Study of MeV continuum from the Cas A SNR with COMPTEL

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Abstract. Energetic particles accelerated in supernova remnants provide a variety of continuum emission signatures over the entire electromagnetic spectrum. The measured hard X-ray continuum emission from the Cas A supernova remnant indicates in fact the presence of high-energy electrons and makes it an interesting candidate for study at MeV energies.

We have analysed COMPTEL data with respect to continuum emission in addition to the previously detected ^{44}Ti line. The results provide useful constraints on models of electron shock acceleration in this object.

I INTRODUCTION

Supernova remnants are likely sources of cosmic rays. Energetic particles accelerated in these objects should provide a variety of continuum emission signatures over the entire electromagnetic spectrum. Models predict that electron synchrotron emission may be detected from radio to hard X-ray energies, while at higher energies, in the MeV regime and above, the high-energy electrons are expected to be visible through bremsstrahlung.

The Cas A SNR is the brightest radio source on the sky. It exhibits a power-law spectrum of continuum in X-rays [1–3] suggesting the presence of high-energy (10^{14} eV) electrons emitting synchrotron radiation. OSSE has measured the spectrum in hard X-rays [4], with the most recent results reported at this conference [5]. EGRET has not detected Cas A, upper limits being given in [6]. A detection at TeV energies by the HEGRA instrument has been reported [7].

An extensive updated study of the original Cas A ^{44}Ti line result [8] is given in [9].

The hard X-ray continuum emission from the Cas A supernova remnant indicates in fact the presence of high-energy electrons and makes it an interesting candidate for study at MeV energies; both a detection or upper limits would be of interest in constraining models for the emission mechanisms. Detailed models of the emission from this SNR [10] predict fluxes near to COMPTEL sensitivity levels and give the motivation for a study with COMPTEL data, since these can significantly constrain the models. Specifically, a transition of the emission mechanism from synchrotron radiation to bremsstrahlung would be expected to appear as a flattening of the spectral slope towards the MeV region.

II METHOD

The standard COMPTEL source-fitting program SRCFIX was used to fit the data taken from Cycles 1-6. A model for the diffuse Galactic emission was included by full-sky fitting, using total hydrogen column densities (based on HI and CO maps) and an inverse-Compton model. The standard COMPTEL event selections were applied. Fits were made in the broad 'continuum only' energy ranges, 1.3–3.0, 3-10 and 10-30 MeV ranges. The first range excludes the ^{44}Ti line at 1.16 MeV, taking into account the energy resolution of COMPTEL.

In view of the increase of background after the second CGRO reboost, only pre-reboost data (Observation periods 1-617.1) were used here.

III RESULTS

Table 1 summarizes the results of this analysis. Fig 1 shows the contours of log-likelihood ratio (-2ln λ) for 1.3–3.0 MeV. The signature of Cas A remains at the 2σ level after exclusion of the ^{44}Ti line, suggesting a signal in the continuum. However the 1.3–3.0 MeV map shows other features which are actually stronger than that at Cas A, so that an unequivocal detection cannot be claimed based on this analysis. Also a contribution from diffuse line emission, such as 1.8 MeV ^{26}Al, or diffuse continuum emission, cannot be excluded at this stage. For 3–10 and 10-30 MeV only upper limits were obtained.

The derived photon flux spectrum of Cas A is shown in Fig 2, together with RXTE, OSSE and EGRET results.

TABLE 1. Cas A flux fitting results. All fluxes are continuum only.

Energy (MeV)	σ	flux (10^{-5}cm^{-2} s^{-1})
1.3–3.0	2.1	3.0±1.7
3.0–10.0	2σ u.l	<1.4
10.0–30.0	2σ u.l	<0.63

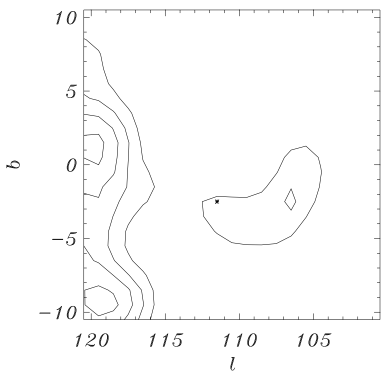

FIGURE 1. Cas A log-likelihood ratio contours (-2ln λ) in the energy range 1.3-3.0 MeV for Observations 1-617.1 . Contour levels: 2.0, 2.5, 3.0, 3.5σ. The asterisk marks the position of Cas A.

IV CONCLUSIONS

The continuum emission from Cas A in the 1.3–3 MeV range appears only at the 2σ level. However there are other features with higher likelihood in the 1.3 - 3 MeV map, which may indicate a poor understanding of the diffuse emission in this region, so the continuum flux should be conservatively regarded as an upper limit. The COMPTEL results are consistent with the OSSE upper limits above 1 MeV given in [5].

Energetic particle shock acceleration models for Cas A [10] are consistent with our results, and suggest that continuum emission, if present, would be bremsstrahlung radiation. Even as upper limits the present results give useful constraints on the parameters of such models.

Even though the continuum level is uncertain, this very uncertainty must reflect on that of the line flux and should always be included explicitly in line studies.

These preliminary results indicate the need for more detailed investigation of the continuum emission of Cas A with COMPTEL data.

REFERENCES

1. Allen, G.E., et al., *ApJ* **487**, L97 (1997)
2. Allen, G.E. *Proc. 26th ICRC* **3**, 480 (1999)
3. Hughes, J.P., et al. *ApJ*, in press, astro-ph/9910474 (1999)
4. The, L.-S.,et al. *A&AS* **120**, 357 (1996)
5. The, L.-S., et al. *this conference*
6. Esposito, J.A., et al. *ApJ* **461**, 820 (1996)
7. Pühlhofer, G. et al. *Proc. 26th ICRC*, **3**, 492 (1999)
8. Iyudin, A.F., et al. *A&A*, **284**, L1 (1994)
9. Schönfelder, V., et al. *this conference*
10. Ellison, D. C., et al. *Proc. 26th ICRC* **3**, 468 (1999) and *this conference*

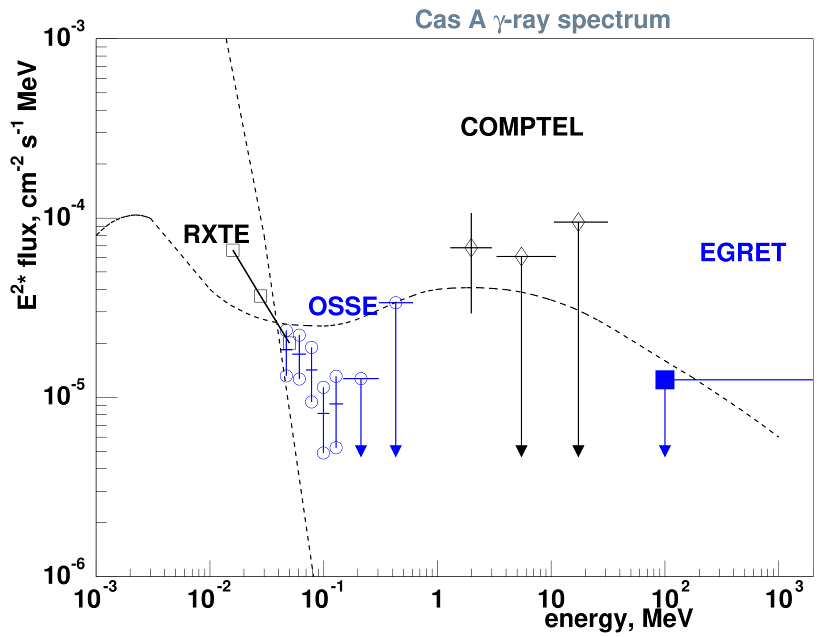

FIGURE 2. Cas A continuum spectrum. Diamonds: COMPTEL points from Obs 1-617.1. Other data: open squares: RXTE (power law fit) [1]; open circles: OSSE [5] ; filled square: EGRET [6]. The dashed curves show the synchrotron and bremsstrahlung emission components in a model for Cas A [10].