Mem. S.A.It. Vol. 84, 580

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Detailed X-ray study of the supernova remnant W51C with Suzaku

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Abstract. We present a detailed analysis of the X-ray emission from the W51 complex, focusing on the middle-aged supernova remnant and star-forming region W51B with Suzaku. The soft X-ray emission from W51C is well represented by a thermal plasma in non-equilibrium ionization state with the enhanced Mg abundance. The hard X-ray emission is spatially coincident with the molecular clouds associated with W51B, overlapping with W51C. The spectrum is represented by a thermal plasma or a power-law model. We discuss the possibility that the hard X-ray emission comes from stellar winds of OB stars in W51B or particles accelerated in W51C. You can see more details in Hanabata et al. 2013, PASJ, 65, 42.

Key words. ISM: individual (W51C) – ISM: supernova remnants – ISM: cosmic rays

1. Introduction

Galactic cosmic rays (CR; mostly protons) are thought to be accelerated in supernova remnants (SNRs). Past observations gave us the evidence of the acceleration of the TeV particles and the signature of the proton acceleration. On the other hand, we currently do not well understand how the acceleration process evolves in SNRs although it is crucial in understanding the acceleration mechanism in SNRs.

Synchrotron X-rays from high energy electrons could have an important clue of the evolution of CR acceleration since the electrons emits the photons immediately after the acceleration. The investigations of thermal plasmas in SNRs can also constrain the evolution of CR acceleration.This is because suprathermal particles injected into the acceleration can be thought to effectively ionize ions in plasma and make the plasma over-ionized in the big solar flares.

W51C is a middle-aged SNR with the age of $\sim 3\times10^4$ yr (Koo et al. 1995). This SNR interacts with some part of molecular clouds associated with the star-forming region W51B. The γ-ray emission overlaps with the cloud is naturally explained by the CRs accelerated in the SNR (e.g., Abdo et al. 2009). The aim of this proceeding is to search for the over-ionized plasma and the synchrotron X-rays for studying the evolution of CR acceleration in SNRs after the free expansion phase.

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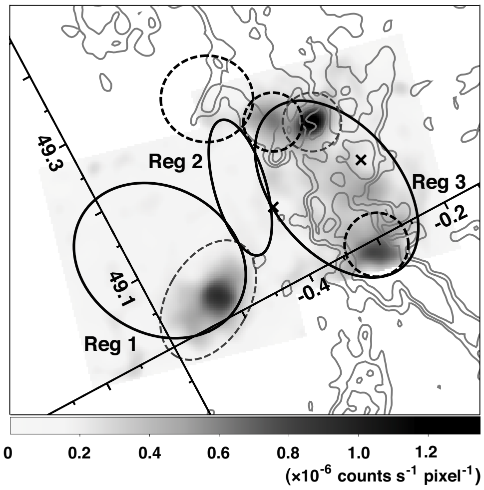

Fig. 1. Suzaku XIS image of the W51C region in the 3.5–8.0 keV band. Grey contours show integrated CO line intensity from 60 to 70 km s^{-1}. Ellipses with solid lines indicate the regions used for the spectral analyses. Thin and thick dashed regions indicate the pulsar wind nebula candidates and the calibration source (largest one) and HII regions, which were excluded from the analyses.

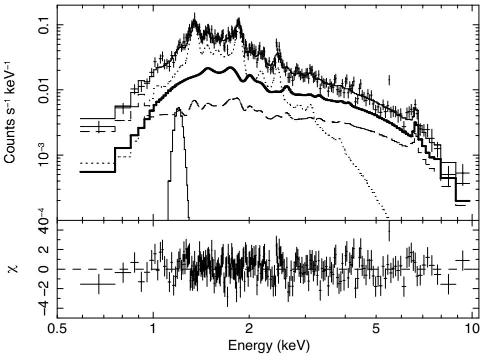

Fig. 2. XIS spectrum of Reg 3 with the best-fit model. Dashed and dotted lines show the background emission unrelated to the W51C region and the thermal emission from W51C. Thick solid line shows the hard X-rays with a thermal plasma model.

2. Results

Figure 1 shows the Suzaku XIS image in the 3.5–8.0 keV band. The hard X-ray emission overlaps with the molecular clouds associated with W51B. The soft X-ray emissions from W51C (Reg 1 and 2) are well represented by a thin thermal plasma under the ionization with a temperature of ~0.7 keV and the enhancement of Mg. This result is consistent with the situation that the CR acceleration continues in W51C but the elapsed time of the ionization by suprathermal electrons is too short to make the plasma over-ionized.

On the other hand, the spectrum of the hard X-ray emission (Reg 3) is represented by a thermal plasma with a temperature of 5 keV or a powerlaw model with a photon index of ~2.2. The luminosity of the hard X-rays cannot be explained by the ensemble of the point sources in Reg 3 and then it has a diffuse nature.

3. Discussion

A pulsar wind nebula would not be the origin of the hard X-ray photons because there is no pulsars in Reg 3. The origin can be interpreted with the thermal or non-thermal emission originating from the stellar winds from the OB stars in the HII regions around Reg 3 in terms of the energetics.

The hard X-rays can be also thought to come from the synchrotron processes of the TeV electrons continuously accelerated by W51C after the free expansion phase without significant Alfvén wave damping (e.g. Nakamura et al. 2012) or in tenuous environment. Meanwhile, it cannot be interpreted with the synchrotron X-rays from the multi-TeV electrons accelerated by the early Sedov phase because of the fast cooling or secondary electrons and positrons produced by the production of hadronic γ-ray emission. The more details are available in Hanabata et al. (2013).

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