Suzaku X-ray Study of Two γ Cas Analogues: HD 110432 and HD 161103

M. Tsujimoto[1], K. Saitou[1,2], T. Shionome[1,3], M. Ishida[1,3], Y. Hatta[4], K. Yamazaki[4], J. Miura[4], & Y. Tsuboi[4]

[1] Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science
[2] Department of Astronomy, Graduate School of Science, The University of Tokyo
[3] Department of Physics, Graduate School of Science, Tokyo Metropolitan University
[4] Department of Physics, Graduate School of Science & Engineering, Chuo University
E-mail(MT): tsujimot@astro.isas.jaxa.jp

Abstract

We present the result of Suzaku observations of two γ Cas analogues. γ Cas analogues are small group of early B-type stars with exceptionally hard thermal X-ray emission up to 30 keV. This is harder than any X-ray emitters of stellar origins. Despite the accumulating observational facts, the X-ray production mechanism of γ Cas analogues is uncertain. We conducted Suzaku observations of two of the sources, HD 110432 and HD 161103, respectively in September 2008 for 25 ks and February 2009 for 72 ks. In this contribution, we summarize the result of our spectral and temporal analysis using the XIS and PIN data.

Key words: stars: individual (HD 110432, HD 161103) — stars: novae, cataclysmic variables — stars: white dwarfs — X-rays: stars

1. Introduction

γ Cas is the familiar star in the middle of W in the Cassiopeia constellation. In the X-rays, the star is quite anomalous. Together with a half dozen stars, it comprises a distinct class of X-ray sources called "γ Cas analogues". They are early B-type stars with exceptionally hard thermal X-ray emission up to ~30 keV (Owens et al. 1999; Torrejón & Orr 2001; den Hartog et al. 2006). This is harder than any X-ray emitters of stellar origins. Despite the accumulating observational facts, the X-ray production mechanism of γ Cas analogues is uncertain.

γ Cas is a B 0.5IV*e* star, which has long been known as an anomalous X-ray source (Mason et al. 1976). It was observed by many satellites including Tenma (Murakami et al. 1986), Ginga (Horaguchi et al. 1994), and ASCA (Kubo et al. 1998). They revealed the X-ray luminosity of 10^{32}–10^{33} erg s^{-1}, the lack of drastic flux variation, the presence of Kα lines from highly ionized Fe (6.7 and 7.0 keV from Fe XXV and Fe XXVI) as well as quasi-neutral Fe (6.4 keV from Fe I). It has an exceptionally high thermal temperature of >10 keV.

γ Cas had been the only star with such properties for ~30 years, until Chandra and XMM recently discovered similar sources one after another (Motch et al. 2005). They share the X-ray properties with γ Cas, including super-hard thermal emission and the 6.4 keV Fe fluorescence line. A class of sources called "γ Cas analogues" is now established. Interestingly, the spectral types of all sources are in a limited range of B1.5–B0.5. Despite the anomalies in the X-ray band, their optical features cannot be distinguished from normal B*e* stars. The binary nature had not been revealed in any of the sources until recently, when Harmanec et al. (2000) reported a 203.59 day periodicity from γ Cas.

Two competing ideas have been proposed to explain the X-ray production mechanism of γ Cas analogues. One is magnetic B*e* star, in which a single B*e* star is responsible for the X-ray emission (Robinson et al. 2002; Smith et al. 2006). X-rays are produced by magnetic activity at the B*e* star surface. The Fe fluorescence occurs by the reflection at the B*e* star disk. The other idea is that γ Cas analogues are cataclysmic variables (CVs), in which matter filling the Roche lobe of the B*e* star accretes on the white dwarf (WD) through a Lagrangian point. Very hard X-rays are attributable to the boundary layer between the inner accretion disk and the WD surface (non-magnetic CVs) or the shock at the base of the accretion funnel very close to a magnetic pole on the surface (magnetic CVs).

2. Observations

Using Suzaku, we observed two γ Cas analogues: HD 110432 at 300 pc on 2008 August 9–10 for 25 ks and HD 161103 at 1.1 kpc on 2009 February 22-24 for 72 ks. The former was obtained with the HXD-nominal position and a significant signal with the PIN was detected. The latter was obtained with the XIS-nominal position and the PIN emission is contaminated by other sources in the field of view.

3. Results

3.1. Spectra

Figs. 1 and 2 show the background-subtracted spectra and the best-fit spectral models for the two targets. For HD 110432, we used both the XIS and PIN spectra. For HD 161103, we only used the XIS data.

We fitted the spectra using a thin-thermal plasma model (APEC) convolved with an interstellar extinction (TBabs). When a large residuals were found, we added extra APEC components. We also added a Gaussian model to account for the 6.4 keV line. HD 110432 shows a complex spectrum that requires at least three spectral components. The best-fit parameters are in Table 1.

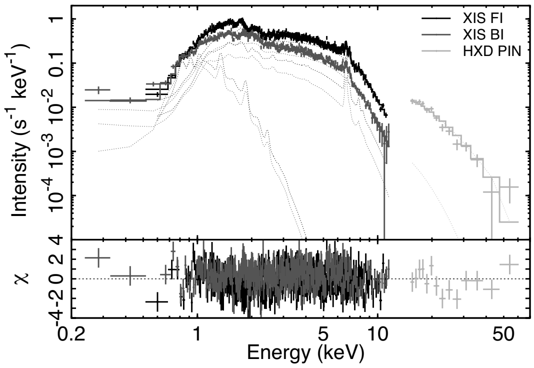

Fig. 1. XIS and PIN spectra and the best-fit models of HD 110432.

Table 1. Sample of an one-column table

Comp	Par	Unit	HD 110432	HD 161103
TBabs	$N_{\rm H}$	10^{21} cm^{-2}	$9.0^{+0.1}_{-0.1}$	$3.2^{+0.3}_{-0.3}$
APEC 1	$k_{\rm B}T$	keV	$38.1^{+2.2}_{-5.1}$	$8.2^{+1.1}_{-0.8}$
	EM	10^{55} cm^{-3}	$2.4^{+0.1}_{-0.1}$	$1.0^{+0.1}_{-0.1}$
	Z	solar	$0.98^{+0.15}_{-0.17}$	$0.90^{+0.21}_{-0.19}$
APEC 2	$k_{\rm B}T$	keV	$4.8^{+0.3}_{-0.3}$	...
	EM	10^{55} cm^{-3}	$0.88^{+0.07}_{-0.04}$	...
APEC 3	$k_{\rm B}T$	keV	$0.29^{+0.01}_{-0.01}$	...
	EM	10^{55} cm^{-3}	$1.2^{+0.1}_{-0.1}$	...
Gaussian	E	keV	$6.39^{+0.02}_{-0.02}$	6.40 (fixed)
	EW	eV	$71\ ^{+11}_{-11}$	56^{+59}_{-41}

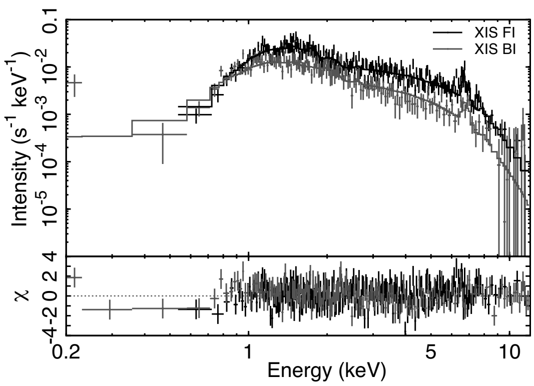

Fig. 2. XIS and PIN spectra and the best-fit models of HD 161103.

3.2. Light Curve

Figs. 3 and 4 show the background-subtracted count rate curves for the two targets. Both sources show a hint of flux variability.

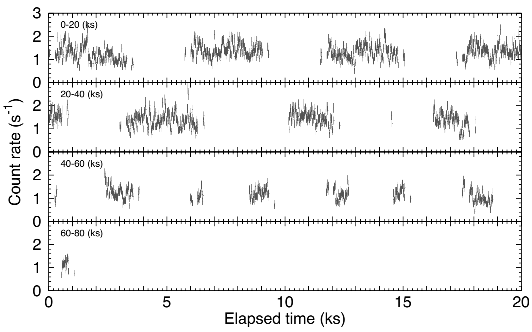

Fig. 3. Light curve of the XIS count rate of HD 110432.

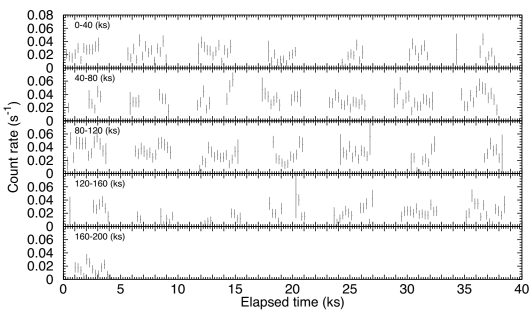

Fig. 4. Light curve of the XIS count rate of HD 1611103.

References

den Hartog et al. 2006, A&A, 451, 587
Ezuka & Ishida 1999, ApJS, 120, 277
Harmanec et al. 2000, A&A, 364, L85
Horaguchi et al. 1994, PASJ, 46, 9
Kubo et al. 1998, PASJ, 50, 417
Mason et al. 1976, Nature, 260, 690
Motch et al. 2005, arXiv:astro-ph/0512556
Murakami et al. 1986, ApJ, 310, L31
Owens et al. 1999, A&A, 348, 1700
Robinson et al. 2002, ApJ, 575, 435
Safi-Harb et al. 2007, ApJ, 659, 407
Smith et al. 2006, ApJ, 647, 137
Torrejón & Orr 2001, A&A, 377, 148