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SEARCH FOR DOPPLER-SHIFTED GAMMA-RAY EMISSION FROM SS 433 USING THE *SMM* SPECTROMETER

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ABSTRACT

We have searched data accumulated from 1980 to 1983 with the Gamma Ray Spectrometer aboard NASA's *Solar Maximum Mission* (*SMM*) satellite for evidence of red and blue Doppler-shifted 1.37 MeV ^{24}Mg nuclear lines from SS 433. The *SMM* data base covers 270 days when SS 433 was in the field of view and includes periods of radio flaring and quiescence. No evidence was found for Doppler-shifted line emission in any of our spectra. The range of 3 σ upper limits for individual 9 day integration periods was (0.8–2.3) $\times 10^{-3}$ photons cm^{-2} s^{-1} for the blue beam, encompassing the reported $\sim$1.5 MeV line (reported by Lamb *et al.* in 1983), and (0.8–2.0) $\times 10^{-3}$ photons cm^{-2} s^{-1} for the red beam, encompassing the reported $\sim$1.2 MeV line; the average 3 σ upper limit in each beam for shifted $\sim$1.37 MeV lines is 1.5×10^{-3} photons cm^{-2} s^{-1} for single 9 day integrations. The 3 σ upper limit on 1.37 MeV gamma-ray emission over 23 9 day integration intervals (207 days) for the red beam and 28 intervals (261 days) for the blue beam is 2×10^{-4} photons cm^{-2} s^{-1}. These new limits from *SMM* can be reconciled with the *HEAO 3* results only if SS 433 emits gamma radiation at or above the *SMM* sensitivity limit on rare occasions due to variable physical conditions in the system.

Subject headings: gamma rays: general — stars: individual (SS 433)

I. INTRODUCTION

Lamb *et al.* (1983) reported the detection of relatively narrow, 8–12 keV full width at half-maximum (FWHM) gamma-ray lines at 1.2 and 1.5 MeV from SS 433 using *HEAO 3* data obtained in 1979 October/November. They also presented evidence for the detection in data obtained in 1980 April, although the data quality was not as high due to instrumental degradation. These authors suggested that the observed features were red and blue Doppler-shifted lines of the 1.37 MeV transition from ^{24}Mg. The reported intensity of the "blueshifted" feature was $(1.5 \pm 0.3) \times 10^{-3}$ photons cm^{-2} s^{-1} averaged over 46 days, and there were indications of variability on a time scale of a few days. The intensity of the "redshifted" feature was $(1.1 \pm 0.2) \times 10^{-3}$ photons cm^{-2} s^{-1} averaged over 46 days.

A balloon-borne attempt to confirm the *HEAO 3* result was conducted by MacCallum *et al.* (1985). They found no evidence for Doppler-shifted 1.37 MeV line emission at the reported level (1.5×10^{-3} photons cm^{-2} s^{-1} 2 σ) during a 9 hr observing period when SS 433 was in quiescent radio state. Assuming that the radio and gamma-ray activity of SS 433 is correlated (Lamb *et al.* 1983), this negative result is not surprising.

In this paper we discuss a search for Doppler-shifted gamma-ray line emission from SS 433. The observations were made with the Gamma Ray Spectrometer (GRS) aboard NASA's *Solar Maximum Mission* satellite (*SMM*) over a 3 yr period from 1980 to 1983, covering a total of 270 days of source observation. Our search was conducted during both flaring and quiescent periods of radio activity as determined by monitoring at 3.7 and 11.1 cm wavelength with the Green Bank interferometer (Waltman *et al.* 1986).

The principal objectives of this analysis were (1) to augment and extend the *HEAO 3* study of Doppler-shifted gamma-ray lines by using a larger data sample and by allowing for radial expansion of the beams in the search for gamma-ray emission, and (2) to compare the observations with the suggested models for the gamma-ray emission.

We find no evidence for any Doppler-shifted gamma-ray lines from SS 433 in the *SMM* data. The *HEAO 3* and *SMM* results and their implications for the theoretical models are discussed.

II. OBSERVATIONS AND DATA ANALYSIS

a) Instrumentation

The details of the GRS on *SMM* were discussed by Forrest *et al.* (1980). The spectrometer is composed of seven cylindrical 7.6 × 7.6 cm gain-stabilized NaI scintillation detectors, whose outputs are summed. The effective collecting area of the instrument for line radiation is $\sim$90 cm^2 at 1.37 MeV. The measured resolution of the spectrometer has been a constant 7% at 0.662 MeV since launch. This stability allows spectra obtained over the 3.5 yr time base to be compared reliably without correction. A field of view of $\sim$150° (FWHM) is defined by a 2.5 cm thick CsI annular shield and a large 7.6 cm thick CsI backplate. Plastic scintillation counters complete the 4π sr rejection of charged particles.

In spite of its large field of view, the GRS is a sensitive instrument to use for celestial line studies because of its large effective area, excellent stability, and long observation time. This has been demonstrated by the observations of the narrow gamma-ray line from interstellar ^{26}Al and of the Galactic 0.511 MeV electron-positron annihilation line by the GRS (e.g., Share *et al.* 1985; Share *et al.* 1988). In studies of line emission from SS 433, the precessing beams of the object provide an additional unique signature for any associated emission.

b) Analysis Techniques—General Considerations

In order to minimize the instrumental background, only data obtained more than 10^4 s after the last passage through the South Atlantic Anomaly were included in the data set (e.g., Share *et al.* 1985). All contributions from detected solar flares, gamma-ray bursts, geomagnetic disturbances, and times with poor telemetry transmissions were removed prior to the analysis.

In searching for SS 433 line emission, we used line energies predicted by the optical ephemeris given by Anderson and Margon (1983), which is similar to the ephemeris used by Lamb *et al.* (1983). At some epochs, Doppler-shifted line positions periodically fell near calibration or background lines which caused spectra obtained at those times to be unusable in this study. Also, this ephemeris provides only an estimate of the line position. Due to a vector combination of the outward flow of matter and radial expansion of the beam, the measured radial velocities on any given day can depart from the ephemeris by up to 3000 km s^{-1} (B. Margon, private communication) which is equivalent to $\sim$15 keV at 1.37 MeV. The moderate energy resolution of the instrument ($\sim$80 keV FWHM at 1.37 MeV) encompasses this possible deviation. Furthermore, the line search technique we employed, which is discussed later, eliminated the need to correct the fitted line amplitudes for this beam jitter.

Three techniques to reduce the effects of background radioactive and calibration lines were employed: (1) subtraction of sky-viewing spectra from Earth-viewing spectra, (2) use of spectra accumulated in adjacent 3 day intervals to correct for the background, and (3) when necessary, use of data taken at vertical magnetic cutoff rigidities >11 GV to reduce the contribution from atmospheric gamma rays.

In an earlier analysis (Geldzahler *et al.* 1984), corrections to the line intensities caused by the possible 15 keV departure from the ephemeris were not included. Although the results of the former and current approaches are not significantly different, the current analysis is more conservative. In the earlier analysis, Geldzahler *et al.* (1984) attempted to reduce the impact of any residual background features by using the measured intensities of other related lines. For example, the intensity of the 2.754 MeV from ^{24}Na line was used as a means of measuring the intensity of the residual background 1.37 MeV line arising from ^{24}Na. However, because of the presence of other unresolved background lines, this approach was prone to error for some observations.

SS 433 appears closest to the center of the GRS field of view on January 7 of each year. The data set selected for analysis spans ± 45 days from this central position during each year. We limited our measurements to this interval so that SS 433 was occulted more than 75% of the time each day during the Earth-viewing orientations of *SMM* which aided in background subtraction. Due to these Earth occultations and to times when the instrument was turned off, the duty cycle for SS 433 observations was about 50%. Spectra were summed in 9 day intervals to provide a time scale comparable to that used by Lamb *et al.* (1983). Three day integrations were also studied to search for the short-term variability suggested by the *HEAO 3* results.

The use of 9 day integrations necessitated a correction to the upper limit to the line emission from SS 433. On the steep portions of the sinusoidal change of the spectral line Doppler shifts, a line shift of up to 45 keV can occur during the integration interval thus smearing any line emission present and diminishing its apparent amplitude. Since we chose the central day of each integration period to determine the predicted Doppler shifts, the magnitude of this effect is limited to ≤ 22 keV. The fitted amplitude and error of the lines in each integration period were corrected individually according to the maximum possible smearing from the predicted energy.

III. RESULTS: LINE SEARCHES IN THE 1–2 MeV ENERGY RANGE

a) 9 Day Integrations

Figure 1 shows representative spectra from 1 to 3 MeV accumulated over one 9 day interval. We used all the quality-selected data at vertical geomagnetic rigidity cutoffs ≥ 4 GV in order to maximize the exposure to SS 433. The spectrum accumulated with the instrument pointed at Earth (Earth-viewing spectrum) is given in Figure 1*a*, while the spectrum accumulated with the instrument pointed away from Earth (sky-viewing spectrum) is plotted in Figure 1*b*. These spectra are dominated by ^{60}Co calibration lines at 1.17 and 1.33 MeV (with a sum peak at $\sim$2.5 MeV) and by other background-induced radioactive lines such as ^{24}Na (1.368, 2.754 MeV), ^{22}Na (1.275 MeV), and lines near 1.8 MeV (see Share *et al.* 1985).

These radioactive lines have half-lives in excess of a few hours so their contribution to the Earth-viewing and sky-viewing spectra is expected to be the same. Subtraction of a sky-viewing spectrum from a contiguous Earth viewing spectrum creates a difference spectrum with most of the background lines removed as shown in Figure 1*c*. The intensity of the radioactive lines is reduced by over an order of magnitude in the difference spectrum although the atmospheric continuum and lines at 1.63 and 2.31 MeV from ^{14}N* (Letaw *et al.* 1986) are apparent. The sensitivity of this approach is indicated by the fact that the measured intensities of these atmospheric lines at the instrument are $\sim 0.7 \times 10^{-3}$ photons cm^{-2} s^{-1}, about half of the intensity of the SS 433 lines reported by Lamb *et al.* The differencing technique, therefore reduces the systematic variations to the level of the SS 433 signal for which we searched.

Note that because sky-viewing data were subtracted from Earth-viewing data, narrow lines from a celestial source will appear as a depression below the continuum in the difference spectra with a shape determined by the instrument's energy resolution.

Our search for Doppler-shifted gamma-ray line emission was conducted both by visually inspecting various GRS spectra over the 1–2 MeV range and by least-squares fitting at the energies predicted by the optical ephemeris. We fitted the data by using a power law to model the background continuum plus a Gaussian line profile fixed at the 80 keV (FWHM) instrumental width. The Gaussian line profiles were initially placed at the energies predicted by the optical ephemeris. The

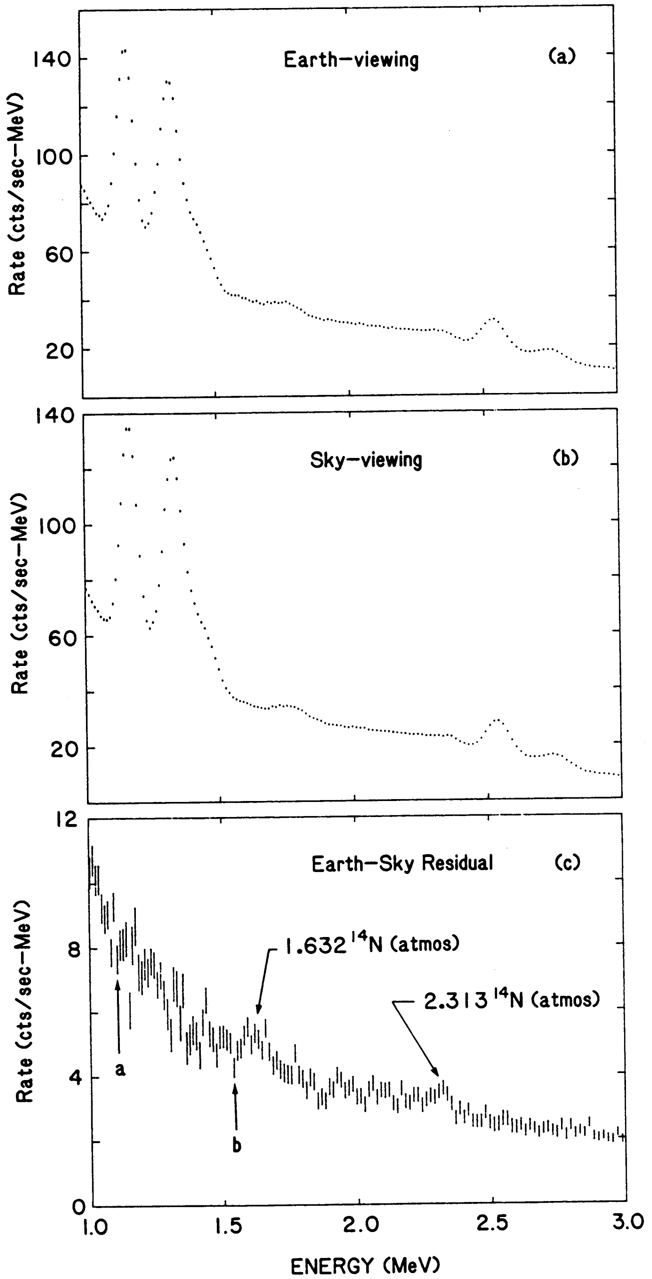

FIG. 1.—Representative (*a*) "Earth-viewing," (*b*) "sky-viewing," and (*c*) "Earth-viewing" minus "sky-viewing" difference spectra for a 9 day integration period centered on 1981 day 364 showing the atmospheric 1.632 and 2.313 $^{14}N^*$ lines with fitted fluxes of $(0.7 \pm 0.1) \times 10^{-3}$ photons cm^{-2} s^{-1} and $(0.5 \pm 0.2) \times 10^{-3}$ photons cm^{-2} s^{-1}, respectively. The arrows "a" and "b" mark the locations of the predicted red (1.168 MeV) and blue (1.522 MeV) Doppler-shifted lines of ~ 1.37 MeV. The fitted fluxes are $(0.4 \pm 0.3) \times 10^{-3}$ photons cm^{-2} s^{-1} and $(0.04 \pm 0.3) \times 10^{-3}$ photons cm^{-2} s^{-1}, respectively. Note that celestial emission lines will appear as depression below the continuum in this difference spectrum due to the order of subtraction.

line energies were then allowed to vary over a fixed energy range of $\pm$ 50 keV to search for gamma-ray emission so as to account for possible beam jitter of order 15 keV. The data for each spectrum was binned in 12 keV intervals, and the energy range over which the background was fitted, typically about 300 keV, bracketed the predicted position of the emission line and was sufficient to give a good estimate of the continuum emission as determined by χ^2 tests. A reduced χ^2 greater than 2 was the criterion used for rejection of a fit. In such a case, the energy range was adjusted and the fit repeated. In those cases where a calibration or background line was sufficiently close to the predicted SS 433 line such that use of a single Gaussian line was inappropriate, the fits were performed using two Gaussians, one for the SS 433 line and one for the confusing line. The epochs when the SS 433 lines were predicted to fall within a few keV of the calibration lines were not included in the final presentation because line blending precluded adequate fits.

TABLE 1

DISTRIBUTION OF STANDARD DEVIATIONS OF 1.37 MeV LINE FITS

	RED BEAM		BLUE BEAM	
DEVIATION	Observed	Expected Statistical Distribution ($n = 23$)	Observed	Expected Statistical Distribution ($n = 29$)
$0 < \sigma < 1$......	18	13.8	19	18.3
$1 < \sigma < 2$......	5	6.7	8	8.7
$2 < \sigma < 3$......	0	1.5	2	2.0
$3 < \sigma$..........	0	0	0	0

Table 1 lists for each beam the distribution of standard deviations of the line fits for amplitudes uncorrected for Doppler smearing. The distributions are consistent with those expected from random distributions indicating that systematic errors introduced by background lines in the intervals considered are well below the quoted sensitivity limit of the observations.

Our principal results from the search of the 9 day integrations in the 1–2 MeV energy range are presented in Figure 2. Figure 2*a* is a plot of the fitted gamma-ray flux measurements versus Julian date for a Doppler-shifted SS 433 1.37 MeV line in the blue beam from *HEAO 3* and *SMM*. Figure 2*b* is a similar plot for the red beam. These plots represent the results of the Gaussian fits and include the correction factors described above. The 1 σ error bars for the *SMM* data represent statistical errors based on our fits. We used a dual branch procedure to compute the 3 σ upper limits to the emitted gamma-ray line flux from SS 433. If the fitted intensity, I, at the position of the predicted energy was greater than zero, then $3\sigma = I + 3 * \sigma$. If I was less than zero, $3\sigma = 3 * \sigma$. The 3 σ upper limits corrected for Doppler line smearing ranged from $(0.8–2.3) \times 10^{-3}$ photons cm^{-2} s^{-1} for the blue beam and from $(0.8–2.0) \times 10^{-3}$ photons cm^{-2} s^{-1} for the red beam. The largest values occurred in those spectra where the predicted SS 433 line fell close to a background or calibration line. The average 3 σ upper limit for line emission in the 9 day integration periods is 1.5×10^{-3} photons cm^{-2} s^{-1} for each beam (Table 2), comparable to the average detected values reported by Lamb *et al.* (1983). The 3 σ upper limit on 1.37 MeV gamma-ray emission averaged over 23 9 day integration intervals (207 days) for the red beam and 28 intervals (261 days) for the blue beam is 2×10^{-4} photons cm^{-2} s^{-1}. Figure 2*c* is a plot of the 2695 MHz radio light curve for comparison of the simultaneous radio frequency activity of SS 433.

As a final, albeit extreme test of our upper limits, we compared our results with the results of an identical analysis performed on a control group of data centered in July, exactly 6 months later than the SS 433 observations, and chosen to have the same phase of the orbital precession period of *SMM*. The average 3 σ limit for the 9 day integration periods in each

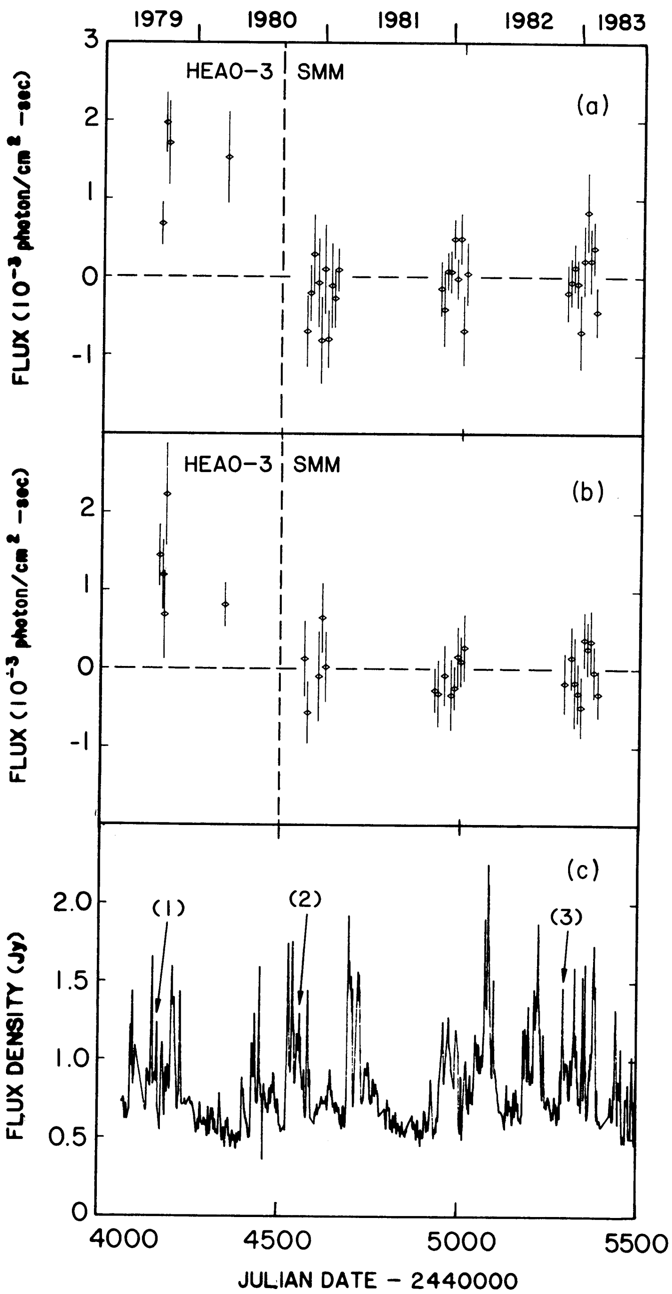

FIG. 2.—Light curves of the Doppler-shifted ~1.37 MeV gamma-ray line data from SS 433 in 9 day integration periods: (*a*) blue beam, (*b*) red beam, and (*c*) 2695 MHz radio light curve for SS 433 (adapted from Johnston *et al.* 1984 and Waltman *et al.* 1986).

beam was again 1.5×10^{-3} photons cm^{-2} s^{-1}. Thus, we believe that 1.5×10^{-3} photons cm^{-2} s^{-1} accurately represents the true 3 σ sensitivity limit of the 9 day integration *SMM* observations of SS 433 and that no gamma-ray line emission from SS 433 above that level was present during our observations.

b) Short-Term Variability

Although we did not detect any gamma-ray line emission from SS 433 in 9 day integrations, we also carried out the analysis for 3 day integrations discussed in § II*b* to set limits on the short-term gamma-ray variability described by Lamb *et al.* (1983). The 3 day integration limits take on added significance since the gamma ray line emission reported by the *HEAO 3* group seems to have come mostly from 1 or 2 day outbursts (Lamb 1983). Thus, a 10 day average flux reported by Lamb *et al.* (1983) should have been about 3 times higher if all the flux was emitted in a 3 day integration.

A different and independent method for background correction was employed in the 3 day analysis. This analysis is sensitive only to the change in intensity from one interval to the next because it uses adjacent 3 day intervals for defining background levels. The sky-viewing data were summed into 3 day bins to look for short-term variability on the same time scale as indicated by Lamb *et al.* (1983). From each 3 day sum, a background defined as the average of the two adjacent 3 day sums was subtracted. These resulting difference spectra were then analyzed in a manner similar to that described above for the 9 day integrations. The difference in the analysis techniques was that only single line fits were performed. Again, spectra in which background lines fell within a few keV of the predicted energy of the SS 433 line were excluded from the study so as to minimize the effects of line blending. The range of 3 σ upper limits for individual 3 day integration periods was (0.5–2.3) $\times 10^{-3}$ photons cm^{-2} s^{-1} for the blue beam and (0.6–2.6) $\times 10^{-3}$ photons cm^{-2} s^{-1} for the red beam; the higher upper limits in the case of the red beam arose because of blending with background lines. The average 3 σ upper limit in each beam for shifted ~1.37 MeV lines is 1.6×10^{-3} photons cm^{-2} s^{-1} for single 3 day integrations (Table 2). This value has been corrected for the maximum 7 keV Doppler smearing effect. If SS 433 emitted short-duration gamma-ray flares during our observations similar to those reported by Lamb (1983), then we should have seen events at the (5–6) σ level. No such events were detected and we conclude that there were no gamma-ray flares during the *SMM* observations.

TABLE 2

RESULTS OF SMM SEARCH FOR 1.37 MeV GAMMA-RAY LINES FROM SS 433

Integration Period (days)	Beam	3 σ Upper Limit (10^{-3} photons cm^{-2} s^{-1})
3	Red	1.6
	Blue	1.6
9	Red	1.5
	Blue	1.5

NOTE.—Fluxes used to compute the upper limits have been corrected for a possible loss of amplitude caused by Doppler line smearing.

IV. DISCUSSION

a) General Remarks

As seen in Figure 2 and detailed in Table 2, we found no evidence in the 270 day *SMM* data base for Doppler-shifted 1.37 MeV gamma-ray line emission from SS 433 in single 3 day or 9 day integrations. The 3 σ upper limits for 9 day integrations of the *SMM* data ranged from (0.8–2.3) $\times 10^{-3}$ photons cm^{-2} s^{-1} for the blue beam and from (0.8–2.0) $\times 10^{-3}$ photons cm^{-2} s^{-1} for the red beam. The largest values occurred in those spectra where the predicted SS 433 line fell close to a background or calibration line. The average 3 σ upper limit for line emission in the 9 day integration periods is

1.5×10^{-3} photons cm^{-2} s^{-1} for each beam, comparable to the average detected values reported by Lamb *et al.* (1983). The range of 3 σ upper limits for individual 3 day integration periods was $(0.5–1.3) \times 10^{-3}$ photons cm^{-2} s^{-1} for the blue beam and $(0.6–2.6) \times 10^{-3}$ photons cm^{-2} s^{-1} for the red beam; the average 3 σ upper limit in each beam for shifted $\sim$1.37 MeV lines is 1.6×10^{-3} photons cm^{-2} s^{-1} for single 3 day integrations. In this section we attempt to reconcile the *HEAO 3* and *SMM* results.

MacCallum *et al.* (1985) have pointed out four difficulties with the suggestion of Lamb *et al.* (1983) that the reported lines originate in redshifted and blueshifted emission from ^{24}Mg. The difficulty most applicable to the comparison of the *HEAO 3* and *SMM* observations is that the line widths are much smaller than one would expect in 10 day integrations because line smearing would occur unless the gamma rays are emitted in a small fraction of the integration period. Such a small "duty cycle" may actually be the case (Lamb 1983) just as there are episodic optical events (e.g., Margon 1982) and radio events (e.g., Johnston *et al.* 1984).

A point which needs strong emphasis is that we find absolutely no evidence for the reported correlation between radio flaring and gamma-ray line emission from SS 433 (Lamb *et al.* 1983). If such a correlation were real, then we would expect to see activity at radio frequencies coincident or nearly coincident with the gamma-ray emission observed by *HEAO 3*. The range of flaring activity of SS 433 was unavailable to the *HEAO 3* group when they did their study, but as can be seen clearly by comparing Figures 2*a* and 2*b* with 2*c*, there is nothing unusual in the magnitude or timing of the flares during the *HEAO 3* observations of SS 433. The reported correlation was based on the small flare labeled (1) in Figure 2*c*. The *SMM* observations show no evidence for gamma-ray line emission from the source although there are many radio flares that are substantially more powerful [e.g., events (2) and (3) in Fig. 2*c*] than that discussed by Lamb (1983).

The simplest ways of reconciling the *HEAO 3* and *SMM* observations of SS 433 are by supposing that (1) the *HEAO 3* group misinterpreted statistical or systematic fluctuations as genuine signals, or (2) the gamma-ray emission from SS 433 is variable and has a small duty cycle. In the first case, seemingly real statistical or systematic fluctuations have been known to occur. In balloon-borne SS 433 observations, MacCallum *et al.* (1985) found one 4.6 σ and six 3 σ false detections in their data. In the second case, perhaps the *SMM* group was unlucky and SS 433 did not happen to be in the field of view or was occulted by Earth when any gamma-ray flares occurred. After all, SS 433 is variable at all other wavelengths at which it has been studied, so it would be surprising if it were not also variable in gamma rays. A low duty cycle for the occurrence of extraordinarily intense radio flares is known for the source Cyg X-3 (e.g., Gregory *et al.* 1972; Geldzahler *et al.* 1983). We now briefly review two theoretical models for the gamma-ray line emission from SS 433, trying to reconcile them with the results of the *HEAO 3* and *SMM* observations.

b) Physical Explanations for Gamma-Ray Variability of SS 433

Variable conditions within the SS 433 complex are the most likely means of reconciling the *HEAO 3* and *SMM* results. In fact, Lamb *et al.* (1983) have shown that in the fall of 1979, the flux of the Doppler-shifted 1.37 MeV features is consistent with zero a large portion of the time.

i) Jet Opacity

Lingenfelter and Ramaty (1977) have discussed the production of gamma-ray line emission from grains, and Ramaty, Kozlovsky, and Lingenfelter (1984) applied this model to SS 433. One possible explanation for gamma-ray variability suggested by Ramaty, Kozlovsky, and Lingenfelter (1984) is variable extinction in the jets and the ambient medium. They point out that the jets are transparent to gamma rays at jet radii greater than about 10^{10} cm. A particle density of $\sim 10^{14}$ cm^{-3} is necessary to inhibit transmission of gamma rays through the jets. For an opening angle of 6°, the jets are opaque to gamma-ray emission at 1.37 MeV at distances of $< 10^{11}$ cm from the compact source. If supercritical accretion is the norm in SS 433, then we should not expect to observe gamma-ray line emission unless the density of accreted matter were somehow significantly lessened. However, Helfer and Savedoff (1986) have questioned the validity of the dusty jet model because it does not correctly predict the observed optical, infrared, and Hα emission.

ii) Accretion Rate

Another mechanism for creating variable emission is a variable mass accretion rate. This mechanism and the variable extinction mechanism could, of course, be coupled.

The radio light curves of SS 433 (Johnston *et al.* 1984; Waltman *et al.* 1984) showing sporadic, erratic flares and outbursts argue strongly for a variable accretion rate. Avni and Schiller (1982) have shown that in a semidetached misaligned binary system, mass transfer might be limited to only two places in the orbit. This could explain the short-term variations reported by Lamb *et al.* (1983). It does not, however, account for the *SMM* limits which are based on 9 day integrations each of which is 70% of the 13 day binary orbital period and cover the entire 13 day period over the course of the entire *SMM* data set.

Theoretical studies of thick, steady state accretion disks with variable accretion rates (e.g., Pacyński and Wiita 1980) provide a natural means of producing the observed highly collimated beams in SS 433. These models were developed for disks surrounding black holes, but might be applicable to neutron stars under special conditions. The inner edge of the disk acts as a fuel storage ring. As the accretion rate increases, the edge moves closer to the beam axis and inhibits the conversion of infalling mass to radiation. At times of high accretion rates, the density of the infalling matter may be great enough to inhibit transmission of gamma-ray emission (P. J. Wiita, private communication). Times of low accretion rates then correspond to quiescent periods—at least at radio wavelengths. For this model to be applicable to the reported gamma-ray line emission from SS 433, there must be a delicate balance between gamma-ray production and the density of the infalling material. The *SMM* results indicate that this balance is rarely, if ever, achieved.

V. SUMMARY

We have analyzed data obtained over 270 days when SS 433 was optimally viewed by the *SMM* Gamma Ray Spectrometer during the years 1980–1983 in an attempt to detect gamma-ray line emission similar to that reported by the *HEAO 3* group. The 3 σ upper limits for individual 9 day integration periods ranged from $(0.8–2.3) \times 10^{-3}$ photons cm^{-2} s^{-1} for the blue beam and from $(0.8–2.0) \times 10^{-3}$ photons cm^{-2} s^{-1} for the red beam; the average 3 σ upper limit for line emission is 1.5×10^{-3} photons cm^{-2} s^{-1} for each beam, comparable to the average detected values reported by Lamb *et al.* (1983). The 3 σ upper limit on 1.37 MeV gamma ray emission averaged over 23 9 day integration intervals (207 days) for the red beam and 28 intervals (261 days) for the blue beam is 2×10^{-4} photons cm^{-2} s^{-1}. The range of 3 σ upper limits for individual 3 day integration periods was $(0.5\text{–}2.3) \times 10^{-3}$ photons cm^{-2} s^{-1} for the blue beam and $(0.6\text{–}2.6) \times 10^{-3}$ photons cm^{-2} s^{-1} for the red beam; the average 3 σ upper limit in each beam for shifted ~1.37 MeV lines is 1.6×10^{-3} photons cm^{-2} s^{-1}. No evidence for line emission at other energies was found in our visual inspections of the data in the 1–2 MeV range.

Assuming that the lack of detection of gamma-ray line emission from SS 433 by *SMM* was due to a quiescent gamma-ray state, the *SMM* and *HEAO 3* results can be reconciled only if gamma radiation at or above our sensitivity limit emanates from SS 433 only rarely due to variable physical conditions in the system.

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