Concluding Remarks

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Abstract

The scientific issues discussed at the 3rd MAXI Workshop "The Astrophysics with All-Sky X-Ray Observations" are summarized. MAXI will contribute to the science of Galactic compact X-ray sources, GRBs, AGN, and diffuse X-ray emission from the entire sky. Importance of follow-up observations with focusing X-ray telescopes and multiwavelength coverage are particularly noted.

Key words: MAXI — X-ray transients — X-ray surveys

1. The MAXI mission

At the 3rd MAXI Workshop "The Astrophysics with All-Sky X-Ray Observations" held on June 10–12 at RIKEN, 41 oral papers and 42 poster papers were presented with subjects pertinent to the X-ray all-sky observations with MAXI. The MAXI team members presented the mission concepts, instrument design, science objective, and the data release plan. The characteristics of the MAXI mission and its policies are outlined as follows.

- MAXI has improved sensitivities over the preceding all-sky X-ray monitor missions such as RXTE ASM.
- Most of the sky is covered at least once every 94 minutes with ∼10 mCrab sensitivity.
- There is no intentional bias in the sky coverage. It is limited only by avoidance of the SAA and the direct illumination of the sun.
- Detection of outbursts of X-ray sources will be notified to the community in near real time when ISS has contact with the ground.
- The light curves, and spectra of catalogued sources and the X-ray source map will be made public regularly.
- MAXI has modest position resolution of ∼1.5°. Its localization accuracy for bright X-ray sources is ∼0.1°.
- MAXI's instantaneous field of view is ∼1/60 of the sky, limiting to its capabilities short transient events like gamma-ray bursts.
- MAXI will perform the first all-sky survey since HEAO-1 in the traditional X-ray band of 2–15 keV, down to a confusion limit of ∼0.5 mCrab in <1 year.

With the understanding of the characteristics of the MAXI observations, papers were presented to discuss the scientific issues that can be addressed by MAXI. I highlight some scientific subjects discussed in the workshop, though it is by no means the complete summary of papers and discussions at the workshop.

2. Science of X-ray binaries and compact Galactic sources

Accreting X-ray binaries show a huge variety of phenomena on various time scales, thus constitute prime targets for MAXI. Recent progress in understanding the accretion phenomena onto black holes and neutron stars was discussed.

Their X-ray spectral states, which MAXI will monitor, are correlated with the X-ray power spectra (red noise and QPO's) and fluxes in other wavebands, and are related to the activities of jets and accretion disks. MAXI is expected to provide very quick alerts for outbursts and state changes of black hole binaries and other microquasars, so that timely TOO observations can be triggered for multiwavelength coverage and pointed X-ray observation with higher time resolution. Coordination with ground-based observatories in radio, optical/IR, and UHE gamma-rays, in-orbit X-ray and gamma-ray observatories is essential. (related talks: Makishima, Matsumoto, Fender, Ebisawa, Trushkin, Thompson, Paul, Takahashi, Ubertini, Kuiper)

There are also scientific topics that can be addressed mostly by MAXI alone. Detection of periodicities in the light curves provides direct evidence for spin and/or orbital motion. Slow-rotating X-ray pulsars, either accreting pulsars or magnetars, may be discovered solely by MAXI. Long-term super-orbital periodicities hint the third-body effects or disk precession. Aperiodic vari-

ations (red noise and QPO) have information on the physics of accretion, and possibly the mass of the accreting black holes (or neutron stars). (Zdziarski, Morii, Hayashida, McHardy)

MAXI is also expected to detect number of new X-ray transients. Identification of new source may require precise location, which calls for prompt TOO observations using X-ray telescopes such as on Swift, followed by multiwavelength ground coverages. (Negoro, Wijnands, Reimer, Gehrels, Kulkarni, Uemura)

3. Active galactic nuclei

The discussions on the AGN studies with MAXI may be categorized into three topics: (1) measurements of power spectra of X-ray variability, (2) multiwavelength variability study, and (3) population study.

In unbeamed AGN, it was argued that the frequency of break or QPO in the power spectrum density is related to the central black hole mass, and we can learn the accretion physics by studying PSD over decades of time scales. MAXI will be useful for longer time scale ($>$ days), and should be complemented by other X-ray missions like Suzaku or XMM to cover the shorter time scales. In this respect, desire for long operation of MAXI of 4–5 years or more was strongly expressed by participants. (McHardy, Hayashida, Sakano, Yuan)

For beamed AGN, multiwavelength obervations over the entire electromagnetic spectrum from radio to TeV gamma rays are important to understand emission mechanism, jet production, and its relation with the accretion. Rapid notification of outbursts by MAXI is highly expected. For unbeamed AGN, the reverberation analysis of the X-ray and optical/IR light curves will provide insights on the structure, the luminosity, and the mass of the source. (Madejski, Wagner, Minezaki, Lindfors)

MAXI will be also useful as a survey machine. MAXI will reach its confusion limit (a fraction of milliCrab) within a year, and at this level, MAXI will detect more absorbed (type 2) AGN than any other mission flown. The MAXI catalog of bright AGN, both absorbed and non-absorbed will be unique and valuable. (Ueda, Geherls)

4. Gamma-ray bursts

Although MAXI is not an ideal instrument to monitor GRBs, handful of them are expected to occur within it field of view that covers $\sim$1/60 of the sky at any given time. The number of detection is yet uncertain. A simulation of MAXI observations of GRBs, in particular the soft class of GRBs called X-ray flashes, with realistic combination of flux, spectra, and burst profile in the X-ray range is required for accurate estimation of the GRB detection rate. While the locations will be disseminated in real time, the coordinate in the direction of scan has intrinsic uncertainty due to the burst profile modifying the triangular collimator response. Rapid, coordinated follow-up observation by Swift is highly desirable. In addition to the prompt emission of GRBs, some of the early X-ray afterglows will be detected if scanned within $\sim 10^3$ s of the burst. The challenge would be how to identify these "orphan" events. If a transient X-ray emission is detected only at a single scan at a position of no known X-ray source, it may be a GRB afterglow. However, it could also be an AGN flare on a very short time scale or a stellar object in the Galaxy. Follow-up observations with high-sensitibity X-ray telescopes and in other wavelengths would be eagerly desired for these events. (Wilson-Hodge, Angelini, Piro, Burrows, Yamaoka, Suzuki)

5. Survey and mapping

In both Galactic and extragalactic sciences, the MAXI catalog will be valuable, but it will be more useful with accurate positions. It is even more necessary for transient new sources, for which the follow-up observations, in particular by Swift, is expected to play crucial role. (Gehrels)

MAXI can also contribute to the sceince of diffuse emission. With SSC, MAXI will be the first X-ray mission that covers most of the sky with the energy resolution of CCD. Earlier observations with rockets and ROSAT indicate that there are extended "thermal" emission associated with the galactic disk and isotropic emission presumably associated with the local hot bubble or charge exchange processes in the solar system. The repeated mapping of the sky with the emission lines of characteristic X-rays from O, Ne, Si, etc. will provide constraints on their origin, and give us clearer view of the solar system and the Galaxy. (McCammon, Miyata)

5.1. Action items before the launch

In order to start producing useful science immediately after the launch, we will need better characterization of the instruments: sensitivity, localization accuracy, and alert latency.

As discussed repeatedly in the workshop, good follow-up plans of the MAXI-detected transients are necessary. There should be close coordination with space missions like Suzaku, Swift, and also with ground-based UHE gamma-ray observatories and optical monitoring projects. Preparation for TOO observing proposals at big facilities such as VLBI should be made.

The MAXI team needs inputs from the wide community of the high-energy astrophysics., and will be collecting advice from the advisers and from the MAXI users forum.