Suzaku Observation of the Anomalous X-Ray Pulsar CXOU J164710.2–455216

Sachindra Naik, Tadayasu Dotani, Nobuyuki Kawai, Motohide Kokubun, Takayasu Anada, Mikio Mori, Tatehiro Mihara, Teruaki Enoto, Madoka Kawaharada, Toshio Murakami, Yujin E. Nakagawa, Hiromitsu Takahashi, Yukikatsu Terada, and Atsumasa Yoshida

1 Institute of Space and Astronautical Science, JAXA, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510
2 Space and Astronomical Science, School of Physical Sciences, The Graduate University for Advanced Studies, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510
3 Department of Physics, Tokyo Institute of Technology, 2-12-1 Okayama, Meguro-ku, Tokyo 152-8551
4 Department of Physics, Rikkyo University, 3-34-1, Nishi-Ikebukuro, Toshima-ku, Tokyo 171-8501
5 Cosmic Radiation Laboratory, Institute of Physical and Chemical Research, Wako, Saitama 351-0198
6 Department of Physics, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033
7 Department of Physics, Kanazawa University, Kadoma, Kanazawa, Ishikawa 920-1192
8 Graduate School of Science and Engineering, Aoyama Gakuin University, Sagamihara, Kanagawa 229-8558
9 Department of Physical Science, Hiroshima University, 1-3-1 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8526

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Abstract

A Suzaku TOO observation of CXOU J164710.2–455216 was performed on 2006 September 23–24 for a net exposure of 38.8 ks. Pulsations were clearly detected in the XIS light curves with a pulse period of 10.61 10^{-5} s. The XIS pulse profile is found to be highly non-sinusoidal. It shows 3 peaks of different amplitudes with an RMS fractional amplitude of ~11% in the 0.2–6.0 keV energy band. The 1–10 keV XIS spectra were well fitted by two different models consisting of a power-law and a blackbody component and two blackbody components, respectively. Although both the models are statistically acceptable, a difference in the pulse profiles at soft (0.2–6.0 keV) and hard (6–12 keV) X-rays favors the model consisting of two blackbody components. The temperatures of two blackbody components are found to be 0.61 ± 0.01 keV and 1.22 ± 0.06 keV, and the value of the absorption column density is 1.73 ± 0.03 × 10^{22} atoms cm^{-2}. Pulse phase resolved spectroscopy shows that the flux of the soft blackbody component consists of three narrow peaks, whereas the flux of the other component shows a single peak over the pulse period of the AXP. The blackbody radii change between 2.2–2.7 km and 0.28–0.38 km (assuming the source distance to be 5 kpc) over the pulse phases for the soft and hard components, respectively. The details of the results obtained from the timing and spectral analyses are presented.

Key words: stars: neutron — stars: pulsars: individual (CXOU J164710.2–455216) — X-rays: general — X-rays: individual (CXOU J164710.2–455216)

1. Introduction

Anomalous X-ray pulsars (AXPs) are a small group of X-ray pulsars that show common properties, such as (i) known to present within 1° of the galactic plane, (ii) pulse period in a very narrow range of 5–12 s, unlike radio pulsars and accreting X-ray pulsars, (iii) large and more or less steady spin-down or braking, in contrast to most accretion-powered pulsars, which show spin ups and downs, (iv) similar spectra with a soft component characterized by a blackbody model with the temperature below 1 keV, with an additional harder component in some cases, and (v) a relatively high X-ray luminosity (~10^{34}–10^{36} erg s^{-1}) that cannot be obtained from the loss of rotational energy of a neutron star alone. Some of the AXPs also emit at optical and/or infrared wavelengths (Hulleman et al. 2000; Durant & van Kerkwijk 2006). The AXPs are considered to be very young (10^3–10^5 yr), some of which are associated with supernova remnants (SNRs). The AXPs are considered to be neutron stars with the strongest known magnetic field (10^{14}–10^{15} G), though a direct measurement to confirm the presence of such high magnetic field strengths is still needed. The source of energy for the radiative emission in AXPs is described by a magnetar model, in which the decay of an ultra-strong magnetic field powers the high-luminosity bursts and also a substantial fraction of the persistent X-ray emission (Thompson & Duncan 1996). A competing model for the mechanism of powering the X-ray emission in AXPs is that the AXPs are neutron stars surrounded by fossil disks that were acquired during supernova collapse or during a common-envelope interaction (Corbet et al. 1995; van Paradijs et al. 1995; Chatterjee & Hernquist 2000). The properties of AXPs are summarized by Mereghetti et al. (2002), Kaspi and Gavriil (2004), Woods and Thompson (2006).

Recently discovered AXP CXOU J164710.2–455216 is located in the young, massive galactic star cluster Westerlund 1 (Muno et al. 2006). Coherent pulsations with a period of...
10.61 s were detected from 2005 May 22 and June 18 Chandra observations of the cluster. The best-fit periods obtained from the above-mentioned two observations were $10.6112(4)$ s and $10.6107(1)$ s, which put a limit on the period derivative of $\dot{P} < 2 \times 10^{-10}$ s$^{-1}$. The 0.5–8.0 keV Chandra ACIS spectrum of the AXP was equally well described by a blackbody, power-law, or bremsstrahlung continuum model modified by interstellar absorption (Muno et al. 2006). Analysis with a more complex model of the magnetar atmosphere suggested that the emission likely arises in one or more hot spots covering a small fraction of the surface (Skinner et al. 2006). A search for an infrared counterpart with the Son of ISAAC instrument on the European Southern Observatory (ESO) New Technology Telescope (NTT) yielded a negative result within the $0.7 \pm 0.3$ uncertainty at the location of the AXP (Muno et al. 2006).

Following the detection of an intense ($\sim 10^{39}$ erg s$^{-1}$) and short (20 ms) burst from CXOU J164710.2–455216 with the Burst Alert Telescope (BAT) on Swift on 2006 September 21 (Krimm et al. 2006), the AXP was observed by various X-ray observatories. A Chandra Target of Opportunity (TOO) observation of the AXP on 2006 September 27 showed the presence of 10.61069 s pulsations in the ACIS-S event data (Gavriil et al. 2006). Using the Swift, XMM-Newton, and Chandra data, Israel et al. (2007) obtained a phase-coherent solution for source pulsations after the burst. The solution required an exponential component decaying with a time scale of 1.4 d, which was interpreted to indicate a recovery stage following a glitch with $\Delta P / P \sim -10^{-4}$. They also detected a spin-down of $\dot{P} \sim 9 \times 10^{-13}$ s$^{-1}$, which implies a magnetic field strength of $10^{14}$ G. Suzaku performed a TOO observation of the AXP CXOU J164710.2–455216 on 2006 September 23–24. The results obtained from the analysis of the Suzaku observation are presented in this paper.

2. Observation

Following the outburst detected by the BAT, Suzaku performed a TOO observation of the AXP CXOU J164710.2–455216 on 2006 September 23 from 06:52 UT to 04:56 UT the next day. The TOO observation was carried out at the “XIS window” option, which gave a time resolution of 1 s. The 0.2–600 keV energy range with two sets of instruments, X-ray CCDs (X-ray Imaging Spectrometer: XIS) covering the soft X-rays in the 0.2–12 keV energy range, and Hard X-ray Detectors (HXD), which cover 10–70 keV with PIN diodes and 30–600 keV with GSO scintillators. There are 4 XISs (one back illuminated and three front illuminated), each with 1024 x 1024 pixels X-ray-sensitive CCD detectors at the focus of each of the four X-ray Telescopes (XRT). The HXD is a non-imaging instrument that is designed to detect high-energy X-rays. It has 16 identical units made up of two types of detectors, silicon PIN diodes ($< 70$ keV) and GSO crystal scintillator ($> 30$ keV). For detailed descriptions of the XIS and HXD detectors, refer to Koyama et al. (2007) and Takahashi et al. (2007), respectively.

3. Analysis and Results

We used public data (rev-1.2) for the Suzaku TOO observation of the AXP CXOU J164710.2–455216 in the present work. For XIS data reduction, the accumulated events were discarded when the telemetry was saturated, the data rate was low, the satellite was in the South Atlantic Anomaly (SAA), and when the source elevation above the Earth’s limb was below 5° with night-Earth and below 20° with day-Earth. We corrected the known shift of the XIS time assignment in rev-1.2 data (7 s for the current data). Applying these conditions, the source spectra were accumulated by selecting a circular region having a radius of 3.4 arcmin around the image center; the circle covers 99% of a point source flux. Using the same circular region, X-ray light curves of 1 s time resolution were also extracted from the XIS event data. Because this extraction circle is larger than the optional window, the effective extraction region is the intersection of the window and this circle. The XIS background spectra were accumulated from the same observation by selecting rectangular regions away from the source. The response files and effective area files for XIS detectors were generated by using the “xissimarfgen” and “xisrmfgen” task of FTOOLS (version 6.2). For HXD/PIN data reduction, we used the cleaned event data to obtain the source light curve and the spectrum. The simulated background events were used to estimate the HXD/PIN background (Kokubun et al. 2007).

It was found that, during the Suzaku TOO observation, GX 340+0, a bright Z-source which is located at about 21° away from the AXP, contaminated the HXD data. The RXTE/ASM monitoring data of GX 340+0 shows a more or less constant flux around 30 counts s$^{-1}$. Though GX 340+0 was outside the field-of-view of the AXP, it was well within the HXD field-of-view. Considering a steep power-law spectrum at hard X-rays for AXPs, a roughly estimated 10–50 keV flux of CXOU J164710.2–455216 is found to be a few orders of magnitude lower than that of the observed HXD/PIN flux in the above-mentioned energy band. This suggests that the HXD data of the Suzaku observation of the AXP is significantly contaminated by the contribution of the nearby hard X-ray source GX 340+0. In fact, we could not detect any significant X-ray pulsation at 10.6106 s in the HXD/PIN data. Therefore, in the present work, we used only the XIS data.

3.1. Timing Analysis

For a timing analysis, a barycentric correction was applied to the arrival times of the X-ray photons using the “aebarycen” task of FTOOLS. As described above, light curves with a time resolution of 1 s were extracted from XIS (0.2–12 keV) event data. Light curves with a binsize of 1, 10, 25, 50, 100, and 200 times the pulse period (10.61063 s) were investigated without any success in finding significant variations of the count rate. The light curve with 200-times the pulse period obtained from all four XIS detectors during the entire observation is shown in figure 1.  

1. [http://www.astro.isas.jaxa.jp/suzaku/analysis/xis/timing/].
Fig. 1. XIS light curves of CXOU J164710.2–455216 obtained from the Suzaku TOO observation of the AXP. The light curves are plotted for a binsize of 200-times the spin period of the AXP.

Fig. 2. Results of an epoch-folding analysis on the XIS light curve (all four XIS light curves added together) of CXOU J164710.2–455216 obtained from the Suzaku TOO observation of the AXP.

To determine the pulse period of CXOU J164710.2–455216, all four XIS light curves were added together to improve the statistics. Because the XISs have very low backgrounds, background subtraction from the light curves was not done. A pulse folding and $\chi^2$ maximization method was first applied to the added XIS light curve using the XRONOS task “efsearch”. The result is shown in figure 2. This analysis yielded a pulse period of 10.61063 s. To improve the estimation of the pulse period, we next applied a phase-fitting technique to the XIS data. We divided the XIS light curve into 8 segments and calculated a folded pulse profile for each segment with a common epoch (MJD 54001.000081) and a period (10.61063 s). All segments have a consistent profile with 3 peaks, but the statistics was poor for the 8th segment, which was not used for a subsequent analysis. We determined the phases of the main peak by fitting a Gaussian to the profile. The phases were converted to the relative arrival times of the pulse by multiplying the pulse period. The results are plotted in figure 3 (this is the so-called O–C curve). The slope of the plot indicates the adjustment to the trial period used for calculating the folded profile. The slope was found to be $0.2 \pm 1.3 \times 10^{-6}$. This means that the pulse period of the AXP was 10.61063(2) s, where the error corresponds to the 90% confidence limit. This pulse period is consistent with that obtained from an XMM-Newton observation on 2006 September 22 (Muno et al. 2007).

The pulse profile obtained from the added XIS light curve of the Suzaku observation of the AXP is shown in figure 4. The RMS fractional amplitude of the pulse was found to be $\sim 11\%$. From the figure, it is observed that the shape of the pulse profile in the XIS energy band (0.2–12 keV) is not sinusoidal in nature, rather it is a three-peaked profile. Such a three-peaked profile was also observed by XMM-Newton on September 22 (Muno et al. 2007), and Chandra on September 27 (Gavriil et al. 2006). Possibly this is the only AXP that shows a three-peaked profile.

Fig. 3. Relative arrival times of the main pulse plotted for an assumed constant period of 10.61063 s and an epoch of MJD 54001.000081. See text for calculation details. This plot represents the so-called O–C curve. The broken line is the best-fit linear function to the data, whose slope represents the offset of the assumed pulse period from the true one.

Fig. 4. Pulse profile of CXOU J164710.2–455216 obtained from the Suzaku TOO observation of the AXP. The error bars represent 1σ uncertainties. Two pulses are shown for clarity.
pulse profile. To investigate the energy dependence of the pulse profile of the AXP, we generated light curves in different energy bands from all four XIS event data. The light curves were folded with the pulse period using the XRONOS task “efold”, and the corresponding pulse profiles are shown in figure 5. The RMS fractional amplitude tends to decrease slightly toward higher energies: ∼11% in 1.8–6.0 keV, while ∼8% in 6–12 keV. The energy-resolved pulse profiles in XIS energy band are found to be different: three peaked profiles with different amplitudes in the 0.2–6.0 keV energy band and a single peaked profile in the 6–12 keV energy band.

We carried out a model fitting to the pulse profiles to study the energy dependence of the profile quantitatively. We adopted a model consisting of a constant and three Gaussian functions to represent the pulse profile. The results of the model fitting are summarized in table 1. We can see in the table that all of the model parameters are same within the errors between 0.2–1.8 keV and 1.8–6.0 keV. On the other hand, the profile in the 6–12 keV band seems to be intrinsically different from those in the lower energy bands. The main peak is significantly broader in the 6–12 keV region. The 2nd peak, even if present in 6–12 keV, should be significantly smaller than that below 6 keV. Because of these two differences, the pulse profile in 6–12 keV appears to be more or less sinusoidal. We consider from these differences that the pulse profile in the 6–12 keV region is intrinsically different from that below 6 keV.

| Component | 0.2–1.8 keV | 1.8–6.0 keV | 6–12 keV |
|-----------|-------------|-------------|---------|
| Constant  | 0.87 ± 0.03 | 0.86 ± 0.02 | (0.86)  |
| Main Gaussian |            |             |         |
| Centroid  | 0.42 ± 0.01 | 0.43 ± 0.01 | 0.40 ± 0.03 |
| Width     | 0.09 ± 0.02 | 0.09 ± 0.01 | 0.16 ± 0.03 |
| Normalization | 0.36 ± 0.05 | 0.41 ± 0.02 | 0.30 ± 0.05 |
| 2nd Gaussian |            |             |         |
| Centroid  | 0.76 ± 0.02 | 0.74 ± 0.01 | (0.74)  |
| Width     | 0.06 ± 0.02 | 0.06 ± 0.01 | (0.06)  |
| Normalization | 0.15 ± 0.05 | 0.20 ± 0.02 | < 0.13  |
| 3rd Gaussian |            |             |         |
| Centroid  | 1.02 ± 0.02 | 1.03 ± 0.01 | (1.03)  |
| Width     | 0.08 ± 0.03 | 0.07 ± 0.02 | (0.07)  |
| Normalization | 0.14 ± 0.05 | 0.09 ± 0.02 | < 0.12  |

* Gaussian is defined as $N \exp\left[-\frac{(x-c)^2}{2w^2}\right]$, where $N$ is a normalization, $c$ is a centroid, and $w$ is a width. Errors are in 90% confidence limit. Values in the parentheses are fixed in the fitting.
Table 2. Spectral parameters for CXOU J164710.2–455216.

| Parameter                  | Blackbody+Power-law | Blackbody+Blackbody |
|---------------------------|---------------------|----------------------|
| $N_H$ ($10^{22}$ atoms cm$^{-2}$) | $2.55 \pm 0.01$     | $1.73 \pm 0.03$     |
| $kT_{BB1}$ (keV)          | $0.67 \pm 0.01$     | $0.61 \pm 0.01$     |
| $kT_{BB2}$ (keV)          | $1.22 \pm 0.06$     |                      |
| Power-law index ($F_1$)   | $3.14 \pm 0.08$     |                      |
| Blackbody flux ($F_{BB1}$) | $1.3 \pm 0.1$       | $1.8 \pm 0.1$       |
| Power-law flux ($F_{PO}$)  | $1.3 \pm 0.1$       |                      |
| Blackbody flux ($F_{BB2}$) | $—$                 | $0.8 \pm 0.1$       |
| Total source flux         | $2.6 \pm 0.1$       | $2.6 \pm 0.1$       |
| Reduced $\chi^2$         | $1.15$ (384 dof)    | $1.19$ (384 dof)    |

* Errors are defined in 1σ confidence limit.

† Flux (in $10^{-11}$ erg cm$^{-2}$ s$^{-1}$) is estimated in 1–10 keV energy range without the correction of the absorption.

Fig. 6. Energy spectrum of CXOU J164710.2–455216 obtained with the four XIS detectors of the Suzaku observation, along with the best-fit model comprising a blackbody component and a power-law continuum model. The bottom panel shows the contributions of the residuals to the $\chi^2$ for each energy bin.

Fig. 7. Energy spectrum of CXOU J164710.2–455216 obtained with the four XISs in the Suzaku observation, along with the best-fit model comprising two blackbody components as continuum model. The bottom panel shows the contributions of the residuals to the $\chi^2$ for each energy bin.

We tried to fit the XIS spectra of CXOU J164710.2–455216 using a power-law continuum component along with the interstellar absorption. A simultaneous spectral fitting of 0.8–10 keV spectrum with the above model yielded a poor fit with a reduced $\chi^2$ of 3.9 for 386 degrees of freedom (dof). We tried to fit the spectra with a blackbody model modified with the interstellar absorption. This model improves the spectral fitting with a reduced $\chi^2$ of 2.7 for 386 dof. We tried to fit the spectrum using a model consisting of a blackbody and a power-law components with interstellar absorption. This two-component model provided a best-fit to the XIS spectra of the AXP with a reduced $\chi^2$ of 1.15 for 384 dof. The spectral parameters of the best-fit model obtained from the simultaneous spectral fitting are given in table 2. The count rate spectra of the Suzaku observation is shown in figure 6 along with the model components (top panel) and residuals to the best-fit continuum model (bottom panel). Though the estimated absorption column density is found to be high, the other parameters obtained from the Suzaku observation of the AXP are found to agree with that reported from Chandra and XMM-Newton observations (Gavriil et al. 2006; Muno et al. 2007).

Though the two-component model (power-law and blackbody components) fits very well to the 0.8–10.0 keV XIS spectra, this model is not compatible with the energy dependence of the pulse profile. From figure 5, the pulse profile is three peaked at soft X-rays, but tends to be single peaked at hard X-rays. On the other hand, it is found that the power-law component dominates below 2 keV and above 5 keV, and the blackbody component dominates in the 2–5 keV energy band (figure 6). This means that the pulse profile should be similar below 2 keV and above 5 keV, which is not the case. Therefore, the model with a blackbody and a power-law as model components is not favored. Following this, we tried to fit the 1–10 keV spectra with a model consisting of two blackbody components. This model fits the data very well with a reduced...
χ² of 1.19 for 384 dof. The best-fit parameters are given in table 2 and the spectra with the fitted model components are shown in figure 7. The two blackbody model was reported to fit the XMM-Newton data (Muno et al. 2007) and the Swift data (Israel et al. 2007) just after the burst. The best-fit parameters obtained with Suzaku are comparable to those obtained by these satellites.

The addition of a narrow Gaussian function at 6.4 keV (for iron Kα fluorescent line) did not yield any change in the value of the reduced χ² and the spectral parameters. The corresponding equivalent width is found to be about 6 eV, and the flux of the emission line is estimated to be 8.4 × 10⁻¹⁵ erg cm⁻² s⁻¹, which is about three orders of magnitude lower than the source flux. This suggests a lack of reprocessing matter surrounding the neutron star to produce iron fluorescent-emission.

3.2.2. Pulse phase resolved spectroscopy

A different type of pulse profiles of CXOU J164710.2−455216 in different energy bands prompted us to perform a phase-resolved spectral analysis of the Suzaku observation of the AXP. To investigate the changes in the spectral parameters at soft X-rays at different pulse phases, the source spectra were accumulated into 10 pulse phase bins by applying phase filtering in the FTOOLS task XSELECT. The XIS background spectra and the response matrices used for phase-averaged spectroscopy were also used for phase-resolved spectroscopy. A simultaneous spectral fitting was done in the 1–10 keV energy band.

The phase-resolved spectra were fitted with the same two blackbody component model used to describe the phase-averaged spectrum. The value of the absorption column density (N_H) and the temperature of the second blackbody component (kT2) did not show any significant variability over the pulse phase. We kept fixed the values of N_H and kT2 to that of the phase-average values during the spectral fitting of the phase-resolved spectra. The parameters obtained from the spectral fitting to the XIS phase resolved spectra are shown in figure 8 along with the XIS pulse profiles in the top panels, and are listed in table 3. As the soft blackbody component dominates the spectrum at soft X-rays and the second blackbody dominates the spectrum at > 5 keV, the change in the estimated flux of the two blackbody components over the pulse period is expected to resemble the pulse profiles at corresponding energy bands. From the figure, it is found that the soft blackbody (marked as BB1 in figure) flux profile shows two prominent and narrow peaks and a third small peak at the same phases as in the 0.2–12 keV pulse profile of the AXP. On the other hand, the second blackbody (BB2) flux shows a single-peak

![Fig. 8. Spectral parameters obtained from pulse phase-resolved spectroscopy of a Suzaku observation of CXOU J164710.2−455216. In the figure, the change in the soft blackbody flux (F_{BB1}), and the second blackbody flux (F_{BB2}) over pulse phases are shown along with the blackbody temperature, kT_{BB1} and the radii (assuming the source distance to be 5 kpc) of the blackbody emitting regions (R_{BB1} and R_{BB2}) with 1σ errors. The blackbody flux is in units of 10⁻¹¹ erg cm⁻² s⁻¹. The XIS pulse profiles (XIS PP) in the 1.8–6.0 keV and 6–12 keV energy bands are also shown in the left and right-top panels, respectively.](https://academic.oup.com/pasj/article-abstract/60/2/237/1408436)
Although the pulse profile below 7 keV was presented before the burst, which changed to a three-peaked profile on September 22. These peaks were seen in the 0.5–7.0 keV range. Although the pulse profile below 7 keV was presented in Muno et al. (2007), the current Suzaku data show that the pulse profile is single peaked at a higher energy band, in the 6–12 keV region. Because the spectral parameters are comparable between the XMM-Newton data and the Suzaku data, we consider that the nature of the pulse profile, especially the energy dependence, is basically the same between these two sets of observations. Though the pulse profiles of some of the AXPs show change before and after the burst (Kaspi et al. 2003), the change from a single peak profile to a three-peak profile is unique to CXOU J164710.2–455216.

Before the intense, short burst, the spectrum was described by a single blackbody component and the pulse profile was single-peaked (Muno et al. 2007). A hardening of the source spectrum (after the burst) was seen from XMM-Newton observations, which was explained by adding a power-law component. Though the pulse profiles of some of the AXPs show change before and after the burst (Kaspi et al. 2003), the change from a single peak profile to a three-peak profile is unique to CXOU J164710.2–455216.

The observed changes in AXP CXOU J164710.2–455216 before and after an intense and short burst in 2006 September are remarkable. The XMM-Newton observation on 2006 September 22 and the Suzaku observation on September 23 summarize various changes in the AXP, when compared with the pre-burst data of XMM-Newton on September 16 (Muno et al. 2007). The pulse profile of the AXP was single peaked before the burst, which changed to a three-peaked profile on September 22. These peaks were seen in the 0.5–7.0 keV range. Although the pulse profile below 7 keV was presented in Muno et al. (2007), the current Suzaku data show that the pulse profile is single peaked at a higher energy band, in the 6–12 keV region. Because the spectral parameters are comparable between the XMM-Newton data and the Suzaku data, we consider that the nature of the pulse profile, especially the energy dependence, is basically the same between these two sets of observations. Though the pulse profiles of some of the AXPs show change before and after the burst (Kaspi et al. 2003), the change from a single peak profile to a three-peak profile is unique to CXOU J164710.2–455216.

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component with an index of $\sim 2.0$ to the blackbody component to describe the spectrum. The pulse profile also changed to a three-peaked profile, as seen from XMM-Newton and Suzaku observations. However, energy-resolved pulse profiles of the Suzaku observation shows that the hard X-ray (6–12 keV) pulse profile is similar to that of the pre-burst profile obtained from XMM-Newton, whereas the soft X-ray pulse profile is found to be three-peaked. This energy-dependent pulse profile of Suzaku observation ruled out the model with blackbody and power-law as spectral components, and favored a model with two blackbody components. The phase-resolved spectroscopy of the Suzaku observation also showed that the change in the soft blackbody flux over pulse phase shows two narrow and intense peaks and a third minor peak exactly at the same phases of the peaks in the pulse profile. The second blackbody flux, however, shows only a single peak, which is similar to the 6–12 keV pulse profile. These findings suggest that the single blackbody component that described both the spectrum and the pulse profile before the outburst is also required to describe the source properties after the outburst with an increased temperature, and hence at the hard X-ray band. The three-peaked profile, seen after the outburst, is interpreted as being due to the emergence of a new spectral component that dominates at soft X-rays. This new spectral component may have originated from giant flares in the AXPs/SGRs during which a significant amount of the magnetic energy was released.

The multi-peaked pulse profiles in AXPs/SGRs are attributed to the presence of multi-pole structures of the external magnetic fields. A rearrangement of these multi-pole magnetic fields changes the shape of the observed pulse profiles in these objects. Muno et al. (2007) suggested that the observed changes in the pulse profiles and the spectral properties of the AXP before and after the burst are due to a change in the distribution of the currents in the magnetosphere. This change in the magnetosphere is triggered by plastic motions in the crust of the neutron star. The observed three-peaked profile in AXP CXOU J164710.2–455216 suggests that three magnetic field foot points developed in response to a change in magnetosphere. Above the foot points, there might be hot plasma columns, like an accretion column of the accretion powered pulsars. The temperatures distribution is for a hotter temperature at the lower altitude and for a lower temperature at the higher altitude. The electron–positron plasma within the column cannot moves in a direction perpendicular to the magnetic field. However, they can move in a direction parallel to the magnetic field. Therefore, the X-ray photons that pass through along with the magnetic field can escape freely. However, the X-ray photons passing in the transversal direction to the magnetic field are restricted by electron–positron scattering. In that case, blackbody radiation from such a foot point is beamed into the magnetic filed direction. This can explain the narrow three-peaked profile of the blackbody flux in CXOU J164710.2–455216.

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