25th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Small Space Science Missions (2)

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MONITORING OF GAMMA-RAY BURSTS WITH A FLEET OF NANOSATELLITES

Abstract

Here we present the results of a feasibility study for a fleet of nanosatellites to perform all sky monitoring and timing based localisation of gamma-ray transients. The fleet shall provide all sky coverage with high sensitivity and localisation accuracy, as well as rapid data downlink following triggers.

We propose a constellation of nine 3U CubeSats equipped with CsI scintillator based gamma-ray detectors, read out by multi-pixel photon counters. Each nanosatellite shall carry four thin, 9mm, and relatively large, 8.4x15cm, detectors as lateral extensions on its surface, on two perpendicular sides. The large thin detectors provide high sensitivity, while leaving enough room for electronics.

In terms of all sky monitoring, the proposed fleet will outperform all past and existing gamma-ray burst (GRB) monitoring missions. For bright short GRBs, by cross-correlating their light curves, the fleet shall be able to determine the time difference of the arriving GRB signal between every two satellite with an accuracy better than 0.1 millisecond. For a constellation of nine satellites, this is the required precision to determine the position of a bright GRB with an accuracy of around 10 arcminutes. This requirement demands precise time synchronisation between the satellites and accurate time stamping of the detected gamma-ray photons. This will be achieved by using miniaturised space borne GPS receivers.

The sources of short GRBs are among the most important sources of gravitational waves (GW) detected with the Laser Interferometer Gravitational-wave Observatory (LIGO). LIGO has a modest localisation accuracy, limiting our knowledge about these astrophysically extremely important events. Simultaneous detections of GWs and GRBs, with accurately measured locations in the sky, will therefore be important for enabling follow up observations, providing valuable multi-messenger information about these exciting events.

Rapid follow up observations at other wavelengths require the capability for fast, nearly simultaneous downlink of data for the triggered events from all satellites in the fleet. This can be achieved using satellite-to-satellite communication using the Iridium network.

The same payload will also provide important secondary science, such as monitoring of outbursts of soft gamma-ray repeaters, Solar flares, terrestrial gamma-ray flashes (produced in thunderstorms), and space weather phenomena, such as monitoring of changed particles in low Earth orbit.

This constellation of satellites is a mission which provides ample potential for international cooperation. Because the proposed fleet is scalable and extendable, we also envision future partners joining with different satellite designs, potentially extending the capabilities of the originally proposed constellation.