ASCA SKY SURVEY OBSERVATIONS AND THE COSMIC X-RAY BACKGROUND IN 2–10 KEV

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1. Introduction

The X-ray background in the energy range above 2 keV is highly uniform except for an excess component along the Galactic plane. The excess along the plane is considered to be associated with our Galaxy, whereas the rest of the emission is believed to be of extragalactic origin. In this paper, the X-ray background at high Galactic latitude is discussed and is designated as the CXB (cosmic X-ray background) to distinguish it from the Galactic origin.

The most likely explanation of the CXB is that the observed CXB flux is supplied by a collection of unresolved, weak discrete sources. The deepest sky survey of X-ray sources in 0.5 – 2 keV was done by ROSAT (Hasinger et al. 1993; 1994). The contribution to the 1–2 keV CXB from sources with flux above 2.5×10^{-15} erg cm^{-2} s^{-1} in 0.5 – 2 keV is estimated to be about 60 %. The discrete source contribution to the CXB in 2 – 10 keV were so far estimated through the deep survey observations with HEAO-1 A2 (Piccinotti et al. 1982) and with Ginga (Kondo 1992; Hayashida 1990). These results show that the contribution to the CXB in 2–10 keV from sources with flux above 10^{-12} erg cm^{-2} s^{-1} is $\sim$10 % and that the averaged spectral slope is still significantly steeper than that of the CXB.

ASCA carries nested thin-foil X-ray mirrors with an spatial resolution of about an arcminute even in the 2 – 10 keV band. This enables us to

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observe very faint sources with flux down to several times 10^{-14} erg cm^{-2} s^{-1} in 2 – 10 keV for the first time and to resolve a larger fraction of the CXB into a number of faint sources than previously possible.

2. ASCA sky survey

Two kinds of sky survey observations have been being done with ASCA.
Large sky survey (LSS): 76 pointing observations with mean exposure of about 30 ks were performed to cover a fairly wide field of sky ($\sim$ 5.4 Sq. Deg.) near the north Galactic pole.
Deep sky survey (DSS): ASCA was pointed to some sky fields (the SA 57 field, the Lockman Hole field, the Lynx field and so on) for a hundred to several hundreds ks.

In parallel to the LSS and DSS observations, a serendipitous source survey is being done for the ASCA public archive data and it is called as the ASCA medium sensitivity sky survey (MSS). Form the public archive data before Aug. 1995, 481 pointed fields satisfying some criteria ($|b| > 10°$, net exposure > 10 ks, the primary target < 10 c/s/GIS) were selected and 992 sources were serendipitously detected in the GIS fields. The catalogue of these sources will soon be open to public as the GIS Source Catalogue (Ver.1) via WWW (Ishisaki et al. 1997).

3. log N – log S relation in 2 – 10 keV

Figure 1 shows the log N – log S relations in 2 – 10 keV obtained from the DSS mainly in the SA57 field (Ogasaka et al. 1997), and from the LSS (Ueda et al. 1997). The results are consistent with an extrapolation of a $N \propto S^{-3/2}$ relation from the results of the Ginga fluctuation analysis (Hayashida 1990), the Ginga high-latitude survey (Kondo 1992) and the HEAO-1 A2 survey (Piccinotti et al. 1982). If we integrate source-fluxes down to the ASCA DSS limit of $\sim 4 \times 10^{-14}$ erg cm^{-2} s^{-1}, it is 40% of the CXB at most.

The 2–10 keV log N – log S relation is also obtained from the MSS and the result is consistent with those from the LSS and DSS (Ishisaki et al. 1997). Furthermore, the analysis of the angular fluctuation of the CXB is in progress. Although the result is still preliminary, we can say that the non-fluctuating component in the CXB is 20% at most and that the discrete source contribution to the CXB should be more than 80%.

Fig.2 shows the average of the spectral photon indices of sources in 2 – 10 keV in the flux range of $(1 - 4) \times 10^{-13}$ erg cm^{-2} s^{-1} detected in the LSS as a function of the source flux, in comparison with that obtained in the higher flux range by the fluctuation analysis of the Ginga background (Hayashida 1990). The average spectral index of sources detected in the

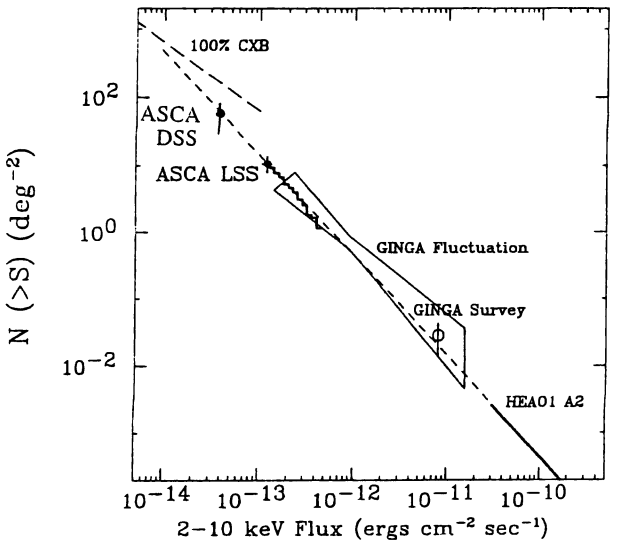

Figure 1. The log N – log S relation of X-ray sources in 2 – 10 keV obtained from the DSS observation (Ogasaka et al. 1997), and from the LSS observation (Ueda et al. 1997). The dimmer and brighter points are from the DSS and from the LSS, respectively. A dash-dotted line is an extrapolation of a $N \propto S^{-3/2}$ relation from the results of Ginga fluctuation analysis (Hayashida 1990), Ginga high-latitude survey (Kondo 1992) and HEAO-1 A2 survey (Piccinotti et al. 1982).

ASCA LSS is significantly harder and closer to the CXB index than that obtained from the previous measurements in the much higher flux range in this energy band. This result implies that a population of sources with an average index similar to the CXB begins to dominate in the flux range around 10^{-13} erg cm^{-2} s^{-1} in 2 – 10 keV.

4. What are the dim, hard sources?

Some DSS observations were done in fields overlapped with fields in which deep ROSAT observations and the optical follow-up observations were done (Lockman Hole: Hasinger et al. 1997; Schmidt et al. 1997. GSGP4, QSF3, F855: Georgantopoulos et al. 1997; Boyle et al. 1997).

In the Lockman Hole observations, sources detected with ASCA in 2 – 10 keV in the field overlapped with the ROSAT field are almost all identified with ROSAT sources to which optical counterparts were found. Almost all the optical counterparts (11/12) are classified as AGNs by Schmidt et al. (1997) and their luminosities and the cosmological redshifts distribute 10^{43-45} erg cm^{-2} s^{-1} and 0.5 – 2.

The ratios of the 0.5 – 2 keV ROSAT flux to the 2 – 10 keV ASCA flux largely scatter by an order of magnitude and several sources have the

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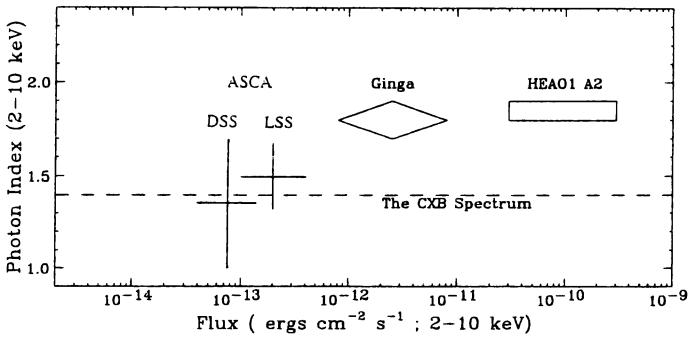

Figure 2. The average spectral photon index of sources detected in the lowest flux range of the LSS (Ueda et al. 1997) and of the DSS (Ogasaka et al. 1997), in comparison with those obtained in the higher flux range: the results of the fluctuation analysis of the Ginga background (Hayashida 1990) and of the Piccinotti sample by HEAO-1 A2. The spectral index of the cosmic X-ray background is also indicated.

ratio as low as 0.1. The low 0.5 – 2 keV flux relative to the 2 – 10 keV flux suggests that those AGNs would suffer from heavy obscuration. In fact, some of them show no optical broad line (Schmidt et al. 1997).

Other optical follow-up observations of the ASCA DSS or LSS sources are also in progress. An observation of a ASCA source in the SA57 field discovered a type-2 quasar at $z \simeq 0.9$ (Ohta et al. 1996). Another optical observation also found a type-2 Seyfert galaxy at the position of a very hard source in the LSS field (Sakano et al. 1997; Akiyama et al. 1997). These all seem to support the idea that most of the dim, hard sources would be highly obscured AGNs at the cosmological distance.

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