Suzaku observations of the massive twin star HD159176

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Abstract

HD159176 is a close binary system which is composed with O7V+O7V type stars. The system is in the young open cluster NGC6383 with a distance of about 1.5 kpc. With almost the same masses, the two stars orbit circulary with a separation of two stellar radii with an orbital period of 3.367 days (Pachoulakis 1995). On this target, one report exists which treated the results of an XMM-Newton observation which was executed in 2001. To investigate the long-term variability, we observed the binary on Feb. 19th 2010 with Suzaku satellite. The Suzaku data showed spectral hardening above 2 keV and showed brighter flux by twice than that of XMM-Newton. We will discuss the origin of the spectral changes in this paper.

Key words: X-ray, Massive star, O-type

1. Introduction

HD 159176 has been well studied in the visible, UV wavelengths, and X-ray. The system was detected as a rather bright X-ray source with EINSTEIN (Chlebowski et al. 1989) , ROSAT (Berghofer et al. 1996) and XMM-Newton (De Becker et al. 2004). Chlebowski & Garmany (1991) suggested that the excess X-ray emission observed in many O type binaries compared to the expected intrinsic contribution of the individual components is produced by the collision of the stellar winds (Stevens et al. 1992). Therefore, it seems likely that at least part of the X-ray flux of HD 159176 may originate in the wind interaction region. In contrast with this picture, (Pfeiffer et al. 1997) suggest that the bulk of the X-ray emission arises primarily from the intrinsic emission of the individual components, rather than from a colliding wind interaction. To investigate the long-term variability of X-ray emission, we observed the binary with Suzaku satellite.

2. Observation

We conducted a Suzaku observation centered at (R.A., dec.) = (17:35:07.2 , -32:36:30) in the equinox J2000.0. The observation was conducted on 2010 Feb. 19–20 for a telescope time of ~52.5 ks. And the phase of Suzaku observation is at 0.53-0.86, while the XMM-Newton observation on 2001 was executed at the phase 0.53-0.66 (Table 1). So they were almost the same phases.

The Suzaku satellite (Mitsuda et al. 2007) produces simultaneous data sets taken by two instruments; one is the XIS (Koyama et al. 2007) sensitive in the energy range below ~12 keV and the other is the Hard X-ray Detector (Kokubun et al.2007 , Takahashi et al. 2007) sensitive in the higher energy band. We use the XIS data in this paper.

Table 1. observation status of Suzaku and XMM-Newton satelite.

Mission	date	Exposure [ks]	phase
Suzaku	2010/02/19	52.5	0.53–0.86
XMM-Newton	2001/03/09	25.4	0.53–0.66

XIS is equipped with four X-ray CCDs (XIS0–3) mounted at the focal planes of the four independent X-Ray Telescopes (Serlemitsos et al. 2007) aligned to observe a ~18'×18' region. One of them (XIS1) is a back-side illuminated (BI) CCD chip and the remaining three (XIS0, XIS2, and XIS3) are front-side illuminated (FI) chips. The BI and FI chips are composed of 1024×1024 pixels and are superior to each other in the soft and hard band responses, respectively. One of the FI chips (XIS2) turned dysfunctional in November 2006. We therefore use the data obtained by the remaining three CCDs.

3. Result

The source spectrum was extracted within a circular region of 3 arcmin radius, and the background region is taken in consideration of contribution from G355.6-0.0 (Supernova Remnant) as shown in Fig.1 . To extract the contribution from other stars that cannot resolve in Suzaku satelite, we added an extra model which reproduces the background spectrum in the annulus region in the XMM image (Fig.2).

First of all , to examine the long-term spectral changes,

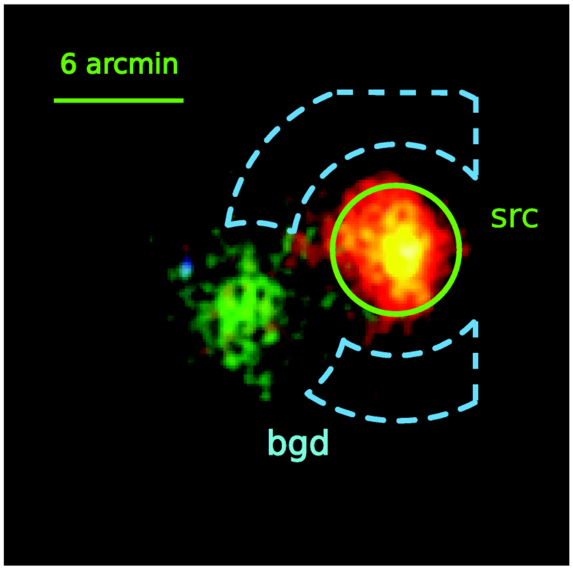

Fig. 1. HD159176 image by Suzaku

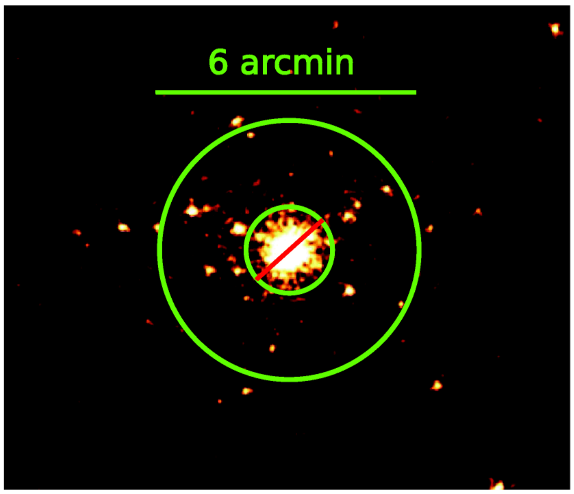

Fig. 2. XMM-Newton image

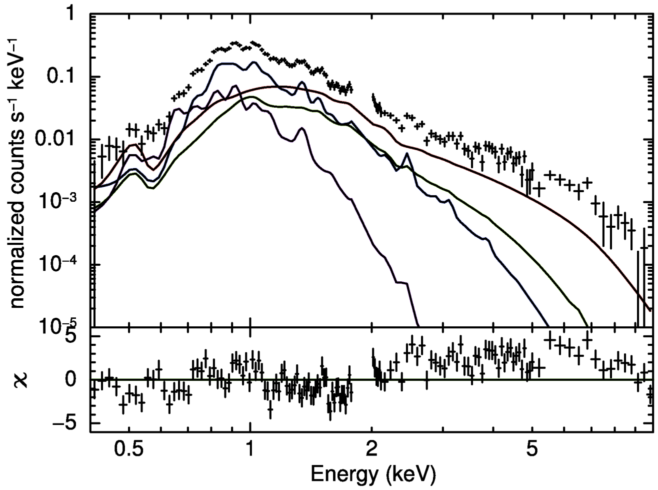

Fig. 3. The best-fit XMM-model only thawed for the common normalization

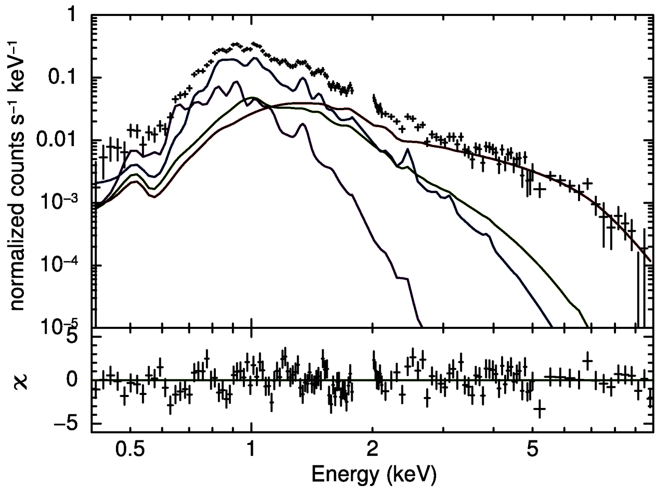

Fig. 4. The same model as in Fig.4 but with the free parameters norm1, norm2, and photon-index in the power-law model. Model=norm1(thermal1XMM+thermal2XMM)+norm2×powerlaw

we used the XMM best-fit model (2004) that only thawed for the common normalization (Fig.3). Result in, there is excess above 2 keV, and Suzaku spectral model was not able to be reproduced by the model. When we used again the XMM best-fit model (2004) that thawed for the normalization and Photon-index (Fig.4), the spectrum was able to be reproduced well, and photon-index value is 2.3. In addition, flux is about 2 times as that of XMM data.

Next, when we used three thin-thermal plasma model (Fig.5), spectrum shape was able to be reproduced well, and the highest temperature element reached the value 3 keV.

4. Discussion

In this survey, we found that flux is about 2 times as that of the same binary phase (XMM-Newton 2004) and spectrum is harder. So this shows that the binary has long term valiability. This spectral changes has the possibility caused by the changes in volume of the stellar wind and the mass-loss rate.

Also this system is very close binary, so it cannot be dismissed that spectrum was changed by each other stellar wind and gravity peel off the star surface and change the star shape irregularly.

The highest temperature element with three thin-thermal plasma model reached the value 3keV, and this system is comparatively harder and brighter than other O-type binaries (Table 2). So it is thought that the mass-loss rate of this binary is larger than that of other O-type binaries.

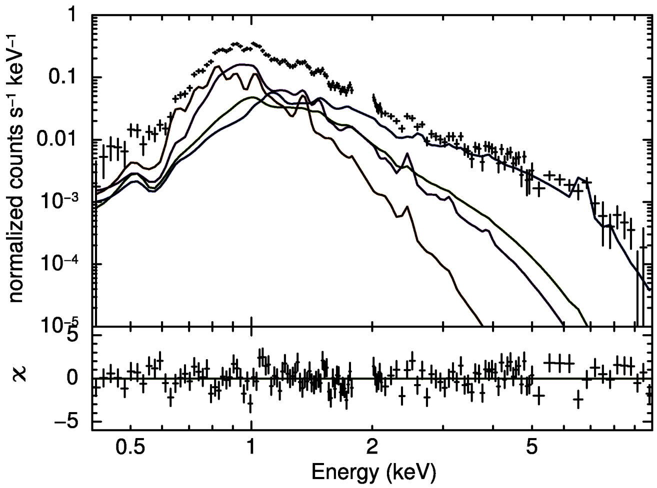

Fig. 5. Spectral fitting with three thin thermal plasma model.

5. Summary

We confirmed long-period variability in the O stellar binary which has circular orbit, and we found the following things.

(a)The obtained temperature is in the hardest level for O stellar binaries.

(b)The variability might originate from the changing of mass loss rate, which is proposed for that in Eta Carinae.

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Table 2. O-type binaries parameters. Photon-index is in two thin thermal plasma + powerlaw model. kT-hot is temperature of hot component in three thin thermal model fitting.

	Cyg OB2#8A	DH Cep	HD47129	HD159176
Spectral type	O6I+O5.5Ⅲ	O6V+O7V	O8Ⅲ/I+O7.5Ⅲ	O7V+O7V
Separation [$R_\odot$]	71	13-17	61	38
Eccentricity	0.24	<0.04	0	0
Photon-index	3	-	2.6 (2.5–2.7)	2.3 (2.2–2.4)
kT-hot component [keV]	2.0 (1.7–2.6)	<1.9	2.4 (2.2–2.8)	3.0 (2.7–3.2)