

SEARCH FOR GAMMA RAY LINES FROM SS433

B.J. Geldzahler
Sachs/Freeman Associates
Bowie, MD 20715, USA

G.H. Share and R.L. Kinzer
E.O. Hulburt Center for Space Research
Naval Research Laboratory
Washington, DC 20375, USA

D.J. Forrest and E.L. Chupp
Physics Department, University of New Hampshire
Durham, New Hampshire 03824, USA

E. Rieger
Max Planck Institute for Physics and Astrophysics
Institute for Extraterrestrial Physics
Garching, FRG

ABSTRACT

We have searched data obtained with the Gamma Ray Spectrometer (0.3-9 MeV) aboard the Solar Maximum Mission satellite from 1980 to 1985 for evidence of the reported Doppler shifted lines from SS433 (1). Our data base covers a total of 468 days when SS433 was in the field of view and includes times of quiescent and flaring radio activity. In 9-day integrations of the SMM data we find no evidence for gamma ray line emission from SS433. The 99% confidence upper limits for 9-day integrations of the shifted 1.37 and 6.1 MeV lines are $1.3 \times 10^{-3} \gamma/\text{cm}^2\text{-s}$ and $7 \times 10^{-4} \gamma/\text{cm}^2\text{-s}$, respectively. The 360-day time averaged upper limits are $<2 \times 10^{-4} \gamma/\text{cm}^2\text{-s}$ (99% confidence limits) for both lines.

1. Introduction. The morphology of the supernova remnant (SNR) W50 is peculiar in that it is basically a circular SNR with extensions to the east and west. In the center of the circular section lies SS433. SS433 is a binary star with orbital period 13 days. Optical and radio studies indicate that the secondary precesses with a period of ~164 days. What makes SS433 interesting is that it is one of the two known Galactic sources to emit dual-opposing relativistic beams. What makes it unique is that it is the only source in which these beams have been imaged. They have been imaged both at radio and X-ray wavelengths. The beam axis is aligned with the extensions of the SNR, and the beams are thought to be responsible for the peculiar morphology of W50.

We have studied SS433 to confirm the HEAO-C results (1,2). These results were the detection of two narrow, γ -ray lines at ~1.5 and ~1.2 MeV which appeared to move in accord with the optical ephemeris of SS433, if the lines are interpreted as the blue and red shifted components of the 1.368 MeV line of ^{24}Mg . The fluxes appeared to vary by a factor of ~3 in 2-3 day integration periods. The fluxes, averaged over 46 days were reported to be $(1.5 \pm 0.3) \text{ f.u.}$ and $(1.1 \pm 0.2) \text{ f.u.}$, for the blue and red beams, resp. (Note: $1 \text{ f.u.} = 10^3 \text{ photon/cm}^2\text{-s}$). Finally, models trying to account for the reported

emission suggested that a line near ~ 6.1 MeV (rest energy) arising from O should accompany the 1.3 MeV line (3,4). The HEAO-C group reported weak evidence for such emission (2,5).

A detailed description of the 1980-1983 study is given in ref. 6. In this paper we augment our previous study to include the 1984-1985 observing season.

2. Data Analysis. We have used the Gamma Ray Spectrometer aboard the Solar Maximum Mission (SMM) satellite to search for γ -ray lines from SS433. The source is in the field-of-view from November to March each observing season. We have analyzed 468 days of data spanning the 1980-1985 seasons, with the exception of the 1983/4 period when the satellite's tape recorders were not operating. Due to Earth occultation, SAA traversals, etc., the effective duty cycle is $\sim 50\%$.

We have taken several approaches to the data analysis. In the 1-3 MeV range: 1. We integrated the data for 9-days (comparable to HEAO-C). Next, we subtracted high rigidity, "sky-viewing" spectra from "Earth-viewing" spectra to reduce the effects of instrumental and calibration lines. 2. We also integrated the data for 3 days to look for the type of short term variability reported by the HEAO-C group. In this case we subtracted adjacent 3-day sums to reduce the effects of background and calibration lines. In analyzing the 3-9 MeV range, we used 9-day integrations of high rigidity, "sky-viewing" spectra. Since this portion of the spectrum does not contain many instrumental lines, no subtractions were performed.

To get a measurement of the intensity of the SS433 lines, we fitted the spectra over the energy range of interest with a continuum and a Gaussian line profile of ~ 80 keV (FWHM- the instrumental width) at the energies predicted by the SS433 ephemeris. Residual calibration and instrumental lines were also included in the fits when required.

3. Results. Figures 1a and 1b show that SMM did not detect any shifted ~ 1.3 MeV lines with intensities comparable to that reported by HEAO-C. Figure 1c shows the 2.7 GHz radio light curve (7,8) for SS433 which is included because of the reported correlation between a radio flare and the detection of the γ -ray line emission (1). However, as can be seen, this radio flare was not unusual. During the course of the SMM observations, SS433 exhibited strong and weak radio flaring episodes as well as quiescent periods; however in no instance was significant γ -ray emission detected.

Our search for the reported narrow, Doppler shifted 6.1 MeV feature was negative (6). We have also searched for Doppler shifted emission from the intrinsically broad 4.4 MeV line of carbon. SMM is sensitive to this line whereas HEAO-C was not due to differing spectral resolutions of the instruments. The results of this search were also negative.

Our results are given quantitatively in Table I. For comparison, recall that the reported HEAO-C fluxes averaged over 46 days were (1.5 ± 0.3) and (1.1 ± 0.2) f.u. for the blue and red beams,

respectively. Note that when we integrate over the 360-day data base for the first 3 years, the resulting limits on the γ -ray line emission from SS433 are at least a full order of magnitude lower than the flux reported by the HEAO-C group.

Table I. Results of SMM Gamma Ray Line Searches of SS433

Rest Energy of Line (MeV)	Integration Period (Days)	Beam	Maximum Upper Limit (10^{-3} photon/cm ² -s)	
1.368	3	red	1.3	
		blue	1.3	
	9	red	1.2	
		blue	0.7	
	360	red	0.17	
		blue	0.13	
4.438	9	red	0.5	
		blue	0.5	
	360	red	0.07	
		blue	0.07	
	6.1	9	red	0.5
			blue	0.5
360		red	0.06	
		blue	0.07	

4. Disussion. How can we reconcile the disparate HEAO-C and SMM results? Either the HEAO-C group misinterpreted statistical fluctuations as real signals or SS433 exhibits unusual variability at gamma ray frequencies. The radio light curve provides ample evidence that variable accretion is occurring in the system. However, the HEAO-C and SMM measurements appear to require SS433 to shift into a low state of gamma-ray activity beginning around 1980. Two possible mechanisms for the variability are (a) variable opacity in the jets and b) variable accretion rate of matter from the secondary. However, to inhibit the transmission of 1.3 MeV radiation, a density in the jets of $n \sim 10^{14}$ cm⁻³ is required.

5. Acknowledgements. This work was supported by NASA contracts S-14513-D at NRL and NAS 5-28609 at UNH, and by BFFT contract 010K 017-ZA/WS/WRK 0275:4 at FRG.

References.

1. Lamb et al. (1983), Nature, 305, 37.
2. Lamb, R.C. (1984), Invited Talk, 163rd AAS Meeting, Las Vegas, Nev.
3. Boyd et al. (1984a), Ap. J., 276, L9.
4. Ramaty et al. (1984), Ap. J., 283, L13.
5. Wheaton et al. (1984), BAAS, 16, 472.
6. Geldzahler et al. (1985), subm. to Ap. J.
7. Johnston et al. (1984), A. J., 89, 509.
8. Waltman et al. (1985), subm. to A. J.

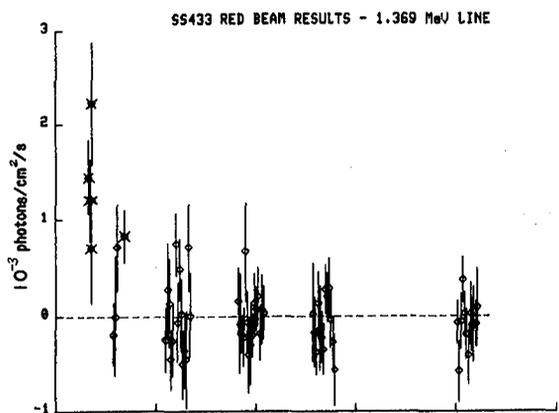
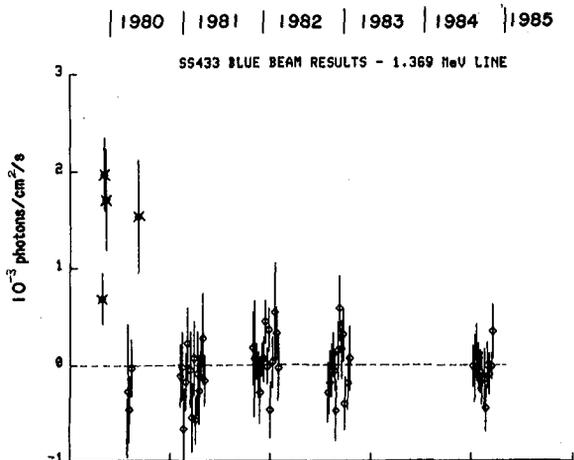


Figure 1. Light curves of the Doppler shifted ~ 1.37 MeV gamma ray line data from SS433. HEAO-C data (crosses), SMM Data (diamonds). a) blue beam, b) red beam, c) 2695 MHz radio light curve.

