Observations of Soft Gamma-Ray Burst Repeaters: 1806-20 and 0526-66

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Two Soft Gamma-ray burst Repeaters (SGRs) among three known were observed in X-ray energy band with ASCA. During the monitoring of SGR1806-20 in 1993, ASCA had detected a burst together with the persistent component: AX1805.7-2025. Despite the large change of the burst activity in 1995 compared with in 1993, there was no obvious change in the persistent component. A burst in 1993 was the rare case observed in the extremely soft X-ray energy band of 1-10 keV. The probable X-ray candidate of SGR0526-66 (RX0525-6607) in N49 was also observed with ASCA but failed to find any hard X-ray component except for the ordinary SNR spectrum in contrast to the AX1805.7-2025's hard spectrum.

I. INTRODUCTION

The SGRs are known in its repetitive activities with soft gamma-ray photons. The identification of SGR 1806−20 by burst (1), with the Galactic SNR G10.0−0.3 (2) and by radio (3), (4) suggests that SGRs are associated with SNRs. At the same time, a quiescent X-ray counterpart, AX 1805.7−2025 (1), (5) to SGR 1806−20 has also been discovered with ASCA. The SGR0525−66 is famous for the 5 March 1979 burst and the tightest localizations. The localization is in the SNR N49 (6) and thus strengthens the physical association of SGR 0525−66 with N49. Interestingly, within the error box of the 5 March 1979 event, a point X-ray source has been seen in both Einstein HRI image (7) and more clearly in the Rosat HRI image (8). However there are differences between SGR 1806−20/AX1805.7-2025 and SGR 0525−66/RX 0525−6607 (9). SGR1806-20 (G10.0-0.3, AX1805.7-2025) can be understood in the framework of the plerion (3) like the Crab (5). In contrast, N49 is a shell and there is no evidence of any long-wavelength counterpart (9). This absence is hard to explain in the framework of the plerion model. ASCA has good high energies response (0.5–10 keV; (10) and offers us an opportunity to measure the high energy spectrum of RX 0525−6607 whether it has a hard spectrum similar to AX 1805.7−2025. ASCA had again monitored the burst activity initiated by the BATSE re-discovery in October 1995 (11). Comparisons of the burst activities in 1993 and in 1995 and the persistent component are the key to understand this system. During the 1993 observation, ASCA had detected a burst of SGR1806-20 in X-ray energy of 1-10 keV. The observation in such the extremely low energy was a rare case and interestingly enough there was a deeper spectrum turn-over than the persistent component/AX1805.7-2025.

II. SGR1806-20/AX1805.7-2025 IN 1993 AND 1995

The ASCA monitoring of SGR1806-20 in 1993 was carried out during the high burst active phase (12), (13). In fact, there were 6 bursts with BATSE and one was detected simultaneously within our ASCA FOV. In contrast to the high burst activity in 1993, there was only one burst with BATSE and this was observed 16 days before the ASCA observation (11). So it is safe to say that the ASCA TOO observation in 1995 was done in the low burst phase. However the persistent component/AX1805.7-2025 remained unchanged not only in the flux but also the spectrum shape. The observed flux of 6×10^{-12} erg^{-1} sec^{-1} cm^{2} in 2-10 keV with 6×10^{22} hydrogens column density was the same in 1993 within the errors (5). Nothing was changed in the persistent component between 1993 and 1995 within the errors except for the burst activity. This strongly supports the plerion hypothesis to the emission model. If this were the accretion-powered, it is very difficult to understand the no change in the persistent flux, despite the large change in the burst activity between the two periods.

III. OBSERVATIONS OF SGR0526-66 (N49)

Observations with the ROSAT HRI show that RX 0525−6607 is a point source, $\sim$ 3 arcsec, and a flux of 1.6×10^{-12} erg cm^{-2} s^{-1} in the energy range of the ROSAT HRI, 0.1–2.4 keV (8). If RX 0525−6607 have a similar spectrum to AX 1805.7−2025, we predict a flux of 1.4×10^{-12} erg cm^{-2} s^{-1} in the energy band of 2–10 keV with ASCA. This flux is easily observable with ASCA, if it exists. An observed ASCA spectrum of N49 is shown in Figure-1 together with the best-fit model. We have used the Non-Equilibrium Ionization (NEI) model (14) to model the emission from the SNR. This model gives a best-fit temperature of 0.98 keV and does not require any power-law component. We derive a 90% upper limit of 2.3×10^{-13} erg cm^{-2} s^{-1} to the presence of any Crab-like component which is an order below the estimate. The observed SIS spectrum (Figure 1) is typical of spectrum from SNRs. A comparison of the spectrum with the SNR N49B in the same FOV, obtained

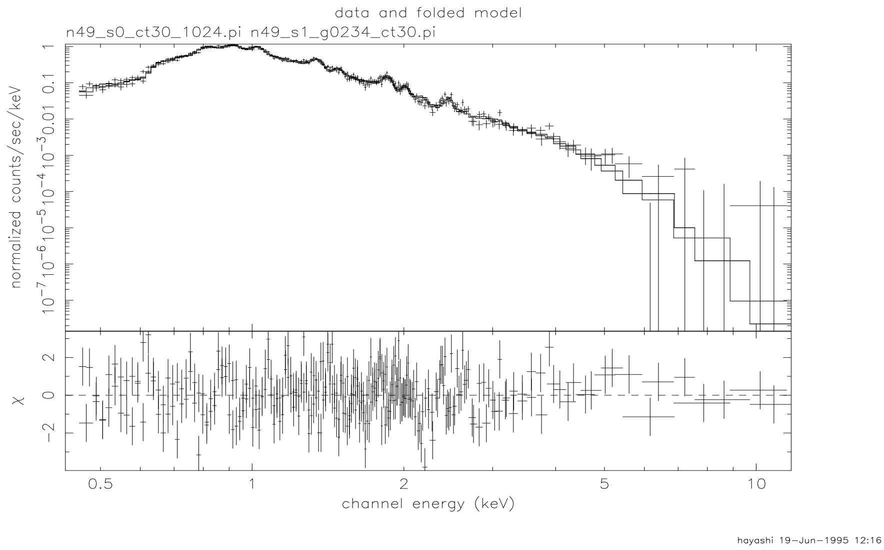

FIG. 1. The observed ASCA spectrum of SGR0526-66 (N49) in 0.5-10 keV. The best-fit NEI model does not require the power-law component. This spectrum can be best explained by the NEI model of 0.98 keV in temperature. There was no appreciable hard X-ray component in the energy band of 2 - 10 keV expected from the ROSAT HRI flux.

after subtracting the same background spectrum, shows that there are small differences in the low energy spectra of the two SNRs but there is no obvious hard component in the spectrum of N49.

IV. BURST SPECTRUM IN THE LOW ENERGY

A burst from SGR1806-20 was observed with ASCA in the FOV simultaneously with BATSE in 1993 (13), (1). This was the very rare case to observe a burst in such the extremely low energy band of 1-10 keV. Before ASCA, there were observations of the bursts above 5 keV with ICE (15). Due to a small number of the detected photons, the statistics is very much limited but the burst spectrum was heavily turn-over to the lower energies than the persistent spectrum which seems to be consistent with the interstellar absorption in this direction. The heavier turn-over than the persistent component suggests that this is not an interstellar absorption but some intrinsic process of the burst emission. The comparison of the two X-ray spectra between the burst and the persistent component is shown in the figure 2. The low energies turn-over can be understandable by some type of self-absorptions (gray body) in thermal process and/or synchrotron process (15).

More interestingly enough, the characteristic temperatures of the SGR1806-20 bursts detected with the ICE, ASCA and BATSE satellites were the same,

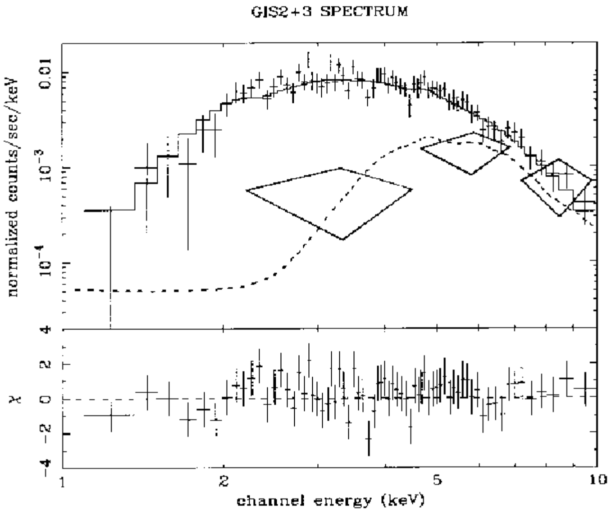

FIG. 2. The ASCA burst spectrum and the persistent component of AX1805.7-2025 in 1-10 keV. Two spectra are normalized at around 10 keV.

despite the large differences in their fluences. The figure 3 shows the hardness ratios of the observed spectra dividing the spectra into two energy bands. The ASCA-BATSE burst was the weakest burst among them and roughly three orders of magnitude weaker than the brightest, but the hardness ratio was constant throughout the rest of them. The underlying emission process is insensitive to the burst fluences. The constant temperatures might be the key to understand the emission process together with the heavy turn-over to the soft energy band. (16).

V. SUMMARY

There was no obvious differences in the persistent component, despite the large difference in the burst activity. This may strongly support the plerion hypothesis, not the accretion-powered. However we could not detect the similar type of hard emission from SGR0526-66 to unify the model. We note that if the possible X-ray counterpart of SGR0526-66/RX0525-6607 were the same order of luminosity with the persistent component/AX1805.7-205, ASCA cannot detect the flux. In this case, the flux of the ROSAT HRI (RX0525-6607) is just a nearby X-ray star independent with N49. We require more observations not only in X-ray but also in other wavelengths. One key to understand the SGR phenomenon is the observation or identification of SGR1900+14 which was not yet observed with ASCA. The reported optical counterparts in SGR1806-20 and in SGR1900+14 are also mysterious (17), (18).

Acknowledgments

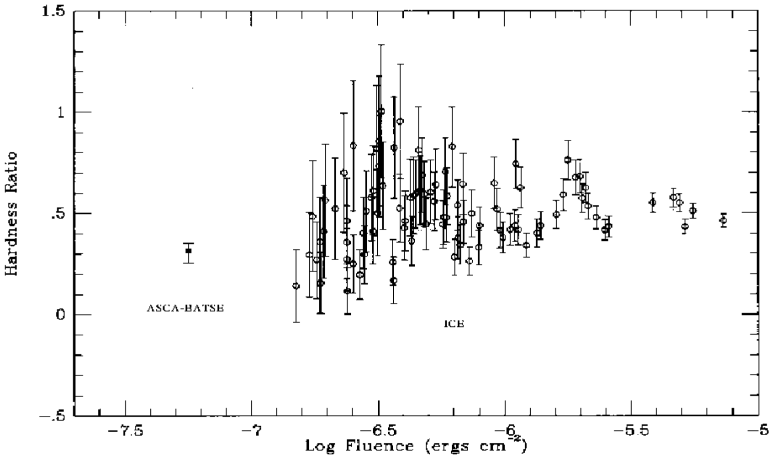

FIG. 3. The constancy of the observed hardness ratio of SGR1806-20 bursts with ASCA-BATSE and the ICE events.

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