iWF-MAXI: Soft X-ray Transient Monitor on the ISS

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Abstract

iWF-MAXI is an X-ray transient monitor mission proposed as an experiment payload on the JEM/EF (Japanese Experiment Module Exposed Facility) of the International Space Station. Its main scientific goals are monitor the large part of the sky in X-ray band to find and localize astrophysical transient events. Prompt X-ray emission associated with gravitational wave events is its prime target. Other targets include gamma-ray bursts, tidal disruption events, stellar flares, nova ignitions, supernova shock breakouts, black hole/neutron star binaries, and active galactic nuclei (AGN). Its main scientific instrument is the Soft X-ray Large Solid Angle Camera (SLC) with a localization accuracy of 0.1 degrees. Its overview and current status are presented.

Key words: Instrumentation: all-sky monitor, X-ray transients, gamma-ray bursts, gravitational waves, X-ray CCD, International Space Station, WF-MAXI

1. *iWF-MAXI* and Overview

iWF-MAXI is an X-ray transient monitor mission proposed as an experiment payload on the JEM/EF (Japanese Experiment Module Exposed Facility) of the International Space Station (ISS). It is designed to be the first X-ray transient monitor in the soft X-ray band (<2 keV) with sufficient localization capability over most of the sky with a cadence of 90 minutes. The detector consists of combination of coded mask and CCD in X and Y coordinates, and is placed on a replaceable small exposed experiment platform named i-SEEP (Fig.1). *iWF-MAXI* has developed with the flight proven technologies from MAXI (Matsuoka et al. 2009) and Hitomi (Takahashi et al. 2014).

Main scientific goal of *iWF-MAXI* is to find and localize the X-ray counterparts of gravitational wave events. The localization enable follow-up observation with X-ray or optical telescopes, leading to measurements of their distance and studies on their environments and progenitors. *iWF-MAXI* is also expected for detection of other transients: 1) short soft X-ray transients such as stellar flares, nova ignitions, and supernova shock breakouts, 2) short high-energy transients such as gamma-ray bursts and tidal disruption events, and 3) Variable X-ray sources such as black hole binaries, neutron star binaries, and active galactic nuclei (AGN). Soft X-ray transient search in the entire sky has huge discovery space for X-ray transients.

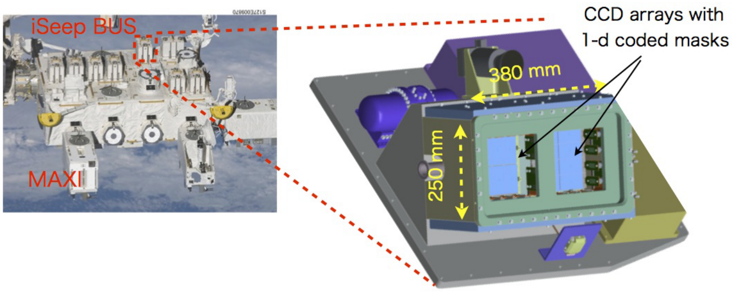

Fig. 1. Schematic view of iWF-MAXI on ISS (©NASA)

2. Important Role of *iWF-MAXI*

The first gravitational wave event GW150916 was detected by Advanced LIGO (Abbott et al. 2016). The waveform matched the prediction of merger of a pair of black holes. A lot of follow-up observation with electromagnetic telescopes were performed but the FoV of them were not enough compared to the localization area by LIGO because the localization by the gravitational wave detector alone are so large. No confirmed electromagnetic counterpart detected. In order to associate the sources with the known astronomical objects, and/or measure their distances, and identify their origins, detection and localization of electromagnetic counterparts are sorely needed. Soft X-ray band is one of the promising channel considering the huge energy density at the source, and yet all-sky monitoring with sufficient sensitivity and cadence has never been performed. *iWF-MAXI* will monitor a large area (15% of the entire sky at any moment) with a high duty cycle (more than 50% of the total real time) to capture rare short X-ray transients. It will localize X-ray transients with positional accuracy of 0.1 degrees. An alert with the coordinates of the source send to the internet for the follow-up observation within several seconds from the in-orbit detection. With MAXI we have demonstrated the flash alert operation (Negoro et al. 2012).

3. Soft X-ray Large Solid Angle Camera (SLC)

The scientific instrument of *iWF-MAXI* is Soft X-ray Large Solid Angle Camera (SLC). it consists 2 units of CCD arrays with 1-d coded masks (X and Y directions). We apply Hamamatsu CCD which is very similar to the model developed for Hitomi/SXI, and with some changes in pixel format and packaging (pin grid array instead of wire bonding). The coded mask for localization is made of 50 μm thick tungsten that stops X-rays with energies below 20 keV. The mask element size is 200 μm. The total opening fraction is about 1/3, determined based on simulations. The energy range of SLC is 0.7 - 10 keV. The sensitivity is 100 mCrab in 100 s (5σ) with effective area of 293 cm^2. Position localization accuracy is 0.1 degrees with FoV of 15% of the entire sky.

We fabricated the bread board model (BBM) of SLC and performed test operations. Figure 2 shows the BBM which consists a CCD chamber, a mechanical cooler and electronics. One CCD was installed inside the chamber. The set up of the SLC BBM was completed and the basic operation of the μ-code in the drive electronics has been confirmed. We plan to evaluate the performance of the CCDs using this SLC BBM, by the end of this fiscal year.

We also performed radiation damage test to the same model CCD at HIMAC. After irradiation equivalent to 8 years in orbit, the SLC CCD performance was similar to that of the spear of the Hitomi CCD (or possibly better), and the charge transfer inefficiency was less than 10^{-4}. Dark current did not affect the energy resolution and dynamic range of the CCD.

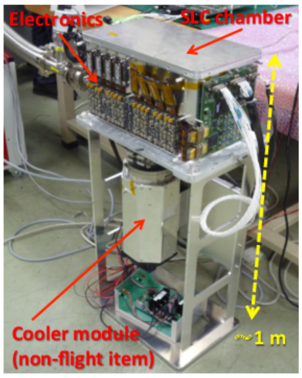

Fig. 2. SLC bread board model

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