year mission, of the zodiacal light intensity and polarization from Earth orbit. Measurements should be obtained, for the first time with a high spatial resolution in the 0.5° to 2° range, over a wide portion of the sky and in four different wavelengths (visible and near-IR domains, roughly equivalent to B, V, R, I wide-band filters).

3. Design and mission

3.1 Instrument

The payload consists of a small telescope, with an optical system (13° x 13° field of view, 50 mm focal length), two rotating wheels (for the spectral filters and the shutter, and for the polarizing filters) and a detector (CMOS image sensor with a bayer pattern).

The total size (before solar panels deployment) is of 340 mm x 100 mm x 100 mm (Fig. 1), with a mass of about 4.8 kg. The maximum available power, provided by the four solar panels, is of 20 W. Telemetry will operate in X-band, to download up to 47 Mb/s. A de-orbiting system, allowing atmospheric re-entry within 25 years, will be included. New on-board technologies, developed by CNES R&D, include a 3-color CMOS camera and a dual-core microprocessor with programmable logic.

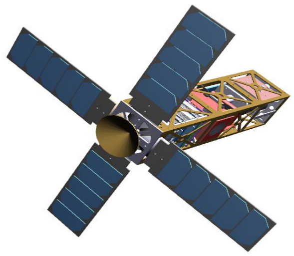

Figure 1: Eye-Sat, with its telescope on the upper right and solar panels on the left

3.2 Observational constraints

Zodiacal light observations need to be free of stray-light, originating not only from the Sun and the Earth, but also from the Earth's atmosphere, the Moon, the bright planets and stars, and our galaxy (typically for galactic latitudes below ± 20°). Constraints in the possibility of observing in a given direction are also related to the onboard startracker's field of view and to the crossing of the South Atlantic Anomaly. Images of major scientific interest are to be obtained by 90° from the Sun near the ecliptic plane (providing, by direct inversion, information on the interplanetary dust properties near the Earth), towards the gegenschein region around 180° from the Sun in the ecliptic (providing information on the dust backscattering properties), and towards the ecliptic poles regions (to assess the geometry of the symmetry plane). Besides, images of the zodiacal cone (along the ecliptic, at a solar distance in the 40° to 90° range) and of the Milky Way are expected to be obtained, at least for outreach purposes.

3.3 Development and launch

Phase A was completed in 2013. Phase B is to be completed in September 2014. The structural model is to be tested for subsystems deployment during a parabolic flight campaign in October 2014. The Qualification Model will be tested in June 2015, and the Flight Model should be ready by January 2016. Eye-Sat is planned to be launched by a Soyuz rocket, in piggy-back with the Microscope micro-satellite in 2016. It will be injected in a Sun-Synchronous Orbit (720 km, 98.27°) for a one-year nominal mission.

4. Conclusions

For the first time, with a single payload in a Cubesat, a one-year high spatial resolution survey of the zodiacal light intensity and polarization, over a wide portion of the sky and in four different wavelengths (in the visible and near IR domains) will be obtained. This will be a new step in understanding the physical properties of the dust particles present in the interplanetary medium, and in estimating their evolution, together with their sources' relative contributions.

Acknowledgements

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