Possible flare of the source Cyg X-3 at $E > 10^{14}$ eV

V. V. Alekseenko, A. S. Lidvanskiĭ, N. A. Metlinskiĭ, S. Kh. Ozrokov, V. V. Sklyarov, V. A. Tizengauzen, N. S. Khaerdinov, and A. E. Chudakov
Institute of Nuclear Research, Academy of Sciences of the USSR

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Observational data on the source Cyg X-3 from an extensive-air-shower installation are reported. The period of an intense burst in the rf range in October 1985 is analyzed separately. At this time, an excess number of showers were observed from the vicinity of this source on three successive days.

The x-ray source Cygnus X-3 is observed over an exceedingly broad energy range.[1] It was reported comparatively recently that a measurable flux of γ rays with energies above 10^{14}–10^{15} eV has been detected at installations for detecting extensive air showers.[2–4] The source Cyg X-3 has been under observation since July 1984 at the Kover installation of the Baksan Neutrino Observatory of the Institute of Nuclear Research. Preliminary results of this experiment have already been published.[5] The data analysis method can be outlined as follows. The shower count rate in an angular cell 2.5° in radius is compared with the count rate in several control cells of the same size. The equatorial coordinates of the centers of the control cells differ from those of the source by $\pm 5°$ in declination and $\pm 6.6°$ ($5°/\cos \delta$) in right ascension. The control cells touch the source cell and have the same solid angle as the source cell. The phase analysis makes use of the ephemeris of Ref. 6; a correction is made for the angular distribution of the showers, and the times are referred to the heliocenter. Figure 1a shows the phase curve for the ratio of the count rate of the source cell to the average control count rate over a year. We see that over this period there is no absolute excess from the source cell: The average ratio in Fig. 1a is 0.993 ± 0.008. The peak at the phase 0.6 has a low statistical significance (2.8σ).

Figure 2 shows data obtained from various installations on the flux of ultrahigh-

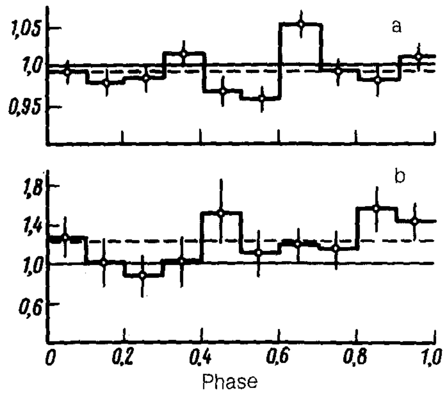

FIG. 1. Ratio of the count rate in the source cell to the average control count rate cells versus the phase of the source. a—Year-long observation period; b—14–16 October 1985.

energy γ rays from Cyg X-3. Our results are shown twice here: as an upper limit on the flux extracted from the fact that there is no absolute excess of showers and as the flux corresponding to the peak at the phase of 0.6. It should be kept in mind that Fig. 2 shows the spectrum of γ rays near the earth. In order to find the spectrum emitted from the source, we need to take into account the absorption in the interstellar medium due to the production of electron-positron pairs in the background radiation. The

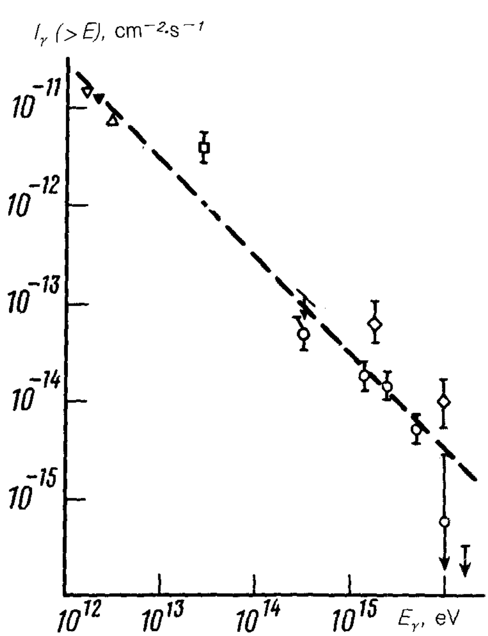

FIG. 2. Flux of ultrahigh-energy γ rays from the source Cyg X-3 according to various studies. O↓—BAKSAN (the present study); □—PLATO ROSA[2]; ◊ KIEL[3]; ●—HAVERA PARK[4]; ∇▼Δ—experiments with Čerenkov detectors.

probability for this process reaches a maximum at the energy of 2×10^{15} eV, and the points in Fig. 2 corresponding to this energy should be raised by a factor of about four. For the energy of 3×10^{14} eV, for which our data are plotted, the effect of the absorption is smaller (a factor of two). The result is to further sharpen the contradiction between our own data and the results obtained from the Kiel[3] and Havera Park[4] installations. Bhat *et al.*[7] have attempted to resolve this contradiction by hypothesizing a constant decrease in the luminosity of the source. The nature of the emission from the source in this energy range has not been finally settled, but the existence of this emission is of great interest for astrophysics.

In this letter we wish to call attention to data on possible flare activity of Cyg X-3 at energies $\gtrsim 10^{14}$ eV. In October 1985, an intense rf burst of this source was observed. According to the newsletter of the Naval Research Laboratory, the rf spectral power density was 1 fu on 1 October, 8 fu on 3 October, 30 fu (the record high over the entire observation time history) on 9 October, and 2 fu on 13 October. All these values are plotted in Fig. 3c. Figure 3a shows the diurnal ratio of the count rate in the source cell to the count rate in the average control cell in October 1985. In the 3-day period from 14 to 16 October, we see a stable increase in the count rate in the source cell above the background, for the first time over the entire observation history. The maximum increase above the background is 40%; this maximum is observed not at the maximum of the rf burst but after it has ended. It is easy to rule out an instrumental origin for the observed increase, since it is found only in a specific direction: There are no structural features in the overall shower count rate over the entire period shown in this figure.

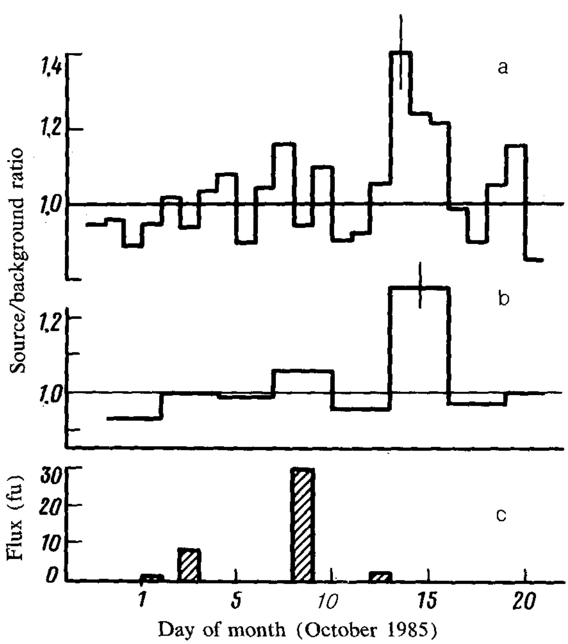

FIG. 3. a—Ratio of the count rate in the source cell to the average control count rate (diurnal average); b—the same, average over 3 days; c—spectral power density in the burst (in flux units).

Although it is more difficult to rule out a statistical origin, the probability for such an event to occur at random is extremely low ($\sim 10^5$). Definite proof would have been the simultaneous detection of this event by at least two installations, but to the best of our knowledge, no other shower installation was observing Cyg X-3 at this time. One of the primary purposes of this letter is to promote a comparison of the data from various installations.

The phase curve for the source/background ratio for all three days, 14–16 October, is shown in Fig. 1b. In contrast with the data from the Kiel group[3] (the only group which has previously observed an excess flux of showers from the source), where the entire excess was concentrated in a narrow phase interval, the curve in Fig. 1b has no narrow peaks. We could thus say that this curve is more reminiscent of a quasisinusoidal x-ray curve. The average rise above the background over the 3 days is 28% and corresponds to the following average flux density over this time interval:

$$1\gamma(> 3\times 10^{14}\,\text{eV}) = (2.8 \pm 0.7)\times 10^{-12}\,\text{cm}^{-2}\cdot\text{s}^{-1}\,.$$

We wish to stress that if such flare activity does indeed occur, it alone definitely could not explain the previously published data from long-term observations. Over a long time interval, the averaging of these flares without clearly identified phases would not result in the phase curves given in Refs. 3 and 4. On the other hand, an activity of a flare type, and specifically after rf bursts, has been mentioned previously by several groups working with Čerenkov detectors at energies $E \sim 10^{12}$ eV (e.g., Ref. 8).

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