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Search for Sc-K Line Emission from RX J0852.0−4622 Supernova Remnant with Suzaku

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Abstract

We searched for evidence of line emission around 4 keV from the northwestern rim of the supernova remnant RX J0852.0−4622 using Suzaku XIS data. Several papers have reported on the detection of an emission line around 4.1 keV from this region of the sky. This line would arise from K-band fluorescence by ^{44}Sc, the immediate decay product of ^{44}Ti. We performed spectral analysis for the entire portion of the NW rim of the remnant within the XIS field of view, as well as various regions corresponding to regions of published claims of line emission. We found no line emission around 4.1 keV anywhere, and are able to set a restrictive upper limit to the X-ray flux: $1.1 \times 10^{-6}\,\mathrm{s^{-1}\,cm^{-2}}$ for the entire field. For every region, our flux upper limit falls below that of the previously claimed detection. Therefore, we conclude that, to date, no definite X-ray line feature from Sc-K emission has been detected in the NW rim of RX J0852.0−4622. Our negative-detection supports the recent claim that RX J0852−4622 is neither young (1700–4000 yr) nor nearby ($\sim$750 pc).

Key words: ISM: supernova remnant — X-ray: individual [RX J0852.0−4622 (Vela Jr.)]

1. Introduction

Supernovae (SNe) are believed to be an agent for producing heavy elements and distributing them to the Galaxy. The theory of supernova explosions predicting nucleosynthesis yields has been developed over the past 50 years. However, there is no observational evidence that allows us to carry out quantitative comparisons with these models, and the explosions themselves are still not understood.

^{44}Ti is a short-lived radioisotope with a half-life of about 60 yr. It is thought to be produced by explosive nucleosynthesis in SNe, and to be the source of stable ^{44}Ca in our Galaxy. The abundance of this species strongly depends on the explosion details, mainly on the so-called "mass-cut" in core-collapse SNe, the energy of the explosion and explosion asymmetries. Thus, the decay-chain of ^{44}Ti offers a unique window into the study of the supernova explosion mechanism (see review Diehl & Timms 1998). The radioactive decay chain ^{44}Ti→^{44}Sc→^{44}Ca produces three gamma-ray lines at 67.9 keV, 78.4 keV, and 1157 keV with similar branching ratios. Several gamma-ray space missions, including COMPTEL, BeppoSAX, and INTEGRAL, have sought these lines in young supernova remnants. The discovery of the ^{44}Ti 1157 keV line emission from the young famous Galactic supernova remnant Cas A with COMPTEL (Iyudin et al. 1994) was the first direct proof that this isotope is really produced in SNe. Subsequent detection of line emission around 70 keV by BeppoSAX and INTEGRAL has strengthened this result (Vink et al. 2001; Renaud et al. 2006). Today, Cas A remains the only SNR from which ^{44}Ti lines have been clearly detected. GRO J0852−4642 has also been reported as a ^{44}Ti emitter with a flux of $(3.8 \pm 0.7) \times 10^{-5}\,\mathrm{cm^{-2}\,s^{-1}}$ based on six yr of COMPTEL data (Iyudin et al. 1998). Schönfelder et al. (2000) examined the robustness of the ^{44}Ti line detection, applying different background modeling and event selection criteria to suppress a large part of the background. They found a significant variation for the line flux, ranging from 2σ to 4σ, depending on the analysis method, whereas the Cas A significance hardly varies (4σ or more). The authors, therefore, conclude that the ^{44}Ti line detection for GRO J0852−4642 is marginal, even though it is the second brightest feature in COMPTEL's survey in the 1157 keV band. For the 67.9 keV and 78.4 keV lines from GRO J0852−4642, von Keinlin et al. (2004) obtained a flux upper limit of $1.1 \times 10^{-4}\,\mathrm{cm^{-2}\,s^{-1}}$ with the INTEGRAL/SPI. The large value is mainly due to systematic uncertainty.

^{44}Ti is an unstable, proton-rich isotope among the many new nuclei synthesized in supernova explosions. Many interesting proton-rich nucleosynthesis products decay by electron capture, leaving primarily K-shell vacancies in the daughter

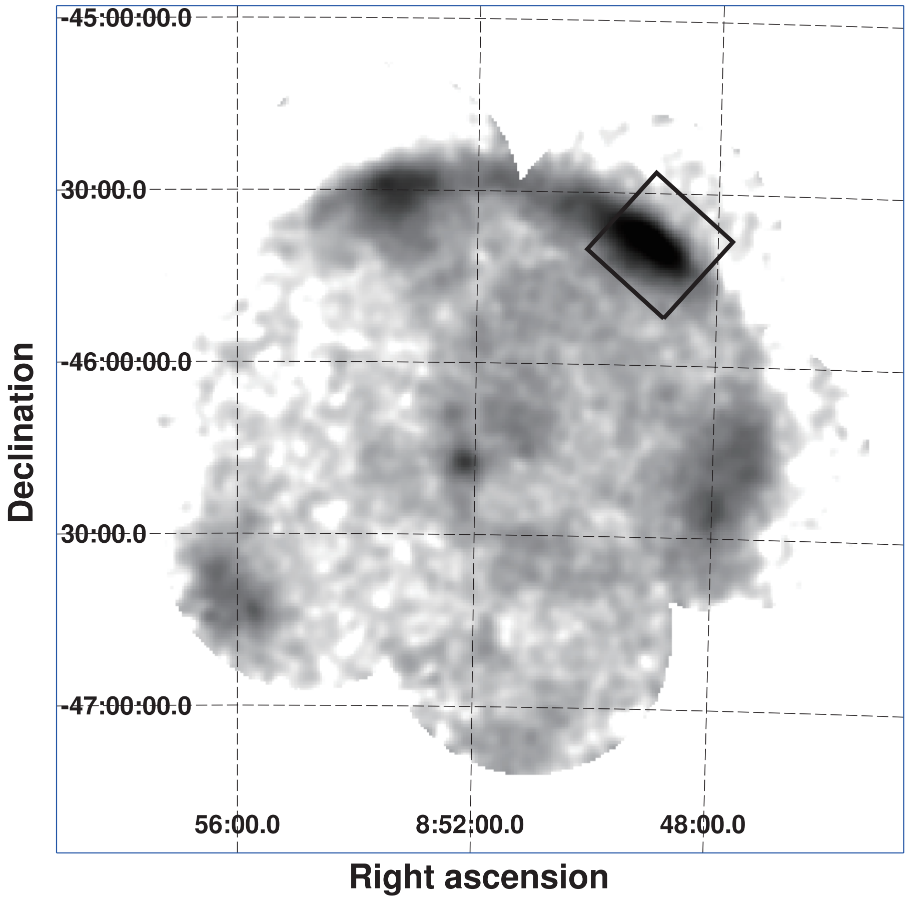

Fig. 1. ASCA observation of RX J0852.0−4622. Suzaku FOV overlayed as a solid black square.

atoms. An adjustment of atomic electrons in response to the vacancies causes the emission of characteristic X-rays (Leising et al. 2001). For the case of ^{44}Ti decay, it produces Sc-Kα (4.086, 4.091 keV) line emission. Currently, and for the near future, X-ray observatories have a much larger effective area, better imaging capability, lower background level and better energy resolution than Gamma-ray observatories; i.e., it is generally suitable for line detection in the X-ray band, rather than the Gamma-ray one. Therefore, searching for the X-ray lines offers an attractive alternative method of a direct measurement of the mass of ^{44}Ti ejected, and furthermore the location of the ^{44}Ti within the remnant. Although the most promising object where substantial ^{44}Ti should exist is Cas A, its large continuum flux prevents us from clearly detecting this X-ray line. On the other hand, the detection of Sc-K emission from the northwestern (NW) region of SNR RXJ0852.0−4622 (Vela Jr.) have been reported in several studies. RXJ0852.0−4622 was recently discovered in the southeastern corner of the Vela SNR with a large apparent radius of about 60′ (Aschenbach 1998), and is coincident with GRO J0852.0−4622. Tsunemi et al. (2000) reported on the presence of line emission around 4.1 keV using an ASCA SIS observation, and concluded that there is substantial Ca produced from ^{44}Ti. On the other hand, Slane et al. (2001), also using ASCA data, found no evidence for a line, and gave a 1σ upper limit of the Sc-K line flux as $4.4 \times 10^{-6}\,\mathrm{cm^{-2}\,s^{-1}}$. Iyudin et al. (2005) reported on the detection of Sc-K line emission from various regions in the remnant using XMM-Newton data. Bamba et al. (2005) also reported on a possible excess at around 4.1 keV from a Chandra observation.

In this paper, we take advantage of the large effective area around 4.1 keV of Suzaku to make the most sensitive search to date for the Sc-K line emission. Spectra extracted from corresponding regions to those in previously published papers were examined for the existence of an emission-line feature. Other X-ray properties of the remnant, such as nonthermal emission and thin-thermal plasma, will be discussed in separate papers.

2. Observation and Data Reduction

The NW part of RX J0852.0−4622 was observed using the Japanese-US X-ray astronomy satellite, Suzaku (Mitsuda et al. 2007) on 2005 December 19 during the Performance Verification (PV) phase. This is the brightest portion in the remnant, with a large apparent radius of about 60′. The field of view (FOV) of our Suzaku observations overlaid on an ASCA image of the whole remnant (Tsunemi et al. 2000) is shown in figure 1. We also observed a nearby sky region with the same Galactic latitude for background determination. Suzaku carries four X-ray Imaging Spectrometers (XIS: Koyama et al. 2007) and the non-imaging Hard X-ray Detector (HXD: Takahashi et al. 2007). Each XIS consists of a CCD detector at the

Table 1. Suzaku Observation log of the NW rim on RX J0852.0−4622 and its background region.

Target	Observation ID	Coordinate RA, Dec	Observation start (UT)	Exposure(XIS) (ks)
RX J0852−4622 NW	500010010	$08^{h}48^{m}58^{s}.01$, $-45°39'02''.9$	2005-12-19	175
RX J0852−4622 NW offset	500010020	$09^{h}00^{m}17^{s}.45$, $-47°56'39''.1$	2005-12-23	59

focal plane of a dedicated thin-foil X-ray telescope (XRT: Serlemitsos et al. 2007) with an $18' \times 18'$ field of view. One of the XIS detectors (XIS 1) is back-illuminated (BI), and the other three (XIS0, XIS2, and XIS3) are front-illuminated (FI). The advantages of the former are significantly superior sensitivity in the 0.2–1.0 keV band with moderate energy resolution, while the latter has a high detection efficiency and a low background level in the energy band above ∼5 keV.

The XIS was operated in the normal full-frame clocking mode without spaced-raw charge injection (SCI) during both observations, and the data format was 3 × 3 or 5 × 5. The data were processed and cleaned using version 2.0.6.13 of the standard Suzaku pipeline software. The CALDB version of the products is hxd-20070710, xis-20070731, and xrt-20070622. We used HEADAS software 6.3.2 and XSPEC version 11.3.2 for the data reduction and analysis. The net exposure times were approximately 175 ks and 59 ks for source and background, respectively. The observations are summarized in table 1. Since the characteristics of the three FI sensors are almost identical and well calibrated to each other, we combined the data from them (hereafter XIS 023), and showed the average spectrum. In this paper, we concentrate on searching for Sc-K line emission. For that purpose, we present an analysis of only the XIS 023 data. XIS 023 has the largest effective area at 4 keV among the current X-ray observatories, $\sim 900\,\mathrm{cm}^2$.

3. Analysis and Results

Figure 2 shows an X-ray image obtained by XIS 0 in the energy range of 2.0–8.0 keV. Two bright rims, an outer and an inner one, are seen, as revealed by previous observations using XMM-Newton and Chandra (Iyudin et al. 2005; Bamba et al. 2005). In the XIS 0 image, they are not distinctly separated.

3.1. *Spectrum from All of Rim Region*

We extracted a representative XIS 023 spectrum from an elliptical region including both the outer and inner rims, as identified by "rim-all" in figure 3. This region includes the site where several papers reported the detection of line emission around 4.1 keV (Tsunemi et al. 2000; Slane et al. 2001; Bamba et al. 2005; Iyudin et al. 2005).

The responses of the XRT and XIS were calculated using the "xissimarfgen" version 2006-11-26 ancillary response file (ARF) generator (Ishisaki et al. 2007) and the "xisrmfgen" version 2006-11-26 response matrix file (RMF) generator. The energy resolution of this data set was ∼ 110 eV (FWHM) at 4 keV (Koyama et al. 2007). A slight degradation of the energy resolution was included in the RMF. A decrease of the low-energy transmission of the XIS optical blocking filter (OBF) was included in the ARF, but this effect had no influence in the 2.0–8.0 keV energy band being used in this paper. The ARF response was calculated assuming that photons come from only the rim-all region (shown in figure 3) with a flat surface brightness profile. We checked that contamination from the source

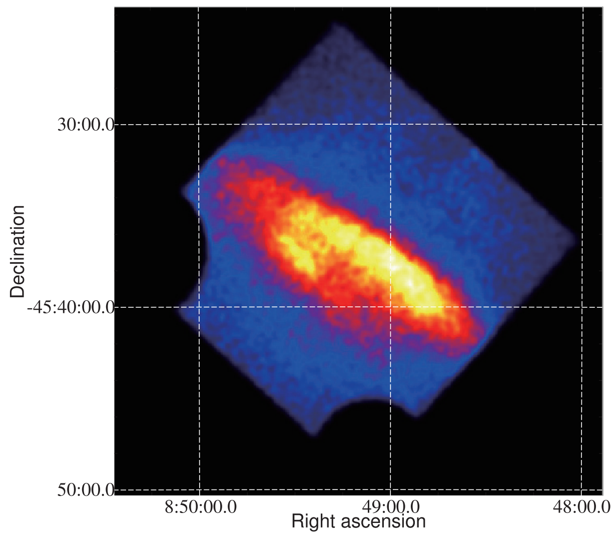

Fig. 2. Suzaku XIS 0 Image of the RX J0852.0−4622 NW rim; 2–8 keV photons are used, excluding the calibration source on two corners.

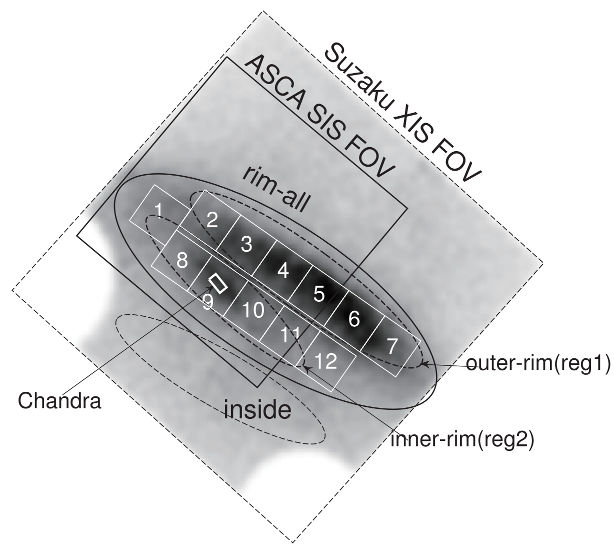

Fig. 3. Various regions where we extracted spectra are shown on a gray-scale Suzaku image, which is the same as in figure 2. Labels of respective regions are described in the text.

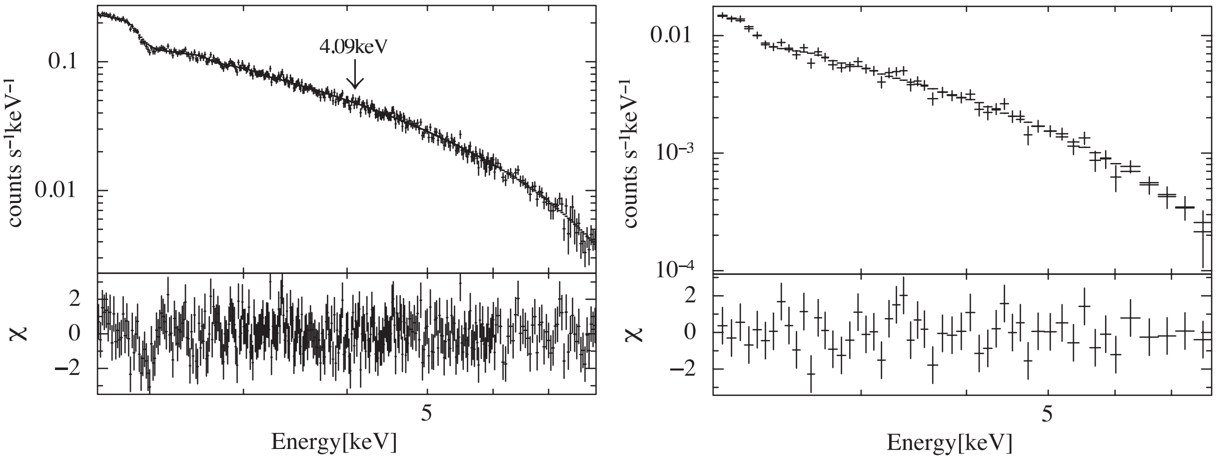

Fig. 4. Suzaku spectrum from the rim-all region of RX J0852.0−4622 in the left panel. The right panel shows the spectrum from a representative small square region (region ID = 9). No line emission is detected around 4 keV.

flux from outside of rim-all was negligible using the region interior to the rim (shown in figure 3), which was about 1/4 dimmer than rim-all region.

A background spectrum was extracted from the offset data using the same detector area as the rim-all region. There was no significant signal beyond the background level above 8.0 keV. Additionally, in order to avoid uncertainty about the thermal emission, which could have contributions from both the Vela SNR and Vela Jr. below 2 keV, we used photons in the energy range of 2.0–8.0 keV for spectral fitting.

The resultant XIS 023 spectrum is apparently dominated by nonthermal emission, as shown in the left panel of figure 4. It is well represented by a single power-law spectrum with interstellar absorption. The derived photon index of $\Gamma = 2.81 \pm 0.05$ and an absorbing column density of $N_{\rm H} = (0.67 \pm 0.11) \times 10^{22}\,{\rm cm}^{-2}$ with $\chi^2/{\rm d.o.f} = 331.4/324$ are in good agreement with previous results by ASCA, XMM-Newton, and Chandra (Slane et al. 2001; Iyudin et al. 2005; Bamba et al. 2005). There appears to be no significant emission feature around 4 keV. In order to search for evidence from Sc-K line emission, we introduced into the model an additional Gaussian component at a fixed energy of 4.09 keV. XIS has an absolute energy error within ± 5 eV (Koyama et al. 2007). However, adding this component did not improve the fit at all, but gave an upper-bound for the line flux of $1.2 \times 10^{-6}\,{\rm cm}^{-2}\,{\rm s}^{-1}$ (90% confidence). Here, the width of channel bin is set to ~ 15 eV around 4.1 keV. If left as a free parameter, the line centroid energy is unconstrained. We therefore performed a spectral fitting with a fixed energy.

3.2. *Spatial Divided Spectral Analysis*

For a more detailed study, we divided the rim-all region into 12 small square cells, indicated in figure 3. The size of one cell is $2' \times 2'$, which is comparable to the point spread function (PSF) of the XRT. In analyzing the spectrum from each cell, a corresponding background spectrum was extracted from the offset data. The responses of the XRT and XIS were calculated assuming the same region as for the rim-all analysis (see subsection 3.1), and normalized by the ratio between the cell size and the assumed source area (that of "rim-all" in this case). All spectra were well fitted by a single power law with interstellar absorption. Figure 4 (right) shows the resultant spectrum of region ID 9 as a representative spectrum. Here, the width of the channel bin was set to ~ 100 eV at around 4.1 keV. No significant excess around 4.1 keV was found in any cell, with upper limits of $F_{\rm line} \leq (0.15\text{–}0.54) \times 10^{-6}\,{\rm cm}^{-2}\,{\rm s}^{-1}$, depending on the surface brightness of the cells.

3.3. *Comparison with Previous Results*

Several papers report a line emission feature at around 4.1 keV from this sky region. In order to directly compare our results to previous work, we extracted spectra from regions corresponding to those used in previous papers. All regions are shown in figure 3. The thin solid black square indicates the ASCA region used by Slane et al. (2001); the small solid white rectangular represents the Chandra detection region reported by Bamba, Yamazaki, and Hiraga (2005). The solid and dashed thin elliptical regions are defined as outer and inner rims, respectively. We performed spectral analyses for all regions mentioned above using the same procedure as for the other regions (see subsections 3.1 and 3.2). There appears to be no line emission in any spectrum; each is well represented by a single power law and interstellar absorption model.

For the "ASCA" region, Tsunemi et al. (2000) suggested a significant excess at around 4.1 keV in the spectrum from the ASCA SIS, which has an $11' \times 11'$ FOV. Using thermal fits, they included the additional line-like feature with the $\sim$99% confidence level, according to an F-test. On the other hand, Slane et al. (2001) reported that the spectrum from one of two detectors, SIS0, contained a feature at $\sim$4 keV, but not the other, SIS1, of the same region. They derived a 1σ upper limit of $4.4 \times 10^{-6}\,{\rm cm}^{-2}\,{\rm s}^{-1}$ for Sc-K emission from this region. Using the Suzaku XIS data, we performed a spectral analysis for the "ASCA" region. We found no line-like feature anywhere, and derived a 90% upper limit of $F_{\rm line} \leq 1.1 \times 10^{-6}\,{\rm cm}^{-2}\,{\rm s}^{-1}$.

Using XMM-Newton data, Iyudin et al. (2005) reported the detection of some emission-line features in the 4.2–4.5 keV band from both bright filaments of the NW rim. These two regions are described as "reg1" and "reg2" in a paper by Iyudin

Table 2. Comparison of the detection and upper limits of Sc-K line emission.

Region ID	Area (arcmin^2)	Observatory	Flux (photons cm^{-2} s^{-1})	Energy (keV)	Reference
rim-all	91	Suzaku	$< 1.2 \times 10^{-6*}$	4.09(fixed)	This work
ASCA	11 × 11	ASCA	$4.4 \times 10^{-6\dagger}$	∼4	Slane et al. (2001)
		Suzaku	$< 1.1 \times 10^{-6*}$	4.09(fixed)	This work
outer-rim(reg1)	31	XMM-Newton	$3.8\ (1.0\text{–}7.4) \times 10^{-6\ddagger}$	4.24(4.10–4.42)	Iyudin et al. (2005)
		Suzaku	$< 5.7 \times 10^{-7*}$	4.09(fixed)	This work
		Suzaku	$< 1.0 \times 10^{-6*}$	4.24(fixed)	This work
inner-rim(reg2)	17	XMM-Newton	$2.4\ (0.9\text{–}5.1) \times 10^{-6\ddagger}$	4.2(4.0–4.2)	Iyudin et al. (2005)
		Suzaku	$< 1.1 \times 10^{-6*}$	4.09(fixed)	This work
		Suzaku	$< 5.0 \times 10^{-7*}$	4.2(fixed)	This work
Chandra	0.34	Chandra	$7.3\ (2.8\text{–}12.4) \times 10^{-7\ddagger}$	4.11(3.90–4.42)	Bamba et al. (2005)
	4	Suzaku(ID 9)	$< 3.8 \times 10^{-7*}$	4.09(fixed)	This work

* 90% confidence upper limit.
† 1σ confidence upper limit.
‡ 90% confidence error.

et al. (2005), but there is no information about their precise location. We therefore defined two elliptical regions (outer and inner rims shown in figure 3) as corresponding regions for "reg1" and "reg2" for Suzaku data. Spectral analyses for these regions were performed. Again, no line-like feature was found. The 90% confidence upper limit for the outer rim (reg1) is $F_{\rm line} \le 5.7 \times 10^{-7}\,\mathrm{cm^{-2}\,s^{-1}}$, and the upper limit for the inner rim (reg2) is $F_{\rm line} \le 1.1 \times 10^{-6}\,\mathrm{cm^{-2}\,s^{-1}}$ at a fixed X-ray energy of 4.09 keV. Remarkably, our derived upper limits are about 6 or 2-times lower than the values claimed by Iyudin et al. (2005). We also verified the line emission at a higher X-ray energy of 4.24 keV for the outer rim and 4.2 keV for the inner rim as being the same as claimed by Iyudin et al. (2005). There are not any line-like features giving the 90% confidence upper limit of $1.2 \times 10^{-6}\,\mathrm{cm^{-2}\,s^{-1}}$ for the outer rim and $5.0 \times 10^{-7}\,\mathrm{cm^{-2}\,s^{-1}}$ for the inner rim.

Bamba, Yamazaki, and Hiraga (2005) reported that there is an excess around 4 keV from a tiny region on the inner filament, indicated as the "Chandra" region in figure 3. They obtained an acceptable fit, including an additional Gaussian component as a narrow line model with a power-law model, although the reduced χ^2 did not improve significantly (χ^2/d.o.f changes from 76.2/81 to 69.5/79). The derived flux was $7.3^{+5.1}_{-4.5} \times 10^{-7}\,\mathrm{cm^{-2}\,s^{-1}}$. In order to compare the Chandra result with our evaluation, we employed region-ID 9 to serve as a corresponding region due to the blurred PSF of Suzaku. It is noticed that our resultant upper limit of the line flux, $F_{\rm line} \le 3.8 \times 10^{-7}\,\mathrm{cm^{-2}\,s^{-1}}$, is about half the value of the derived Chandra flux.

We summarize our derived upper limits of line flux for all regions in table 2, where previous results are also listed. Figure 5 also presents our Suzaku evaluation with each corresponding published claims for a direct comparison. It is noticed that our resultant upper limits indicate a remarkably low flux compared with those obtained in previous studies.

4. Discussion and Conclusion

RX J0852.0−4622 is a unique object from which possible detection of Sc-K line emission (around 4.1 keV) has been claimed (Tsunemi et al. 2000; Iyudin et al. 2005; Bamba et al. 2005). In order to search for evidence of line emission around 4.1 keV, we performed spectral analysis for various regions in the NW rim of RX J0852.0−4622 with the Suzaku observatory. No line-like features were found from any region, including the whole rim region contained in the Suzaku field of view, small subdivisions of the region, and regions from which detections have been claimed using ASCA, XMM-Newton, and Chandra observations. The Suzaku line flux upper limits are 2–6 times lower than those of published claims for all regions. ^{44}Ti would be sufficiently ionized to shift the ^{44}Sc-K lines to higher energy in such a shell of SNR. The featureless spectrum of Suzaku implies that similar results would be yielded even at a higher energy. We thus conclude that, to date, no credible X-ray line from Sc-K has been detected in the NW of RX J0852.0−4622. In this study, we did not consider any other confusing lines as being a thermalized Sc-K line or ionized Ca-K lines from the thermal plasma of RX J0852.0−4622 and/or Vela, which overlays in the line of sight.

Our upper limits presented here employ a 90% confidence interval, determined using χ^2 statistics. For a single parameter of interest, this corresponds to an increase of χ^2 by 2.7 from its minimum value. Such a confidence limit can be directly compared with detection claims by XMM-Newton and Chandra, since they employed 90% confidence intervals for their "detection" values, as is common for a statistical-error assessment in the spectral fitting. In light of a possible controversial difference between our result and others, we also examined the implications of using a more conservative confidence interval of 99.7% (equivalent gaussian width of $3\,\sigma$). According to χ^2-statistics, a $3\,\sigma$ confidence interval corresponds to $\Delta\chi^2$ of 9.0. The 3σ flux upper limit was derived to be

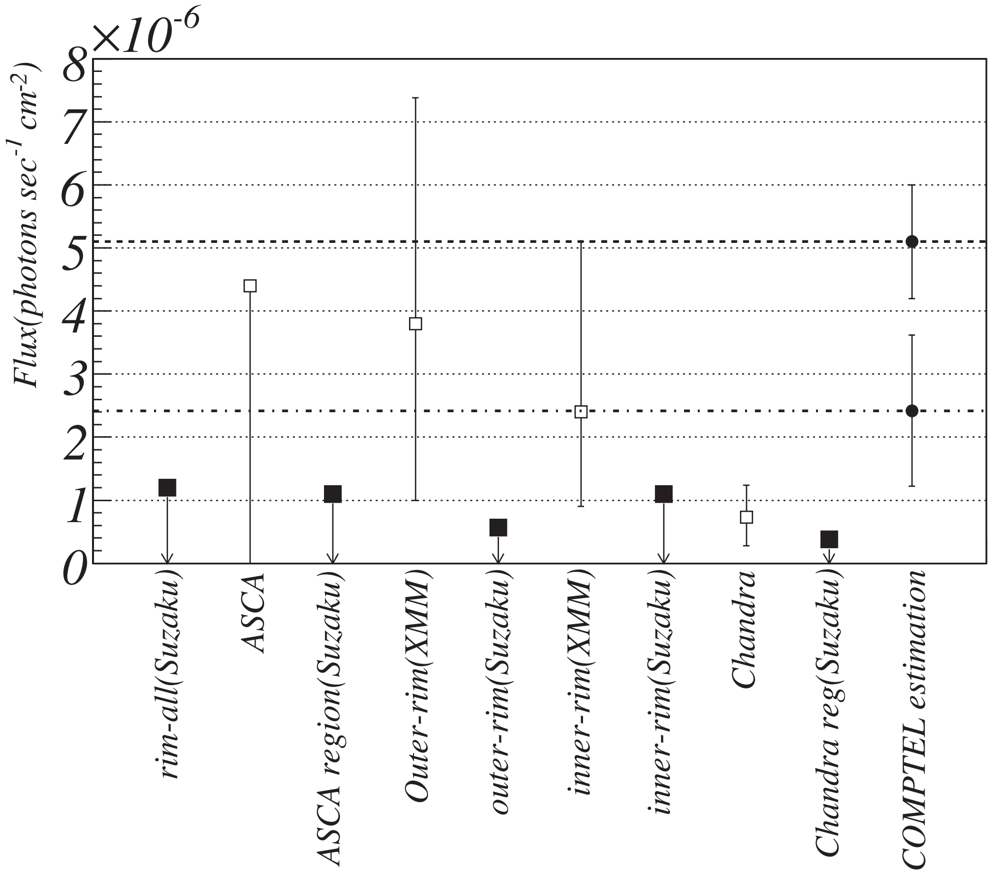

Fig. 5. Direct comparison of the line fluxes around 4.1 keV between the Suzaku XIS 90% upper limits (black filled square) and previous claims of line detections (white square). The estimated X-ray flux values by using the gamma-ray flux reported by Iyudin et al. (1998) and Schönfelder et al. (2000) are shown as black filled circles.

$2.43 \times 10^{-6}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ for the "rim-all" region. We also inferred $\Delta\chi^2$, for a flux of 0, using the best-fit parameter, where the χ^2 value becomes the minimum, and its 90% error described in Iyudin et al. (2005) and Bamba, Yamazaki, and Hiraga (2005) (see reg1, reg2, and chandra in table 2). In this regard, it is assumed to be the parabolic distribution near the χ^2 minimum for an easy comparison. The resultant $\Delta\chi^2$ values were 5.0, 6.9, and 7.1 for the "reg1", "reg2", and "Chandra" regions, respectively. It is noticed that all of "the detection" reports show a low $\Delta\chi^2$ at 0 flux, indicating less than $3\,\sigma$ significance in the χ^2 statistics.

We investigated the consistency with observed gamma-ray flux, while keeping in mind that the gamma-ray detection by COMPTEL is now considered to be marginal (Iyudin et al. 1998; Schönfelder et al. 2000). The expected X-ray flux of the line emission, F_X, can be estimated from the gamma-ray flux (F_γ) using

$$F_\mathrm{X} = \frac{F_\gamma g_\mathrm{X} I_\mathrm{X} f_\mathrm{X}}{I_\gamma f_\gamma}, \tag{1}$$

where g_X is the K-shell electron-capture fraction among the total number of decays, I_X is the fluorescence yield of Kα X-ray emission, I_γ is the absolute intensity of the flux per decay of the parent nucleus, and f_X and f_γ are the escape fractions of the X- and γ-photons, respectively, both of which are definitely equal to 1 for RX J0852.0−4622. Applying $g_\mathrm{X} \sim 8/9$, $I_\gamma(1157\,\mathrm{keV}) = 0.999$, and $I_\mathrm{X}(\mathrm{Sc\text{-}K}\alpha) = 0.17$, we can roughly estimate the expected F_X from F_γ. The decay of F_γ due to about a 10 yr interval between the gamma-ray observation and the X-ray observation was considered. The flux is estimated to be $5.1 \times 10^{-6}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ in the case of $F_\gamma = 3.8 \pm 0.7 \times 10^{-6}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ (Iyudin et al. 1998), indicated by the dashed line in the figure 5, and $2.4 \times 10^{-6}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ in the case of the lowest significance of the gamma-ray source with $F_\gamma = 1.8 \pm 0.8 \times 10^{-6}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ (see figure 4 in Schönfelder et al. 2000), shown as dotted and dashed line in figure 5. It is found that the upper limits given by the Suzaku observation require a lower flux that the lower value of the predicted X-ray flux. Our Suzaku result of no detection of the Sc-K line emission is based on only the NW rim observation. According to a model calculation of nucleosynthesis in the supernova explosion, ^{44}Ti is produced close to the so-called mass-cut, which is the innermost radius of the ejected matter. It is possible that the line emission could appear from the interior of the remnant; further observations and study are required.

Katsuda, Tsunemi, and Mori (2008) recently reported a slow X-ray expansion rate for this remnant of 0.23% $\pm$ 0.006, based on a proper-motion study using XMM-Newton observations taken over a span of 6.5 yr. They estimated a remnant age of 1700–4000 yr, depending on its evolutionary stage. Furthermore, they estimated a distance of $\sim$750 pc, and assumed a high shock velocity of $\sim$3000 km s^{-1}. This result raises serious doubts about the argument that RX J0852.0−4622 is a young ($\sim$680 yr) and nearby ($\sim$200 pc) supernova remnant (Aschenbach et al. 1999). Slane et al. (2001) also suggested a larger distance of 1–2 kpc based on a larger column density for this remnant than that for the Vela SNR from their ASCA analysis. At this larger distance and with an older remnant age, our negative-detection of Sc-K line emission becomes understandable.

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