Hard X-rays and possible pulsation from a SNR 0453−68.5

K. Imanishi[1], **M. Tsujimoto**[1], **J. Yokogawa**[1], **and K. Koyama**[1]

Department of Physics, Graduate School of Science, Kyoto University, Sakyo-ku, Kyoto, 606-8502, Japan

Abstract. We present our detection of hard X-rays and a possible pulsed signal from a SNR 0453−68.5 in the Large Magellanic Cloud (LMC), using ASCA. Our analysis shows that this SNR has a hard tail with a photon index of ∼2.6 and a 1.48sec pulsation period. Various candidates for this hard component are briefly discussed.

1. Introduction

There are a great number of Supernova Remnants (SNRs) in the LMC. Many of them are thought to be shell-type SNRs except two Crab-like pulsars (Ögelman & Hasinger 1990, Cusumano et al. 1998). Hughes et al. (1998) systematically analyzed the X-ray spectra of 10 shell-type SNRs in the LMC using ASCA, and presented that these spectra are well described by the thermal emission model assuming to be in the Sedov phase. These analyses were, however, mainly concentarated in the soft X-ray band (<2keV), thus there was little information about these hard X-ray band (>2keV), in which some SNRs emit X-rays by a characteristic process such as a SN1006-like SNR (Koyama et al. 1995) or a Crab-like pulsar. We thought that these unique SNRs might be hidden in the LMC, and analyzed these data again. Among these, we found one interesting SNR, 0453−68.5, which was caught by the radio (Mathewson et al. 1983) and the previous X-ray (Wang et al. 1991) observations.

2. ASCA data analysis

ASCA observation for SNR 0453−68.5 was made at November 1995. ASCA carries four independent detectors, the two Solid-state Imaging Spectrometers (SIS 0, SIS 1) and the two Gas Imaging Spectrometers (GIS 2, GIS 3), and these detectors are operating simultaneously. Hereafter, we use both data obtained from the GIS and the SIS.

2.1. Spectral analysis

Figure 1 shows the background subtracted spectra of 0453−68.5 obtained from the GIS as black and the SIS as gray. First, we fitted these spectra with an absorbed thin thermal plasma model. However, this model did not sufficiently reproduce these spectra; there was an apparent excess above 2keV. Thus, we considered that there was a hard component together with a thermal emission, and added a powerlaw model. After the spectral fitting, we obtained a photon index of $\sim 2.6^{+0.4}_{-0.5}$ and absorbed flux of 3.6×10^{-13}ergs/sec/cm^2 (0.7–10keV), assuming the distance as 50kpc, converted to the luminosity of 1.1×10^{35}ergs/sec for the hard component.

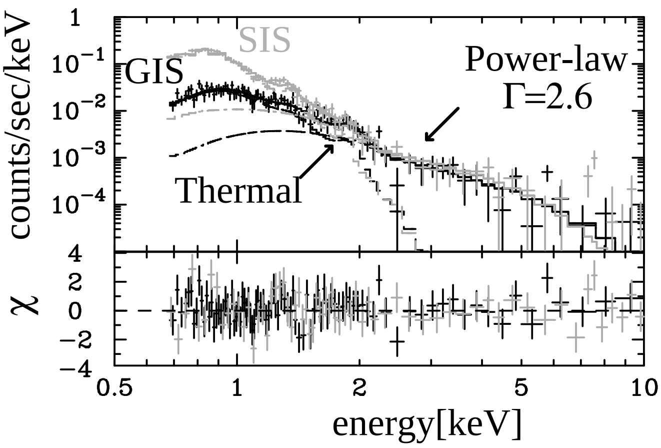

Fig. 1. Background subtracted spectra of 0453−68.5 obtained from the GIS (black) and the SIS (gray). These spectra are well fitted by the two component model; thin thermal plasma (kT∼0.23keV) and powerlaw (Γ ∼2.6) models.

2.2. Timing analysis

To reveal the more evidence for the hard component, we made a timing analysis. In this analysis, we chose the data in the 2–5 keV band because the hard component was seem to be relatively dominant in this energy, and ASCA GIS data, because GIS has higher time resolution than SIS.

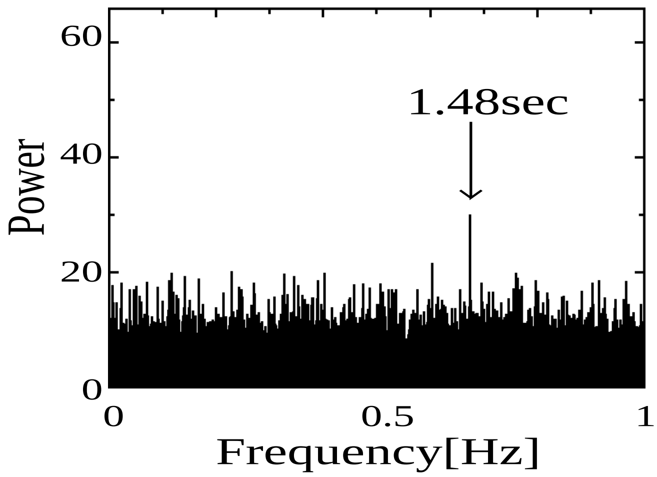

Fig. 2. The power spectrum of 0453−68.5 in 2–5keV

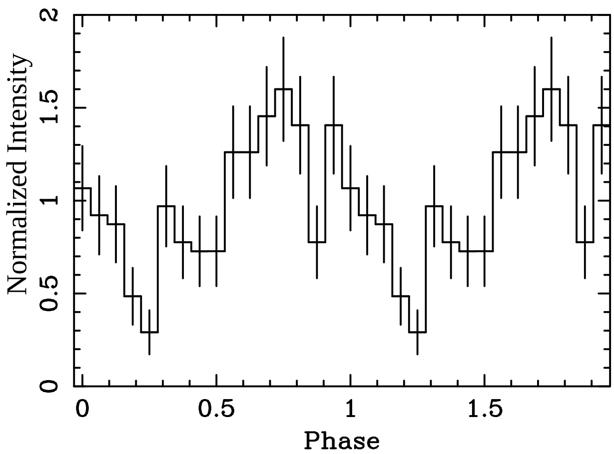

Fig. 3. The folded light curve of 0453−68.5 (P=1.4827sec) in 2–5keV

Figure 2 shows a power spectrum with Fast Fourier Transform (FFT). In this figure, there is a peak at 0.67445Hz corresponding to 1.48sec pulsation period. Even, this peak is not so strong that, if there is no real pulsation, chance probability to get this peak at any frequency is up to 5%. Thus it is doubtful whether this peak is real or not.

To declare that this is real pulsation, we searched a pulsed signal by a different method; using the epoch folding search (EFS). The best period, 1.4827sec, was derived from EFS. The folded light curve with 1.4827sec period is shown in figure 3. Quasi-sinusoidal pulse shape is found.

3. What is the hard component?

Taking into acount the evidence that this is accompanied with the SNR, three candidates can be thought; Crab-like pulsar, SN1006-like SNR, and magnetar. On the other hand, if it is assumed that this is accidentary located near the SNR, the possibility of accretion-powered pulsar or anomalous X-ray pulsar is still left. Hereafter, possibilities for these candidates are discussed.

1. Crab-like Pulsar
   Considering that this is a pulsar accompanied with the SNR, Crab-like pulsar is the most reasonable candidate. However, 1.48sec pulsation period is too slow. Even, we cannot make pulsation search below 1sec because of the lack of time resolution of this observation. Thus, if this has a pulsation on the order of msec not of 1.48sec, there is no negative evidence to think this SNR as a Crab-like pulsar.
2. SN1006-like SNR
   Considering the spectral type of the hard component ($\Gamma \sim$2.6), it is possible that hard X-rays originate from a synchrotron radiation at a SNR shell (SN1006-like SNR; $\Gamma \sim$1.8–3). However, there is no pulsation from the SN1006-like SNR. Thus, if so, the pulsed signal from this SNR must be a wrong result.
3. Magnetar
   Magnetar has a 5–8sec pulsation period and relatively soft spectrum ($\Gamma \sim$3), those are almost consistent with this hard component.
4. Accretion-Powered Pulsar
   If 1.48sec pulsation period is real, it is most resonable to think this hard component as an accretion-powered pulsar. However, photon index of 2.6 is too soft ($\Gamma \sim$1 for accretion-powered pulsar). Thus, there is little possibility.
5. Anomalous X-ray Pulsar
   Anomalous X-ray Pulsars (AXPs) are those group of pulsars that have 5–10sec pulsation periods and relatively soft spectra ($\Gamma \sim$3). Conisdering the spectral type, this pulsar may be categorized as a AXP.

Each possibility cannot be completely rejected because of its limited statistics and probably its poor spacial resolution. To give a critical evidence, it is needed to decide a spectral type and a pulsation period more exactly, and to reveal whether another point source is located or not. To solve these problems, observations with the next generation satellites, AXAF or XMM, are required.

References

Cusumano G. et al. 1998, A&A 333, L55
Hughes J., Hayashi I., Koyama K., 1998, ApJ 505, 732
Koyama K. et al. 1995 Nature 378, 255
Mathewson D. S. et al. 1983, ApJS 51, 345
Ögelman H., Hasinger G., 1990, ApJ 353, 210
Wang Q. et al. 1991, ApJ 374, 475