Energy spectra of bright clusters of galaxies obtained from the MAXI data archive

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Abstract

In order to enhance use of the MAXI data by scientists all over the world, we are developing the MAXI data archive. The archival data and tools will be released from DARTS at ISAS/JAXA by early 2017. Also, it is planned that the data and tools be available from HEASARC at NASA/GSFC. Although MAXI data analysis procedure is complicated, we offer simple analysis tools that enable end-users to easily create standard images, energy spectra and responses, and light curves.

KEY WORDS: workshop: MAXI data archive — Clusters of galaxies

1. MAXI data archive

Long-time MAXI observations are scientifically valuable data for astrophysics. MAXI Archive data are planned to be released from DARTS at ISAS/JAXA in Feb 2017, and from HEASARC at NASA/GSFC in 2017. Because of the peculiar system of MAXI, we offer simple analysis tools for scientists, even who are not familiar with the detector details.

1.1. Design of MAXI data archive system

The MAXI archive data are processed and screened using the latest CALDB and auxiliary data. Users do not need screening. When new CALDB is released, archive data are updated. Daily event files are divided into 768 Healpix regions. Users can download event files and auxiliary files corresponding to a specified sky region. Or, users can locally have the entire MAXI archive (800 Gbytes for seven years). Data archive are updated real-time (typical delay 15 minutes), and released from DARTS at ISAS/JAXA, and mirrored to HEASARC at NASA/GSFC. Using MAXI specific ftools and CALDB (will be included into HEAsoft), users can analyze data easily. Figure 1. shows the structure of MAXI data Archive. Event data are put into a directory of each day, `MJDxxxxxx/`.

1.2. MAXI ftools - mxftools

MAXI analysis ftools consist of nine MAXI ftools, and one script for data download. Users basically use only **mxdownload** and **mxproduct**. **mxdownload** downloads data from the archive for specified coordinates. **mxproduct** is a perl script running the MAXI ftools to generate images, light curves, spectra, and response files, calling the following tools.

mxextract Create a single standard event file from plural region event files for a given coordinates (RA, DEC) and radius.

mxgscancur, mxsscancur Create an observation and instrument specific file to describe observational conditions.

mxgscandat, mxsscandat Create observation and instrument specific scan history files for GSC and SSC.

mxgtiwmap Create an exposure histogram for each incident angle of a given input target.

mxlcscan Create light curve files.

mxrmfgen Create a response file for GSC and SSC.

1.3. How to use analysis tools

First, you must have HEAsoft, CALDB, and also Perl, Python, Ruby. And then, install MAXI software package, mxftools, and set it up. Second, download `events/` and `auxil/` data files for your target using a command, **mxdownload**, with parameters of RA,DEC, start stop time, and radius:

```
 % mxdownload RA DEC tstart tstop radius
--uri=https://maxi.darts.isas.jaxa.jp/mxdata
```

```
obs/
|
MJD55000/  MJD56000/  MJD57000/  (every 10000 days)
|
MJD55000/  MJD55001/  MJD55999/  (every 1 day)
|
events/  auxil/
|           |_  ( files for attitude, orbit, time, ISS data, GSC time data, MKF, HK etc.)
gsc_med/ gsc_low/  ssc_med/    ( for GSC and SSC,  for bit rate med/low )
|           |           |_  mx_mjd55000_ssch_med_000.evt ... mx_mjd55000_sscz_med_767.evt
|           |_ mx_mjd55000_gsc_low_000.evt ...  mx_mjd55000_gsc_low_767.evt
mx_mjd55000_gsc_med_000.evt ... mx_mjd55000_gsc_med_767.evt
                           ( event files for 768 Healpix regions)
```

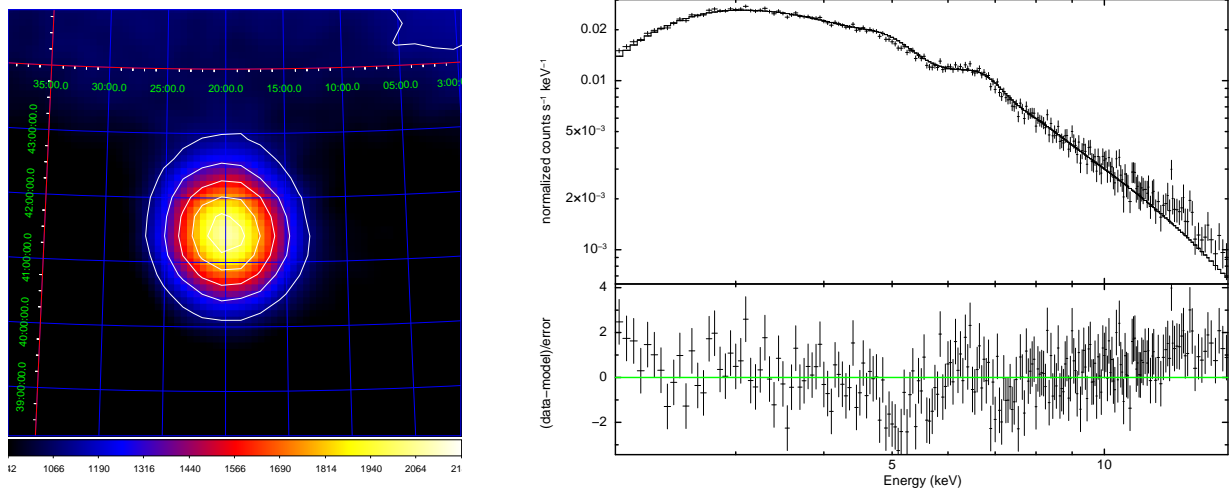Fig. 1. Directory and file structure of MAXI archive.

Fig. 2. Output GSC image and spectrum of Perseus cluster for 6 years.

If users already have local mount data, this step can be skipped. Third, run **mxproduct** with 4 parameters of RA, DEC, start, stop:

`% mxproduct [options] RA DEC tstart tstop`

You can set various options, such as object name, energy bands for light curves, regions, GSC or SSC only, etc. Output files, event files, images (all, wmap), energy spectra (source, background), responses, and light curves are created. Also, you can leave intermediate files if you want to know detailed analysis.

2. Examples of analysis

Here we show an analysis example of the Perseus cluster. Figure 2 shows the GSC image and spectrum of the Perseus cluster for 6 years, 2011–2016. The best-fit parameters agree with the MAXI spectrum by MAXI on-demand analysis (`http://maxi.riken.jp/mxondem/`), as well as with those by other missions. Thanks to MAXI's sensitivity to largely extended emission and wide energy band, we are able to create high-quality spectra in 0.7–20 keV from the entire clusters of galaxies.