Searching for the Time Variation in Supernova Remnant RX J1713.7−3946

Aytap Sezer1, Ryo Yamazaki2, Xiaohong Cui3, Aya Bamba4 and Yutaka Ohira2

1 Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
2 Department of Physics and Mathematics, Aoyama Gakuin University, 5-10-1, Fuchinobe, Sagamihara 252-5258, Japan
3 National Astronomical Observatories, Chinese Academy of Sciences 20A Datun Road, Chaoyang District, Beijing, 100012, China
4 Department of Physics, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

1 Abstract

Supernova Remnant RX J1713.7−3946 emits synchrotron X-rays and very high energy γ-rays. Recently, thermal X-ray line emission is detected from ejecta plasma. CO and H\textsubscript{1} observations indicate that a highly inhomogeneous medium surrounding the SNR. It is interacting with dense molecular clouds in the northwest and the southwest of the remnant. The origin of the γ-ray emission from RX J1713.7−3946 is still uncertain. Detection of rapid variability in X-ray emission from RX J1713.7−3946 indicates the magnetic field $B \sim \mu$G. In this work, we investigate the time variation in X-ray flux, luminosity and photon index of RX J1713.7−3946. For this investigation, we study the northwest part of the remnant using Suzaku data in 2006 and 2010. We present preliminary results based on our analysis and interpretations about these X-ray time variability.

2 Introduction

X-ray emission of supernova remnant (SNR) RX J1713.7−3946 (G347.3−0.5) is dominated by synchrotron radiation (e.g., Koyama et al. 1997; Slane et al. 1999). Recently, Katsuda et al. (2015) detected thermal X-ray emission from this SNR using XMM-Newton and Suzaku data. Sano et al. (2010) showed that the synchrotron X-ray emission is enhanced around the CO clumps in the northwest (NW) region of this remnant.

The time variation of synchrotron X-rays was discovered in compact regions of the NW shell of RX J1713.7−3946 (Uchiyama et al., 2007). They proposed that the magnetic field in these regions is amplified to 1 mG. The X-ray variability provides information about average magnetic field condition. In this work, we investigate the time variation in X-ray flux and photon index of the NW part of RX J1713.7−3946 using Suzaku data in 2006 and 2010. We describe these observations and data analysis in Section 3. We discuss the preliminary results of our data analysis in Section 4.

3 Observation and Analysis

The NW region of RX J1713.7−3946 observed with X-ray Imaging Spectrometer (XIS; Koyama et al. 2007) on 2006 September (Obs ID: 501063010) and 2010 February (Obs ID:504027010) for ~18.4 ks and 61.5 ks, respectively. For our analysis we used the HEASOFT package (version 6.16) and XSPEC version 12.9.0 (Arnaud 1996). For the spectral analysis we generated the response matrix and auxiliary files (RMFs and ARFs) using XISRMFGEN and XISSIMARFGEN (Ishisaki et al., 2007), respectively.

Figure 1 shows the XIS images of 2006 and 2010 observations. We extracted X-ray spectra from a circular region with a radius 2.6 arcmin for both 2006 and 2010 data indicated in Figure 1. We subtracted the non-X-ray background (NXB) from both observations. The NXB spectra were made by using XISNXBGEN (Tawa et al., 2008). We fitted both spectra with a power-law (PL) model modified by an absorption model (TBABS: Wilms et al. 2000). For this fitting, the column density ($N_{\text{H}}$), the photon index ($\Gamma$) and the normalization of PL component were left as free parameters. The results of two observations are given in Table 1, and the XIS spectra are shown in Figure 2.
Figure 1: Suzaku XIS image of RX J1713.7−3946 in the 0.3–10.0 keV energy band, 2006 observation (left) and 2010 observation (right). The spectral analysis regions are shown by circles.

Figure 2: Suzaku XIS spectra of 2006 observation (left) and 2010 observation (right) of RX J1713.7−3946 in the 0.5–10.0 keV energy band fitted with an absorbed PL model.

Table 1: Spectral parameters of the NW region of RX J1713.7−3946. All uncertainties correspond to the 90% confidence level.

| Component | Parameter                  | 2006 Observation | 2010 Observation |
|-----------|----------------------------|------------------|------------------|
| TBABS     | \( N_H \times 10^{22} \) cm\(^{-2}\) | \( 0.83^{+0.05}_{-0.05} \) | \( 0.88^{+0.02}_{-0.01} \) |
| PL        | Photon Index               | \( 2.43^{+0.04}_{-0.03} \) | \( 2.39^{+0.02}_{-0.01} \) |
|           | Flux \( \times 10^{-11} \) erg cm\(^{-2}\) s\(^{-1}\) | \( 1.19^{+0.01}_{-0.01} \) | \( 1.41^{+0.01}_{-0.01} \) |
| \( \chi^2 \)/dof |                        | 5496.7/7801       | 8406/7668        |
4 Discussion

As seen in Table 1, our preliminary results show that the flux increases in 4 years. There is no variation of the photon index within error range. There are a few reasons for the flux increasing. One is that the relativistic electrons emitting synchrotron X-rays are freshly accelerated or reaccelerated. Other possibilities are increasing the emission volume or the amplification of the magnetic field. In any of these cases, the synchrotron X-ray emission becomes brighter.

The angular size of our analyzed region is about 0.03°, which is comparable to the angular resolution of HESS and CTA. Therefore, a variability in TeV gamma-ray could be observed.

It is expected that the diffusive shock acceleration (DSA) occurs at the shock front of SNR. Our observation region is the downstream region in the RX J1713.7−3946. Our initial results indicate that other kinds of acceleration mechanism than DSA, suggesting, e.g., the 2nd order Fermi acceleration (in other words, the turbulent acceleration).

Usually, it is generally expected that the flux is decreasing as SNR ages. However, our result shows that the flux is increasing, which implies that the turbulence becomes stronger. Then, the turbulent acceleration of electrons occurs. Our question is how the turbulence becomes stronger. A possible solution is that the shock-cloud interaction. This SNR is surrounded by many molecular clouds (MCs) (Sano et al., 2013). Our spectral region (NW) is near a large MC, Clump D, which is shown in Figure 5 of Sano et al., 2013. Clump D excited strong turbulence, which accelerate electrons in the downstream region.

In the next step of our search, we will investigate the larger spectral region in the same field of view to test our result.

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