Suzaku Observation of the TeV Gamma-ray Source HESS J1702–420

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Abstract

We present the analysis result of the TeV unidentified source HESS J1702–420 with Suzaku. Inspite of the large flux of $F_{\rm TeV} = 3.1 \times 10^{-11}$ ergs s^{-1} cm^{-2} in the 1–10 TeV band, X-ray counterpart was not detected even with deep exposure. The X-rays in this observation contain cosmic X-ray background (CXB) and Galactic ridge X-ray emission (GRXE) in addtion to the intrinsic emission of HESS J1702–420. To separate these components, we searched archive observation data whose Galactic latitude, on which GRXE depends, is near to that of HESS J1702–420. The data of HESS J1616–508 and its backgdound region were adopted. We assumued the CXB+GRXE component of HESS J1702–420 data is same as that of HESS J1616–508 data. We estimated the upper limit of the intrinsic flux from HESS J1702–420 as $F_{\rm X} < 9.8 \times 10^{-13}$ ergs s^{-1} cm^{-2} in the 2–10 keV band for an assumed power-law of $\Gamma = 2.1$. If the TeV emission were originated from the Compton up-scattered cosmic microwave background (CMB) by high energy electrons, the low X-ray flux indicates weak magnetic field less than ~ 0.5 μG, which is significantly smaller than the typical value in the Galactic plane of 3–10 μG. Thus the TeV emission is likely originated from the high energy protons.

Key words: acceleration of particles — Gamma-rays: individual (HESS J1702–420) — X-rays: ISM

1. Introduction

High-Energy Stereoscopic System (H.E.S.S.) found many unidentified (unID) TeV Gamma-ray sources through the Galactic plane survey (Aharonian et al. 2006). Some of them are associated with pulsar wind nebulae or supernova remnants (SNR), whereas others have no counterpart in other wavelengths. Thus, they are called "dark particle accelerators". Possible origins of the TeV Gamma-ray emission include (1) Inverse Compton scattering of the CMB photons by high energy electrons and (2) decay of pions produced by collisions of high energy protons with interstellar medium (ISM). To identify the origin of the TeV emission, X-ray follow-up observations are important because X-ray is hardly absorbed by ISM, and if the emission mechanism is due to electrons, syncrotron X-ray emission is expected.

HESS J1702–420 is one of the TeV unID sources. The TeV Gamma-ray emission is extended to $\sim$ 18' and the observed spectrum is characterized by a power-law with a photon index of 2.1 (Aharonian et al. 2008). The estimated flux is $F_{\rm TeV} = 3.1 \times 10^{-11}$ ergs s^{-1} cm^{-2} in the 1–10 TeV band. No plausible conterpart is known in the vicinity of HESS J1702–420.

2. Observation

We observed HESS J1702–420 with Suzaku on 2008 March 25–30. We concentrate on the data of the front-side illuminated X-ray Imaging Spectrometers (XIS03). This is because XIS1, which carries the back-illuminated chip, suffers from high intrinsic background and the data of Hard X-ray Detector (HXD) is contaminated by GRXE and bright point sources.

3. Analysis

3.1. Image

Figure 1 shows XIS image in the 2–8 keV band. No new X-ray bright source was seen in the image. To compare the intrinsic emission with the background emission, we used the Suzaku archive data of HESS J1616–508 and its background observation. These data satisfy two criteria as below: (1) Galactic latitude is near HESS J1702–420 ($b \sim -0.2$) and (2) any bright source does not exist in the

FOV. We paid special attention to the Galactic latitude, on which GRXE depends. Table 1 lists the coordinates and count rates of the data analysed here. Count rates are not significantly different, therefore the data of HESS J1616–508 could be regarded as a background.

Table 1. Coordinates and count rates of each observation

Data	(l, b)	Count Rate$^{\#}$
HESS J1702–420	(344.26, –0.22)	4.9 ± 0.1
HESS J1616–508 (src)	(332.40, –0.15)	4.2 ± 0.1
HESS J1616–508 bgd1	(332.00, –0.15)	3.7 ± 0.2

$^{\#}$ In unit of 10^{-2} cnt s^{-1} in the 4–8 keV.

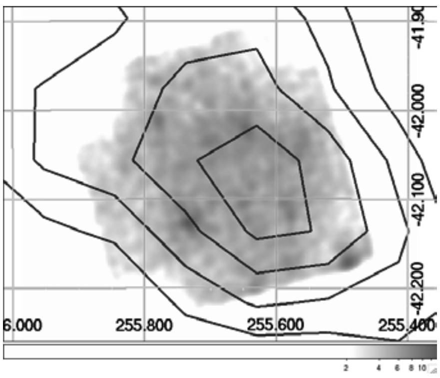

Fig. 1. XIS image of HESS J1702–420 region in the 2–8 keV band is shown in gray scale. The contour of TeV emission is overlayed (Aharonian et al. 2006).

3.2. Spectrum

In order to estimate the upper-limit flux of HESS J1702–420 in X-rays, we assumed the X-ray emission extends uniformly in the XIS field of view. Furthermore, we concentrated on the 4–8 keV band because the spectrum of HESS J1616–508 was contaminated by thermal emission from a SNR below 4 keV. We considered three types of background: (1) non X-ray background (NXB), (2) the CXB and (3) the GRXE. NXB was reproduced using night-earth database (Tawa et al. 2008). To obtain good statistics, we added source (src) and background (bgd1) data of HESS J1616–508. Hereafter, we refer these added data as "1616 region". GRXE is characterized by three iron emission lines (6.40 keV: neutral, 6.67 keV: He-like, 6.95 keV: H-like) (Ebisawa et al. 2008). There was three lines in the spectrum of both HESS 1702–420 and 1616 region. We fitted each spectrum with three gaussians and a power-law, and found that line energies and intensities were consistent within the error range each other. This means that we can model the CXB+GRXE component for HESS J1702–420 using the data of 1616 region. Next, we estimated the upper-limit of the intrinsic flux of HESS J1702–420. We modeled the CXB and GRXE components as three gaussians and a power-law. These components are considered to be same as HESS J1702–420 data and 1616 region. Furthermore, we added another power-law component to represent the intrinsic emission for HESS J1702–420 data. The photon index of this intrinsic power-law is fixed to 2.1, same as that of the H.E.S.S. observation (Aharonian et al. 2008). To constrain the CXB and GRXE parameters to be the same value, the fitting was carried out simulataneously. we took account of the reproducibility of NXB, which is $\sim$10% (in 3σ) (Tawa et al. 2008) or 2.3×10^{-13} ergs s^{-1} cm^{-2}. When both the statistical and systematic errors are considered, the flux from HESS J1702–420 is not significant. We obtained the 99 % upper limit of the flux of $F_{\rm X} < 9.8 \times 10^{-13}$ ergs s^{-1} cm^{-2} for an assumed power-law of $\Gamma = 2.1$.

4. Discussion

Table 2 compares the fluxes of several X-ray faint HESS sources. Because of the large flux ratio, HESS J1702–420 can be regarded as one of the "dark particle accelerators". If the TeV emission is due to electrons, the upper-limit of the flux indicates the magnetic field is smaller than $\sim 0.5\ \mu$G. This is much smaller than the typical value on the Galactic plane (3–10 μG). Therefore, the TeV emission is likely originated not from electrons but from protons.

Table 2. Fluxes of X-ray faint HESS sources

	$F_{\rm TeV}^{\dagger}$	$F_{\rm X}^{\ddagger}$	$F_{\rm TeV}/F_{\rm X}$	Reference
HESS J1804–216	1.0	8.0	> 13	[1][2]
HESS J1616–508	1.7	3.1	> 55	[1][3]
HESS J1702–420	3.1	9.8	> 32	This work

† In unit of 10^{-11} ergs s^{-1} cm^{-2}, 1–10 TeV band.
‡ In unit of 10^{-13} ergs s^{-1} cm^{-2}, 2–10 keV band.
[1] Aharonian et al. 2006
[2] Bamba et al. 2007
[3] Matsumoto et al. 2007

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