MAXI observations of the clusters of galaxies

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MAXI[1] scans all-sky evenly. The 15 years of MAXI data have provided sufficient statistics for the spectrum to be accumulated for any X-ray source. We analyzed the spectra of 249 clusters of galaxies with MAXI (Fig. 1). Data are processed through MAXI-ondemand. The results are summarized at `http://maxi.riken.jp/cluster`. By fitting the spectra, we obtained metal abundances, temperatures, and luminosities. We analyzed these natures statistically.

X-ray from the cluster of galaxies is emitted from the ionized gas in between the galaxies. The spectrum consists of the bremsstrahlung continuum emission and emission lines of the heavy elements. We used the Apec model for these, which models optically thin hot gas in thermal collisional equilibrium. In addition, we used the tbabs model for interstellar absorption caused primarily in our Galaxy.

The redshift distribution of 249 cluster of galaxies was compared with the MCXC catalog primarily based on the ROSAT observation. The number of our samples is approximately 1/10 of the MCXC samples. Even in the nearby region ($z < 0.06$), it is only about 1/3. This would be because MAXI is not sensitive to the low temperature (kT < 2 keV) clusters compared with ROSAT, and such clusters occupy 2/3 in MCXC catalog.

From the redshift-flux distribution, the flux limit of our sample can be estimated as 0.5×10^{-11} erg/cm^2/s. The sample above this level can be considered to be complete. The envelope of the flux distribution is the power-law line of index -2; thus this line is considered the brightest luminosity limit of the clusters ($L_x = 10^{46}$ erg/s).

The log N–log S relation is approximately on the power-law of the index of -1.5 line down to the flux of 1.5×10^{-11} erg/cm^2/s, which means a uniform distribution.

The abundance ratios relative to solar composition were determined for 33 clusters, yielding the weighted average of 0.28 ± 0.09 solar, which is consistent with the previous studies such as 0.2–0.3 solar.[3]

Temperatures were obtained from the 246 clusters. The temperature T-luminosity L relation is plotted in Fig. 2. The values are not on a single line, probably because each cluster has its own property. After assuming that the scatter of the data points should be the scatter of each galaxy's property, we fit the distribution with a power-law function $L \propto T^B$. The index resulted in $B = 3.0 \pm 0.5$, which is consistent with previous works of the index of about 3.[2]

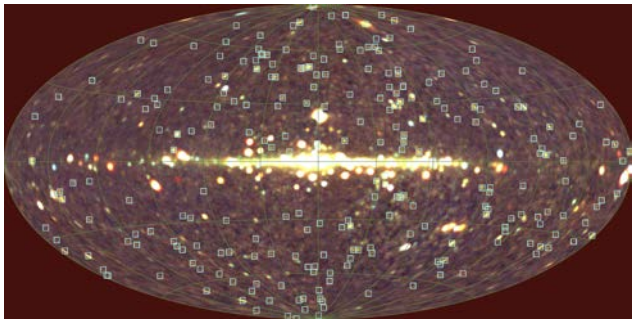

Fig. 1. All-sky map with MAXI. Blue squares are the clusters of galaxies studied in this work.

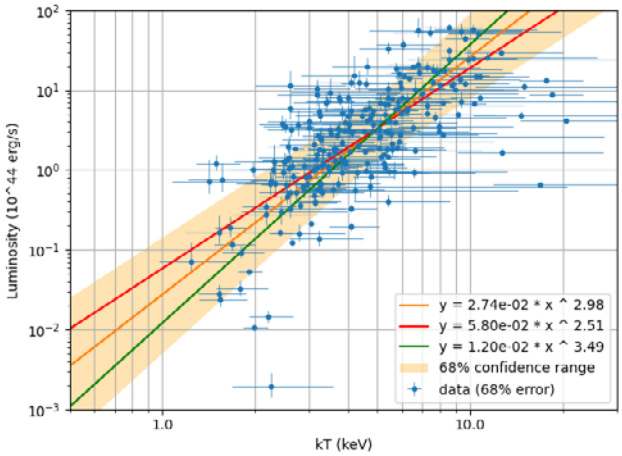

Fig. 2. Temperature and luminosity relation of the 249 clusters of galaxies observed with MAXI.

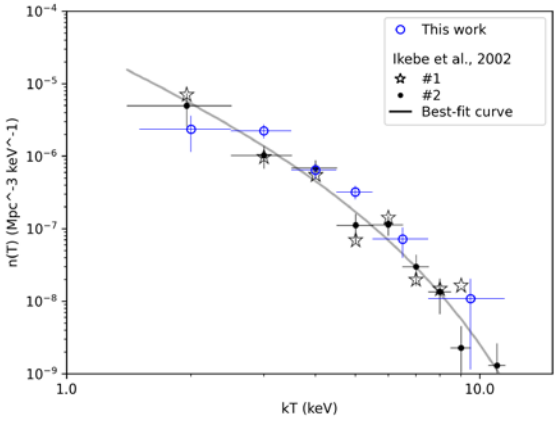

Fig. 3. X-ray temperature function. This work (blue) is plotted over the work with ASCA and ROSAT.[4]

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We can obtain the number density of the clusters in the local universe ($z < 0.2$) in each temperature range. This is called the X-ray temperature function (XTF). We consider a cluster brighter than 1.5×10^{-11} erg/cm^2/s as a complete sample. Using 117 cluster, we created the XTF (Fig. 3). We compare it with Ikebe's 61 samples,[3] which used temperatures primarily with ASCA, and flux with ROSAT whose flux is $>1.99 \times 10^{-11}$ erg/cm^2/s. The MAXI result agrees well.

References

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