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PRELIMINARY MISSION DESIGN OF CUBESAT FOR HIGH ENERGY ASTROPHYSICS POLARIMETRY

Abstract

Nowadays, in the multi-messenger astronomy era, Compton polarimetry may contribute to a wider understanding of gamma-ray transients combined with gravitational waves detection. Furthermore, high-energy polarimetry allows a deep understanding of the physical processes, geometry and magnetic fields of astronomical sources such as pulsars, solar flares, active galactic nuclei or galactic black holes. So far in astrophysics, only a few and limited high-energy polarimetric measurements with fine statistics have been performed, being the most reliable measurements obtained recently by polarimeter POLAR. Therefore, future missions have been proposed to fill the gap using large monolithic satellites.

However, monolithic satellite platforms tend to be costly and provide limited capabilities, while small satellite platforms provide a great opportunity to experiment, test, and validate the future gamma-ray space observatory concepts based on an agile and relatively cheaper framework within a shorter development lifecycle.

A small CZT (Cadmium Zinc Telluride) gamma-ray detector, pixelated with 2 mm size pixels will be the main scientific instrument used on the CubeSat. The back-end electronics system will allow time coincidence detection between pixels. Coincidence measurements are required for Compton polarization analysis, since photons' direction after undergoing Compton interactions depend on the linear polarization of the respective celestial source emission. Therefore, by measuring the Compton generated double-events it is possible to determine the polarization level and polarization direction of the celestial gamma-ray emission, refining the current knowledge.

The scientific case is presented considering that the background noise rate in the Compton regime polarimetry domain ($\approx 100keV$ up to $\approx 1MeV$) is higher than the source signal rate by one or two orders of magnitude, at orbital altitude. Possibly GRBs (Gamma-Ray Bursts) emissions and Crab source emission might be measured with low sensitivity during the flight.

In this paper, an innovative CubeSat scientific mission aiming to perform a technological demonstration is proposed. The scientific objective is to measure the level of double-events' background noise, as well as the level of single events (photons generating a signal in one pixel only) and of multiple events (photons undergoing multiple interactions in more than two different pixels in the detector).

The paper further presents studies in: feasibility, mission analysis, and the preliminary design of the spacecraft, including a discussion about the payload and remaining subsystems. The paper also includes a management overview of the project. The scientific experiment will contribute to the optimized design of future missions in high-energy polarimetry.