

Session 4: Large Scale Hot Plasmas and Their Relation with Dark Matter

OPTICAL FOLLOW-UP OBSERVATIONS OF THE ASCA LARGE SKY SURVEY

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1. The ASCA Large Sky Survey

To reveal the origin of the cosmic X-ray background (CXB) in the hard band, we are now conducting a wide ($\sim 7 \text{ deg}^2$) and deep ($\sim 1 \times 10^{-13} \text{ erg sec}^{-1} \text{ cm}^{-2}$ in the 2–10 keV band) survey with the ASCA (the ASCA Large Sky Survey, hereafter LSS). We have detected 83 sources above 4 sigma level in the 0.7–10 keV band with the GIS and resolved $\sim 30\%$ of the CXB in the 2–10 keV band into discrete sources (Ueda 1996). AGNs (type 1 and type 2) and clusters of galaxies are expected to be major contributors to these X-ray sources.

2. Optical Observations and First Results

We have made optical imaging observations of almost all the LSS region with the KISO 1m Schmidt telescope. Typical magnitude limit is $R \sim 21$. To compensate R band data of 21 X-ray sources and B magnitude data, we also used APM catalog (McMahon & Irwin 1992, limits are $R \sim 20$ and

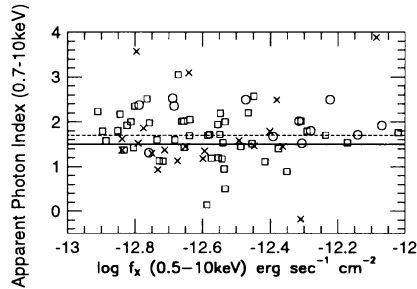


Figure 1. Distribution of X-ray sources in X-ray flux vs. apparent photon index diagram. Circles show candidates of clusters of galaxies, rectangles candidates of type 1 AGNs and crosses remaining sources. The dashed and solid line represent the average photon index of candidates of type 1 AGNs and photon index of the CXB in the LSS region (1.5, Ishisaki 1996), respectively.

$B \sim 22$). Compiling these data, we have made catalogs of optical objects within $1'$ from the center of each X-ray source.

At first, we picked up candidates for clusters of galaxies using number of objects within each error circle in the R band. We identified X-ray sources which have more than 16 optical objects as candidates of clusters. We found 13 candidates in the LSS field. For 6 of these candidates, we have made deep imaging observations with UH 2.2m telescope and confirmed the existence of galaxy concentration. Next, we picked up candidates for type 1 AGNs (type 1 Seyferts and QSOs) in each error circle using the criteria of $B - R \leq 1$ and $-2.5 \log(f_x) - 14.2 \leq R \leq -2.5 \log(f_x) - 12.2$ (f_x in $\text{erg sec}^{-1} \text{cm}^{-2}$ in the 0.5–2 keV band). We picked up 48 sources each of which have a optical object meeting the criteria.

In figure 1, we show the distribution of the X-ray sources in flux vs. apparent photon index diagram. Photon indices of the candidates of clusters (circles) are consistent with thermal (1–10 keV) X-ray spectrum. The distribution of photon indices of the candidates of type 1 AGNs (squares) is also consistent with that of type 1 AGNs in the 0.5–10 keV band in the past observations. Many remaining sources (crosses) distribute around the photon index of the CXB. This result may indicate an existence of a population of objects which have hard X-ray spectrum and different optical characteristics from type 1 AGNs.

References

- Ishisaki Y., 1996, Ph.D thesis, University of Tokyo
 McMahon R., Irwin M., 1992, in *Digitized Optical Sky Survey*, ed. H.T.MacGillivray and E.B.Thomson (Kluwer, Dordrecht). p.417
 Ueda Y., 1996, Ph.D thesis, University of Tokyo