MEETINGS AND CONFERENCES

Scientific session of the Division of General Physics and Astronomy, USSR Academy of Sciences (29–30 September 1976)

Usp. Fiz. Nauk **121**, 539–546 (March 1977)

PACS numbers: 01.10.Fv

A session of the Division of General Physics and Astronomy was held on September 29 and 30, 1976 at the Conference Hall of the P. N. Lebedev Physics Institute. The following papers were delivered:

1. *M. I. Kudryavtsev, A. S. Melioranskiĭ, and I. A. Savenko*, Bursts and Sources of Hard X-Radiation.
2. *V. L. Ginzburg and L. M. Ozernoĭ*, The Nature of Quasars and the Active Nuclei of Galaxies.
3. *I. L. Fabelinskiĭ, V. S. Starunov, A. K. Atakhodzhaev, T. M. Utarova, and G. I. Kolesnikov*, Narrowing of Optical Depolarization-Scattering Spectra Near the Critical Separation Points of Solutions.
4. *V. G. Kurt*, The Motion of the Sun in the Interstellar Medium.

We publish below brief contents of the papers.

M. I. Kudryavtsev, A. S. Melioranskiĭ, and I. A. Savenko, *Bursts and Sources of Hard X-Radiation.* The Kosmos 428 satellite, which was launched on 24 June 1971, carried a narrow-directional hard (≥ 40 keV) x-ray spectrometer. The CsI(Tl) x-ray photon detector was enclosed in both active (plastic 4π scintillator) and passive (tungsten, lead-glass) shields. The field of the instrument was shaped by a slit-type tungsten collimator whose directional pattern had a cross section of $2^\circ \times 17^\circ$ at half-height.[1]

The Kosmos 428 was placed in a nearly circular orbit (altitude 300 km, inclination 52°). The maximum of the x-ray spectrometer's directional pattern was aimed at the local zenith at all times, while the collimator slits (the direction of the broad component of the directional pattern) were perpendicular to the vehicle's line of flight. The field of the instrument scanned an annular belt of the starry sky on each orbital revolution. For the first three days, the path of the directional-pattern maximum was within four degrees of galactic meridians ($l = 350$–340), so that it was comparatively easy to investigate the distribution of the registered effects as a function of galactic latitude.

One of the most interesting phenomena observed in the Kosmos 428 experiment consisted of bursts of hard x-radiation, which were recorded for the most part in three energy channels (40–70, 70–190, 190–290 keV) of the spectrometer.[2–4] Figure 1 shows two examples of these events, which took place on 25 June 1971 at $8^h34^m10^s \pm 1^s$ UT and on 24 June 1971 at $10^h02^m39^s \pm 2^s$ UT. Our attention is drawn to the steep rising front (rise time generally less than 1 sec) and the exponential (sometimes two-component) dropoff of the x-ray burst.

During the 4 hour, 36 minute observing-time interval chosen for analysis, about 20 bursts with energy fluxes (summed over the burst) from 2.7×10^{-7} to 6.9×10^{-6} erg/cm^2 were registered. Figure 2 (curve 1) shows the integral energy flux (P) distribution of the burst numbers $N(P \geq P_0)$. Within the limits of measurement error, this distribution can be described either by $N(P \geq P_0) = KP^{-3/2}$ (uniform distribution of the burst sources in space) (curve 3) or by $N(P \geq P_0) = KP^{-1}$ (distribution of sources in the disk of the Galaxy) (curve 2). However, this distribution and the Galactic-latitude distribution of the burst numbers exclude source positions in the plane of the Galaxy.

It is worth noting that all of the large ($P \geq 3\times10^6$ erg/cm^2) bursts coincided to within 20 minutes of arc (in the direction of flight of the satellite) with hard x-ray sources that were registered by the same instrument in a large number of scans. In all, about 20 sources were found, their intensities varying with characteristic times of 1.5 hours to several days. A higher concentration of hard x-ray sources was observed near the plane of the Galaxy at $l = 330$–360 and $|b| \leq 10^\circ$, and this, considering the variability of the fluxes, made it difficult to localize them with confidence. The galactic-latitude distribution of the averaged intensity of these sources (this distribution is shown in Fig. 3) is consistent with the hypothesis that these objects have a spherical spatial distribution ($m = -0.26$ kiloparsec^{-1}) in the Galaxy. This distribution indicates that the hard x-ray sources are related to old galactic objects, e.g., globu-

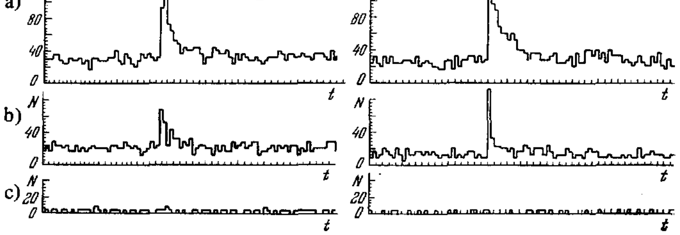

FIG. 1. Time profiles of x-ray bursts observed on Kosmos 428 on 24 and 25 June 1971. a–c) Pulse counts during 0.5 sec in 40–70, 70–190, and 190–290 keV channels, respectively.

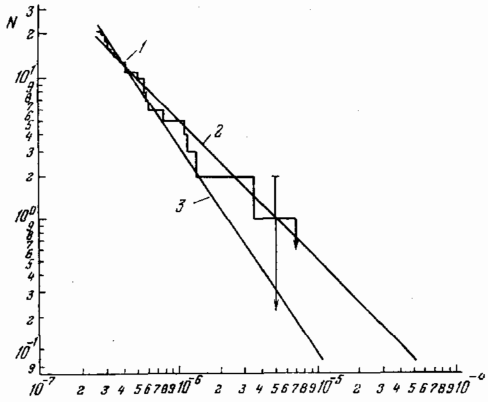

FIG. 2. Integral distribution of x-ray burst numbers as functions of burst energy.

lar clusters. If we assume that all of these sources are at distances of the order of 10 kiloparsecs, their average luminosity is ≈ 10^{36} erg/sec, and there are a total of ≈ 75 of these objects.

All of the hard x-ray sources registered in the Kosmos 428 experiment can be classified into two groups on the basis of their spectral characteristics: the first group includes sources with a "flat" spectrum (the ratios of the fluxes in the 40–70 and 70–190 keV ranges are near unity), while the second group would include sources that are observed only in the first range. With consideration of the fluxes in the 2–6 keV range ("Uhuru" data), the averaged spectrum for the group 1 sources can be represented in the form $K\exp(-E/E_0)$ keV/cm² · sec · keV, where $E_0 \approx 100$–170 keV; for group 2, it takes the form $KE^{-\gamma}$ keV/cm² · sec · keV, where $\gamma > 1.0$.[5]

Some of the hard x-ray sources and bursts in them could be localized spatially with accuracy sufficient for their identification with previously observed (for the most part in the range < 10 keV) x-ray sources and other peculiar objects. One of these sources is the known x-ray source (binary system) 3U 1700–37, for which, according to the Kosmos 428 data, the spectrum can be represented in the form $K\exp(-E/E_0)$ keV/cm² · sec · keV, where $E_0 \approx 100$ keV, while its total luminosity is 1×10^{37} erg/sec.[6] Another interesting source is in the globular cluster NGC 6624 (3U 1820–30). It also presents a quasithermal (optically thin source) spectrum with $E_0 \approx 100$ keV in the hard x-ray band.[7] A powerful burst of hard x-radiation (the first of those shown in Fig. 1) was registered on one of the orbital revolutions at a time when the globular cluster NGC 6624 was in the field of the instrument. The luminosity at the maximum of the burst (the distance to NGC 6624 ≈ 5 kiloparsecs) was 2.5×10^{40} erg/sec. Joint analysis of the positions of other hard x-ray bursts and sources also made it possible to identify them with certain globular clusters (NGC 5904, NGC 6541, and NGC 6388).[8] The luminosities of the sources in these globular clusters reached values around 3×10^{36} erg/sec; the luminosities at the burst maxima were 1×10^{39} to 3×10^{40} erg/sec.

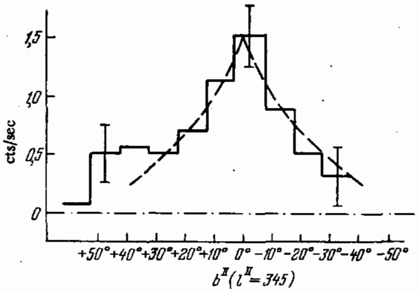

FIG. 3. Galactic-latitude distribution of x-radiation in 40–190 keV band. The dashed curve indicates the distribution of the radiation corresponding to a spherical concentration with $m = -0.26$ kiloparsec⁻¹; the dot-dash line indicates the background level.

It must be noted that at least three of the sources registered on Kosmos 428 with which bursts with energy fluxes from 3×10^{-7} to 7×10^{-7} erg/cm² · sec may coincide within the limits of error (≈ 10 deg²) are situated in regions in which there are no known globular clusters.

A great deal of attention has recently (1976) been given to study of x-ray bursts in discrete sources. Thus, for example, ANS satellite observations confirmed the existence of powerful (up to 5×10^{39} erg/sec in the 1–10 keV range) x-ray bursts in the source situated in NGC 6624. The time profiles of the bursts observed on ANS are similar to those of the hard x-ray bursts recorded in the Kosmos 428 experiment.[9] This ANS satellite and the Ariel 5 and SAS-3 have now made a large number of measurements of x-ray bursts in the energy range from 1 to 30 keV. A number of x-ray bursts were also detected and localized in old data obtained on the Uhuru, OSO-6, and Vela-5A and B satellites. About 20 burst sources (bursters) have now been identified, and some of them coincide with globular star clusters.[10–12]

The high (up to 3×10^{40} erg/sec) peak luminosities of the sources in globular clusters merit attention. If Eddington's luminosity limit $L_{\lim} = 1.3 \times 10^{38}\,(M/M_0)$ erg/sec is valid here, the mass of the object generating the x-radiation is $\lesssim 100\,M_0$, a point in favor of the model with ultramassive black holes in globular clusters.[13–15] Burst sources that do not coincide with known globular clusters may be situated in "invisible" globular clusters with "stripped" coronas. However, it is not yet possible to reject other models of the x-ray burst sources (for example, binary systems with compact objects—neutron stars or black holes).

---

[1] N. L. Grigorov, M. I. Kudryavtsev, A. S. Melioranskiĭ, and I. A. Savenko, in: Issledovanie Kosmicheskikh Lucheĭ (Cosmic Ray Research), Nauka, Moscow, 1975, p. 288.

[2] O. P. Babushkina, L. S. Bratolyubova-Tsulukidze, M. I. Kudryavtsev, A. S. Melioranskiĭ, I. A. Savenko, and B. Yu. Yushkov, Pis'ma Astron. Zh. 1, No. 2, 20 (1975) [Sov. Astron. Lett. 1, 32 (1975)].

[3] O. P. Babushkina, L. S. Bratolyubova-Tsulukidze, R. N. Izrailovich, M. I. Kudryavtsev, A. S. Melioranskiĭ, I. A. Savenko, and V. M. Shamolin, *ibid.*, 1, 6 (1975) [1, 158 (1975)].

[4] A. S. Melioranskiĭ, I. A. Savenko, and V. M. Shamolin, paper at COSPAR Symposium on γ-Bursts and Variable X-Ray Sources (Varna, May 1975), Preprint D-196, USSR Academy of Sciences Institute of Cosmic Radiation, Moscow, 1975.

[5] L. S. Bratolyubova-Tsulukidze, M. I. Kudryavtsev, A. S. Melioranskiĭ, I. A. Savenko, and B. Yu. Yushkov, Pis’ma Astron. Zh. **2**, No. 1 10 (1976) [Sov. Astron. Lett. **2**, 4 (1976)].

[6] L. S. Bratolyubova-Tsulukidze, M. I. Kudryavtsev, A. S. Melioaanskiĭ, A. I. Savenko, and B. Yu. Yushkov, *ibid*. **1**, No. 12, p. 9 (1975) [**1**, 236 (1975)].

[7] L S. Bratolyubova-Tsulukidze, M. I. Kudryavtsev, A. S. Melioranskiĭ, I. A. Savenko, and B. Yu. Yushkov, Astron. Tsirkulyar, No. 896, 6 (1976).

[8] R. Z. Sagdeev, 1976 IAU Circular No. 2959.

[9] I. Grindlay, H. Gursky, and H. Schnopper, Astrophys. J. **205**, L127 (1976).

[10] I. S. Shklovskiĭ, Preprint Pr-280, USSR Academy of Sciences Institute of Cosmic Radiation, Moscow, 1976.

[11] W. Lewin, Preprint CSR-P-76-24, 1976.

[12] J. Grindlay, Preprint No. 562, Center for Astrophysics,1976.

[13] J. Baheall and J. Ostriker, Nature **256**, 23 (1975).

[14] J. Silk and J. Arons, Astrophys. J. (Lett.) **200**, L131 (1973).

[15] I. Grindlay and H. Gursky, Astrophys. J. **205**, L131 (1976).