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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ
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ON INTERPRETATION OF THE WIDE ANGULAR DISTRIBUTION OF PARTICLES ARRIVING FROM DISCRETE SOURCES (Cyg X-3)

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Հ.Ս. ՄԱՐՏԻՐՈՍՅԱՆ

ԴԻՍԿՐԵՏ ԱՂԲՅՈՒՐՆԵՐԻՑ ՄԱՍՆԻԿՆԵՐԻ ԳԱԼՈՒ ՈՒՂՂՈՒԹՅԱՆ ԼԱՅՆ ԱՆԿՅՈՒՆԱՅԻՆ ԲԱՇԽՎԱԾՈՒԹՅԱՆ ՄԻ ԲԱՑԱՏՐՈՒԹՅՈՒՆ

Հենվելով որոշ գիտափորձերի արդյունքների վրա, որոնք Կարապ X-3-ից դիտված հզոր ռադիոբռնկման նկատմամբ մի քանի օրով ուշացած ազդանշան են գրանցել, աշխատանքում հետևություն է արվում, որ բացի գերբարձր էներգիայի γ-քվանտներից Կարապ X-3-ից հավանաբար գրանցվում են նաև ծանր զանգվածով մասնիկներ: Ըստ գնահատման, այդ մասնիկների զանգվածը մոտավորապես 1÷2 ԳէՎ է: Այնուհետև քննարկվում է այդ մասնիկների գալու ուղղության փոփոխության հնարավորությունը՝ նրանց ուշացման և Երկրի օրական պտույտի հետ կապված՝ դիտողի շարժման պատճառով: Հաշվարկների համաձայն նշված պատճառները կարող են երկնային ոլորտի վրա առաջացնել աղբյուրի կեղծ պատկեր: Ընդ որում, եթե ուշացումը մեծ է օրից, ապա աղբյուրի իրական կոորդինատների և կեղծ պատկերի կոորդինատների տարբերության մեծությունը կախված է ոչ թե ուշացման բացարձակ արժեքից (հետևաբար ոչ թե Լորենցի գործակցից և աղբյուրի հեռավորությունից), այլ |Δt-86400.n| մեծությունից, որտեղ Δt-ն ուշացումն է վայրկյաններով, իսկ n-ը ուշացման ամբողջ օրերի թիվն է: Այդ դեպքում, դիտման տեղական աստղային ժամանակից կախված, կեղծ պատկերի կոորդինատները աղբյուրի իրական տեղի շուրջը սիմետրիկ են բաշխվում: Այդ էֆեկտների օգնությամբ կարելի է բացատրել ոչ միայն լայն մարմնային անկյան մեջ Կարապ X-3-ից ազդանշանների դիտման փաստերը (Soudan-I, NUSEX, ՊԻՈՆ) այլ նաև մի շարք գիտափորձերում Կարապ X-3-ից ազդանշանները չգրանցելու պատճառները (Frejus, IMB, Բաքսան):

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Г.С. МАРТИРОСЯН

ОБ ОДНОЙ ИНТЕРПРЕТАЦИИ ШИРОКОГО УГЛОВОГО РАСПРЕДЕЛЕНИЯ НАПРАВЛЕНИЯ ПРИХОДА ЧАСТИЦ ОТ ДИСКРЕТНЫХ ИСТОЧНИКОВ (Cyg X-3)

Основываясь на результатах некоторых экспериментов по регистрации запаздывающего на несколько дней сигнала относительно мощной радиовспышки от "Лебедь X-3", в работе делается вывод, что, помимо γ-квантов сверхвысоких энергий, от "Лебедь X-3", возможно, регистрируются также массивные частицы. Оценочное значение массы этих частиц - порядка 1-2 ГэВ. Далее обсуждается возможность изменения направления прихода этих частиц вследствие их запаздывания и движения наблюдателя, связанного с суточным вращением Земли. Согласно расчетам названные причины могут привести к появлению ложного изображения источника на небесной сфере. При этом, если запаздывание больше одних суток, величина разности истинных координат источника и координат ложного изображения зависит не от абсолютного значения запаздывания (следовательно, не от Лоренц-фактора частицы и расстояния до источника), а от величины |Δt-86400·n|, где Δt-запаздывание в секундах, а n-целое число дней запаздывания. В этом случае, в зависимости от местного звездного времени наблюдения, координаты ложного изображения вокруг истинного расположения источника распределяются симметрично. С помощью этого эффекта можно объяснить как факт наблюдения сигнала от "Лебедь X-3" внутри широкого телесного угла (SOUDAN-1, NUSEX), так и причины ненаблюдения сигнала от "Лебедь X-3" в ряде экспериментов (FREJUS, IMB, Баксан).

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ON INTERPRETATION OF THE WIDE ANGULAR DISTRIBUTION OF PARTICLES ARRIVING FROM DISCRETE SOURCES (Cyg X-3)

On the basis of the results of a few experiments on registration of a signal lagged several days relative to the radio burst of Cyg X-3, there is drawn a conclusion that besides ultrahigh energy gamma-rays there are registered also massive particles. The estimated mass of these particles is of order 1÷2GeV. Then a possible change of the direction of arrival of these particles due to their retardation and the observer's movement with the Earth's daily rotation is considered. According to calculations, the reasons mentioned may lead to a false image of the source in the celestial sphere. If the lag is more than a day, then the difference in the real and false images will not depend on the absolute lag time (subsequently, not on the Lorentz factor of particles and the distance to the source), but on the quantity $|\Delta t-86400\cdot n|$, where Δt is lag time in seconds, n is a whole number of the days of lagging. In this case, depending on the local sidereal time of observation, the false image coordinates are distributed symmetrically around the real position of the source. By this effect one can explain the fact of observing a signal from Cyg X-3 within a wide solid angle (SOUDAN-1, NUSEX) as well as the fact of not observing any signal from Cyg X-3 in a number of experiments (FREJUS, IMB, BAKSAN).

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1. INTRODUCTION

The available experimental data suggest that in modern astrophysics there arises the problem of identification of cosmic-ray sources. To this first of all indicates the analysis of the totality of experimental data on extensive air showers and underground muons observed in the direction of the galactic source Cyg X-3 (for experimental and theoretical problems related with Cyg X-3, and for references to the original works see the reviews [1,2,3]).

Although the phase analysis over the known orbital period indicates that the source of the radiation detected is Cyg X-3, the directions of the observed signal events are distributed inside a wide angular cell. This is clearly seen in case of the underground experiment NUSEX [4], where the size of the angular cell is $10^{o}\times10^{o}$. In the recent work [5] the hadron groups in the direction of Cyg X-3 are reported to be observed inside a $30^{o}\times30^{o}$ cell!

The experimental observation of such a wide angular spread is one of the most hardly theoretically interpreted problems connected with detection of the radiation of an unknown origin from Cyg X-3. Though the earlier efforts have partially solved the problem, in most cases they are based on very exotic assumptions and do not give a full description.

In the present work, assuming that Cyg X-3 emits neutral particles with non-zero mass (cignets) and estimating the cignet mass, we shall try to explain this effect as a consequence of a Lorentz-factor-induced cignet radiation. The results of certain underground experiments are also analyzed from this point of view.

2. SOME POSSIBLE EXPERIMENTAL EVIDENCES FOR REGISTRATION OF ULTRAHIGH ENERGY MASSIVE PARTICLES FROM Cyg X-3

One of the key problems of detection of ultrahigh energy radiation from Cyg X-3 is that of the origin of the radiation. From this viewpoint arresting is the circumstance, that some experiments [6-15] reported the fact of registration of a statistically reliable signal from Cyg X-3 due to its bursting activity. Most essential is the fact that in all the cases the signal was registered in a few days after observation of a powerful radioburst of Cyg X-3. It seems reasonable to assume that the ultrahigh energy radio bursts and particles (cignets) are correlated and occur simultaneously in the source. The consistency of such an assumption is due to the fact, that the measurements of the frequency spectra and linear polarization of the burst-like radio emission testify to the fact, that the radio emission from Cyg X-3 has a synchrotron nature (Ref.[1] and references therein). The synchrotron radiation from Cyg X-3 most probably is due to the process of charged particle injection and acceleration up to ultrahigh energies, which in their turn interacting with the matter in the vicinity of the acceleration region, produce cignets and gamma-quanta. Subsequently, assuming that the radio emission and the cignets escape Cyg X-3 simultaneously, and taking into consideration that the radioburst observation time t_r, the time of registration of the signal most delayed from the radioburst

maximum, t_s, and the energy threshold of the setup, E_t, are known, we can estimate the cignet mass m as:

$$m \simeq E_t \sqrt{\frac{2c(t_s-t_r)}{L}}$$

where L is the distance to Cyg X-3, c is the velocity of light. It is supposed here, that the cignets with energy E_t are the most retarded ones. Table 1 presents the data on observation of the radioburst and the signal maxima, the energy thresholds of the installations and the corresponding estimates of the cignet mass. The data of the underground experiments [13,14,15] are not given here, because the threshold energies of the primary particles are unknown.

Table 1. The Cignet Mass Estimates

Experiment	Maximum of Radioburst	End of signal	Energy threshold in GeV	Lag time in days	Cignet mass in GeV
CRAO [6]	Sep.2-72	Sep.9-72	$2\cdot10^3$	7	2.2
CRAO [7]	Oct.26-80	Oct.29-80	$2\cdot10^3$	3	1.4
DURHAM [8]	Oct.9-85	Oct.12-85	10^3	3	0.7
WHIPPLE [9]	Oct.9-85	Oct.12-85	$4\cdot10^2$	3	0.3
HALEAKALA [10[	Oct.9-85	Oct.12-85	$2\cdot10^2$	3	0.1
GULMARG [11]	Oct.9-85	Oct.12-85	$6\cdot10^3$	3	4.3
BAKSAN [12]	Oct.9-85	Oct.16-85	$2\cdot10^5$	7	220

Though the given estimates are rather rough (first of all due to the fact that the exact threshold of the installations (by a factor of ~2÷3) and the lag time are unknown), nevertheless the obtained masses are rather close to each other, and in the frames of our assumptions we can confirm that the cignet mass is O(1)GeV. As to the sharp difference with the mass data of BAKSAN experiment, the logics of the model suggested allows two possible explanations: either the threshold energy of BAKSAN is overestimated by more than an order of magnitude, or there must be made a more radical assumption that the radiation from Cyg X-3 CONSISTS of cignet families with a rather wide energy spectrum. However, the Fly's Eye data [16] may be interpreted in favour of the first version. The signal of the same radioburst of Cyg X-3 in October 1985 was sought for in the Fly's Eye experiment during October 17-19 in the energy range from 10 to 1000 TeV. But no statistically reliable signal was registered. But, as the signal due to that radioburst of Cyg X-3 had been detected by several independent experiments, then the fact of detecting a signal in the Fly's Eye experiment indicates that if the signal from Cyg X-3 actually consists of massive cignets, then during that period of observations (the delay is ~9 days) one could register only particles with energies lower than the energy threshold set for the Fly's Eye installation. Issuing from the fact that the Fly's Eye did not register radiation with energy E>10TeV delayed by ~9 days, then the cignet mass upper limit will be m<12GeV. This value does not conflict with those in Table 1.

3. THE EFFECT OF RETARDATION ON THE DIRECTION OF ARRIVAL OF MASSIVE PARTICLES

It follows from the assumptions made in section 2, that the burst-like radio emission and gamma-rays from Cyg X-3 are tagged in the sense that they are emitted by the source simultaneously with cignets. Say, with the help of the electromagnetic radiation (gamma-rays, optical, radio emission,

etc.) the coordinates of the source are determined exactly, which will be hereinafter called the real coordinates.

Now assume that at the moment t_0 (corresponding to ϕ_0 phase of the orbital period) Cyg X-3 emits massive cignets and photons simultaneously. Let the observer on the Earth be at O point at t moment of the photon registration (see Fig.1), and the related rectangular coordinate system completely converges at that moment with the stationary coordinate system of the source. We shall assume that the source and the observer are always on XY plane.

The cignets starting from the source together with the photons will reach the observer at

$$\Delta t \simeq \frac{L}{2c} \cdot \frac{m^2}{E^2} \qquad (1)$$

and will be registered at Δt+t. At the moment t of registration of the photon in the point S, the cignet during Δt time travels SO′ distance and is registered in the O′X′Y′ system, which, owing to the fact that the noninertial reference system of the observer rotates with the Earth around its axis, will be shifted relative to OXY by v·Δt at an angle λ=15·Δt (v is the speed of the observer's motion).

The positions of the point S in OXY and O′X′Y′ systems relate as (it is assumed that the OO′ arc is approximately equal to the OO′ chord):

$$\begin{aligned} x &= v\cdot\Delta t + x'\cos\lambda - y'\sin\lambda \\ y &= x'\sin\lambda + y'\cos\lambda \end{aligned} \qquad (2)$$

Denoting the photon arrival direction in the OXY system by θ_γ, and the cignet arrival direction in the O′X′Y′ system by θ_m, from (2) we derive

$$\mathrm{ctg}\theta_\gamma = \frac{x}{y} = \mathrm{ctg}(\theta_m+\lambda) + \frac{v\cdot\Delta t}{y} \qquad (3)$$

After transformation of (3) we obtain:

$$\sin(\theta_\gamma-\theta_m-\lambda) = \frac{v\cdot\Delta t}{y}\sin(\theta_m+\lambda)\cdot\sin\theta_\gamma$$

Using the equality $y=V\cdot\Delta t\cdot\sin(\theta_m+\lambda)$, where V is the cignet velocity, we eventually obtain:

$$\Delta\theta = \theta_\gamma - \theta_m = \lambda + \mathrm{arc\,sin}(\frac{v}{V}\cdot\sin\theta_\gamma) \qquad (4)$$

Thus we have obtained an expression for the shift of the direction of the massive particle arrival relative to that of the photon. If in (4) the particle velocity is substituted by the velocity of light c, then, as far as $\lambda=0$, we obtain the classical expression for star light aberration

$$\Delta\theta = \mathrm{arc\,sin}(\frac{v}{c}\cdot\sin\theta_\gamma) .$$

With account of the dependence of λ on the particle mass and energy, the expression (4) takes the form:

$$\Delta\theta \simeq \frac{15L}{2c}\,\frac{m^2}{E^2} + \mathrm{arc\,sin}(\frac{v}{V}\cdot\sin\theta_\gamma) . \qquad (5)$$

Thus, if the source emits simultaneously photons and particles with mass m and energy E, then the observer on the Earth, according to (5), detects the particles in a direction shifted from that of the photons by $\Delta\theta$.

4. THE EFFECT OF RETARDATION ON THE DIRECTION OF ARRIVAL OF MASSIVE PARTICLES: A REAL THREE-DIMENSIONAL CASE

Let us consider the rectangular coordinate system OXYZ with its origin in the Earth's centre of gravity (Fig.2). The Z axis aligns with the Earth's axis of rotation, and the X axis is

directed to the point of vernal equinox. In this system the position of the source is determined by the radius-vector $\vec{\rho}$. Let the position of the installation at the t moment of registration of the electromagnetic radiation and the related coordinate system oxyz in the OXYZ system be determined by the radius-vector $\vec{R}$. In oxyz the position of the source at that moment of time is determined by the radius-vector $\vec{r}$. And the position of the installation which detects the lagged signal at the moment $t+\Delta t$, and the position of the o'x'y'z' system are determined by the radius-vector $\vec{R}'$. The position of the source in the o'x'y'z' system is determined by the radius-vector $\vec{r}'$. It is obvious that these vectors relate as:

$$\vec{R} + \vec{r} = \vec{R}' + \vec{r}' = \vec{\rho} . \qquad (6)$$

Now, using the notations of Fig.2 (if we pass from the relation (6) to a coordinate form), in the approximation of $R \ll r$ we obtain the following relations between the coordinates of the source in the oxyz and o'x'y'z' systems:

$$x' = r(\sin\theta\cdot\cos\varphi\cdot\cos\lambda - \sin\theta\cdot\sin\varphi\cdot\mathrm{ctg}\psi\cdot\sin\lambda - \cos\theta\cdot\sin\lambda)$$
$$y' = r[\sin\theta\cdot\cos\varphi\cdot\sin\psi\cdot\cos\psi\cdot\sin\lambda + \sin\theta\cdot\sin\varphi(\sin^2\psi+\cos^2\psi\cdot\cos\lambda) + $$
$$+ \cos\theta\cdot\sin\psi\cdot\cos\psi(\cos\lambda - 1)] \qquad (7)$$
$$z' = r[\sin\theta\cdot\cos\varphi\cdot\sin^2\psi\cdot\sin\lambda + \sin\theta\cdot\sin\varphi\cdot\sin\psi\cdot\cos\psi(\cos\lambda - 1) + $$
$$+ \cos\theta(\sin^2\psi\cdot\cos\lambda + \cos^2\psi)]$$

where ψ is the latitude of the installation; λ is the angle of the observer's rotation around the Z axis during Δt; r,θ,φ are the spherical coordinates of the source in the oxyz system at the moment t. One can be easily convinced that when $\lambda=0$ ($\Delta t=0$) the coordinates of the source in both systems coincide.

Since with the help of the electromagnetic radiation detected at the moment t we determine the zenith (θ) and azimuth (φ) angles, then by (7) we can determine the cignet arrival angles θ',φ' at the moment $t+\Delta t$. To do this, one must simply pass from the Cartesian $x'y'z'$ coordinates of the source, determined with the help of (7), to the spherical coordinates, and directly relate θ,φ and θ',φ' as:

$$tg\theta' = (x'^2 + y'^2)^{1/2}/z' \qquad (9)$$
$$tg\varphi' = y'/x'$$

Thus, if the photon registered from the source at the moment t has θ,φ direction, then the massive particle emitted simultaneously with the photon, according to (1) and (9), is registered at the moment $t+\Delta t$ and has θ',φ' direction.

5. THE FALSE IMAGE OF Cyg X-3 RELATIVE TO THE REAL COORDINATES, IN DEPENDENCE WITH THE TIME LAG AND OBSERVATION TIME

We have calculated the equatorial coordinates of Cyg X-3 in case of a delayed signal, depending on the time lag and the observation time. As assumed below, the real coordinates of Cyg X-3 are determined by registering the electromagnetic radiation emitted simultaneously with massive cignets during the burst-like activity of Cyg X-3. Hence, knowing the real equatorial coordinates of Cyg X-3 (the right ascension $\alpha=20.5^h$, declination $\delta=40.8^o$), and using the relations

$$H = t - \alpha$$
$$\cos\theta = \sin\delta\cdot\sin\psi + \cos\delta\cdot\cos\Psi\cdot\cos H \qquad (10)$$
$$\cos\varphi = (\sin\delta - \sin\psi\cdot\cos\theta)/(\cos\psi\cdot\sin\theta)$$

between the equatorial and horizontal coordinates of the source, we can estimate the value of the θ,φ direction of photon arrival for each moment of sidereal time t (with an

hourly period from the moment of the rise to the set) and for the given observation latitude ψ. In eq.(10) H is the hour angle of the source. Then, with the help of the expressions (7), (8), (9) we have calculated the corresponding θ',φ' angles of cignet arrival at the moment $t+\Delta t$ for various values of Δt. Eventually, knowing θ',φ' and $t+\Delta t$, and using transformations inverse to (10), we calculated the corresponding values of α', δ'. The distribution of α',δ' relative to the real location of Cyg X-3 as a function of the lag time and local sidereal time of registration is shown in Fig.3 ($\psi=41.7^o$, IMB latitude).

The calculations show that if the cignets are really retarded, then the equatorial coordinates restored by means of the experimentally registered cignets must be shifted from the real equatorial image of the source on the celestial sphere. This shift depends strongly on both the lag time and registration time. As is seen from Fig.3, with increasing lag time (with decreasing cignet energy) the false image of the source rapidly moves off from the point representing the real location of the source towards large α, and the declination interval rapidly widens with changing observation time. It is also seen that depending on the observation time, the false image of the source is distributed asymmetrically relative to the real coordinates. However, the signal from Cyg X-3, regardless the technique of experiment, is observed inside a cell centered on the real coordinates of Cyg X-3. It turned out that the false image symmetric distribution around the real coordinates can be attained only in the case when Δt is distributed within the interval

$$86400\cdot n - \Delta t_0 < \Delta t \le 86400\cdot n + \Delta t_0 , \qquad (11)$$

where Δt_0 is in seconds; n=1,2,3... is the number of lag days.

It follows from eqs.(7) that there is no digression of the real coordinates not only at $\lambda=0$ ($\Delta t=0$), but also when $\lambda=360^{\circ}$. In the expression (11) Δt_0 is right the value by which the lag time differs from a day (360°), and in this case digression of coordinates depends not only on the lag itself, but on Δt_0. Fig.4 shows the dependence of the false image of the source on the local sidereal time of cignet registration and (11)-type lag for various values of Δt_0 at $\psi=41.7^{\circ}$. As is seen from the figure, the $10^{\circ}\times10^{\circ}$ cell centered on Cyg X-3 corresponds approximately to the value of $\Delta t_0\leq0.25^h$, i.e. in this cell are imaged the coordinates of only those particles the lag time of which differs from a full day by $\pm0.25^h$.

If we consider only the lag time $\Delta t=\Delta t_0\leq0.255^h$ (n=0), then according to (1) it corresponds to particles with energy $E\geq2.4\cdot10^4 m$, the coordinates of which will be imaged only in the right hand part of the cell with size $10^{\circ}\times10^{\circ}$. Hence, the delayed signal in the energy range $E\geq2.4\cdot10^4 m$ must be sought for in a cell positioned asymmetrically relative to the location of Cyg X-3. The problem of the energy profile of the signal consisting of massive particles found inside the symmetrical cell and the possibility of observing a peak on the phase diagram are considered in Ref.[17].

6. ANALYSIS OF SOME DISCREPANCIES IN UNDERGROUND EXPERIMENTAL DATA

The sensational interest in Cyg X-3 is to some extent due to the reports of the SOUDAN-1 [18] and NUSEX [4] underground experiments on observation of a muon excess modulated over the known orbital period of Cyg X-3. But later the underground experiments FREJUS [19], IMB [14], BAKSAN [20] and KOMIOKA [21]

argued the validity of these results.

Below a brief analysis of the results of these experiments is given from the viewpoint of a delayed signal.

FREJUS. In Ref.[19] the signal from Cyg X-3 was sought by means of a phase analysis of the muon events with $E_{\mu}>3$TeV registered from a celestial sphere region with radius 2° and 5° around the location of Cyg X-3. It follows from Fig.3 of Ref.[19], that the FREJUS has observed Cyg X-3 during about $5^h<t<14^h$ of local sidereal time. But at the FREJUS latitude ($\psi=45.1^{\circ}$) $t_{rise}=10.5^h$, and $t_{set}=6.5^h$ for Cyg X-3. Consequently, Cyg X-3 was observed directly about 3.5 hours after the rise (the interval $10.5^h<t<14^h$) and 1.5 hours before the set (the interval $5^h<t<6.5^h$). Fig.5 shows the Cyg X-3 false image distribution as a function of the local sidereal time of observation for $\Delta t_0=20^m$ and 30^m. In the same figure is shown the region with radius 5°, with its centre on the real location of Cyg X-3. It covers an area approximately equal to $\Delta t_0\sim20^m$. If in the mentioned intervals of local sidereal time of observation the FREJUS experiment registered particles from Cyg X-3 with a lag like (11), then the direction of the arrival of these events, in accordance with our assumptions would be imaged on the shaded area, which corresponds to the observation time intervals. If assumed that the events registered are distributed homogeneously over the whole area (in Ref.[19] it is illustrated in Fig.1), then, as is seen from Fig.5a, separation of the region with radius 5° would lead to an artificial growth of noise by more than an order, and hence - to a strong suppression of the signal. Consequently, in this case to separate the signal consisting of massive particles, one must consider only the events which fall in the shaded area.

BAKSAN. As is mentioned in Ref.[20], the profile of the rock over the BAKSAN installation allows to register radiation in the direction of Cyg X-3 only when the hour angle of the source is within 20°-101° (muons with E_μ>200GeV are registered) and 234°-298° (E_μ>500GeV). These intervals of the hour angle of Cyg X-3 correspond to the local sidereal time intervals $21.8^h<t<3.2^h$ and $12.1^h<t<16.4^h$, respectively.

In the present work the phase analysis includes the events which fall in the $10^\circ\times10^\circ$ cell centred on Cyg X-3. In Fig.5c, where this cell is depicted as a square, the shaded area of the cell corresponds to the interval of $21.8^h<t<3.2^h$. If the BAKSAN had registered massive particles from Cyg X-3, then to detect such a signal, they would have to include in the analysis only the events from the shaded area. In this case the choice of the cell with size $10^\circ\times10^\circ$ has led to an artificial growth of the noise by a factor of ~3. From this point of view much worse is the case with the interval of $12.1^h<t<16.4^h$.

Situation is the same in the IMB experiment. For instance, to compare their results with the NUSEX data, they analyzed only the events registered in the zenith angle range 70°-80° and having fallen in a cell with radius 7° around Cyg X-3. If there are registered massive particles, then in accordance with our calculations the area of the celestial sphere where the coordinates of particles with such zenith angles are imaged, makes a negligible part of the total area of the cell considered. The Cyg X-3 observation time is limited also in the KOMIOKA ND experiment.

As is seen from Fig.3 and 4, with increasing time lag the false image of the source rapidly moves off its real position. Though at large time lags the region of the celestial sphere where the coordinates of the registered particles are imaged

broadens, and the number density of signal particles decreases, nevertheless in the cell neighbouring with the cell centred on Cyg X-3 there is a definite number of signal events. In this connection it should be noted that in many experiments the average noise is determined by the number of events in these neighbouring cells, this leading to a higher noise and a lower statistical reliability of the signal. Consequently, when searching for a lagged signal, we must measure the background before the rise and after the set of the source.

7. CONCLUSION

First of all it should be noted that the analysis of the experimental facts of registration of the radiation of unknown origin in the direction from Cyg X-3 which is correlated with the burst-like activity of Cyg X-3 in the radio wave band, brings us to a conclusion that the particles of this radiation have a certain mass. To draw such a conclusion allows us the assumption that these particles and the radio emission were radiated simultaneously from the source. Such a situation leads to the fact that the observer rotating together with the Earth will register massive particles in Δt from the moment of registration of the electromagnetic radiation from directions which lead to a false image of the source in the celestial sphere. The deflection depends on the time lag as well as on the local sidereal time and latitude of observation. If the lag time is less than a full day, then the false image is distributed asymmetrically relative to the real place of the source in the celestial sphere. But when the lag time is more than a full day, then the false image is distributed symmetrically, the deflection from the real coordinates of the source being in this case independent of the total time lag (number of full days of lagging). If the lag is defined as $86400n \pm \Delta t_0$, where n is the number of days, then the deflection depends not only on Δt_0. It is interesting that in this case the deflection practically is independent of the distance to the source. It is also interesting to note that if retardation of massive particles really leads to deflection of their real direction, then apart from other reasons, this effect also can be a reason for the observed cosmic rays isotropic distribution over their direction.

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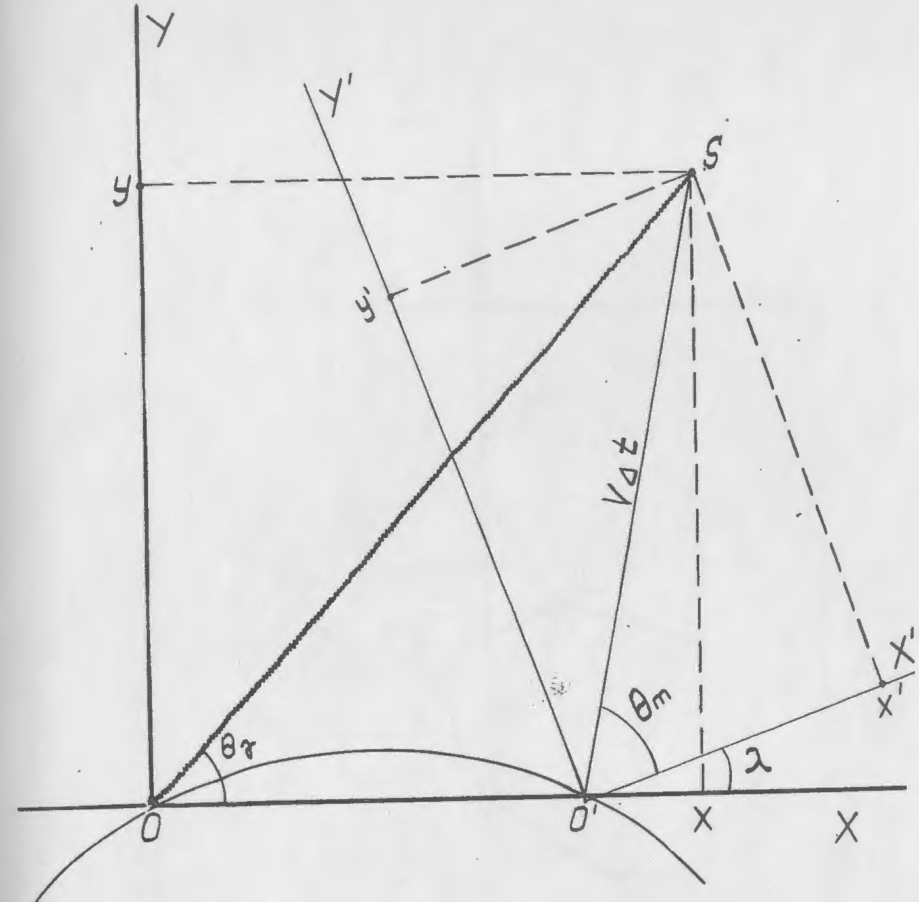

Fig.1

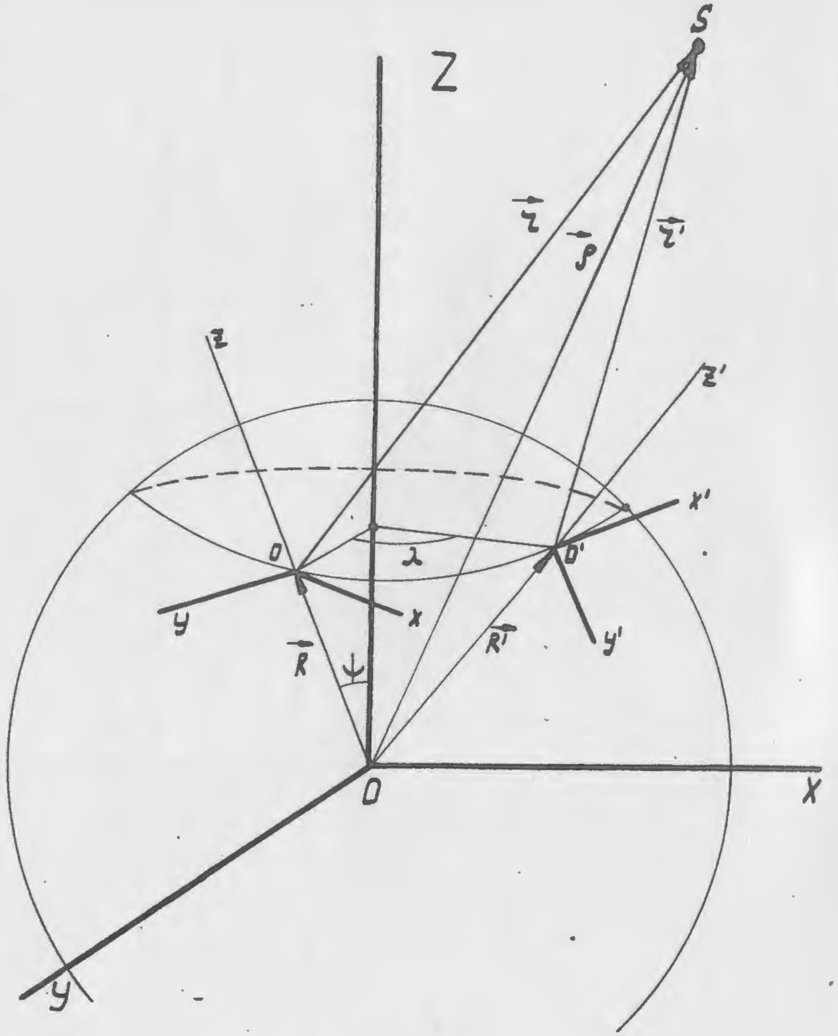
S
Z
O
O'
X
Y
x'
y'
x
y
z
z'
λ
Ψ

Fig.2

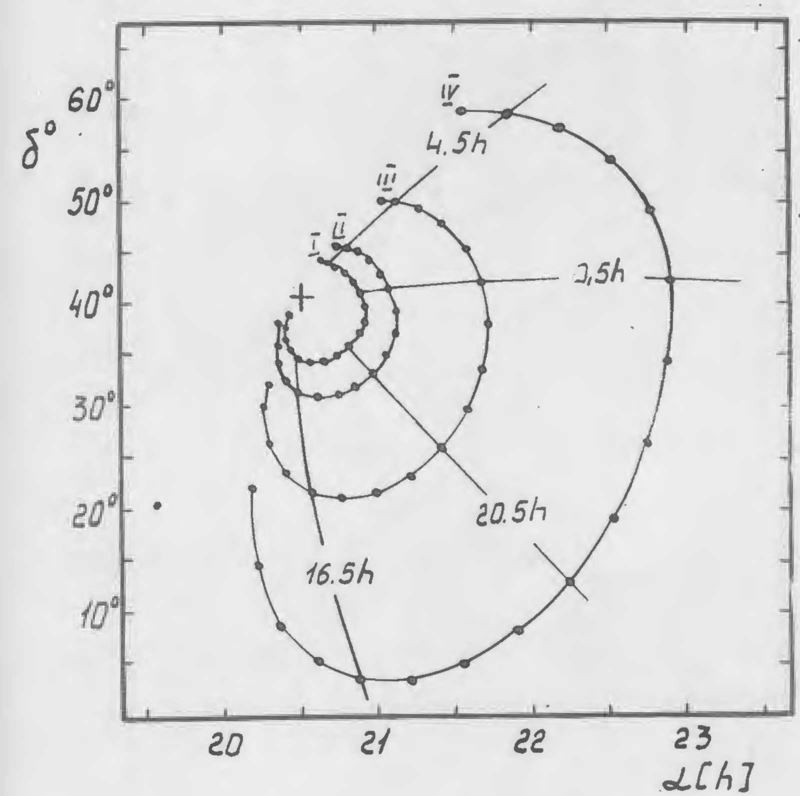
δ°
60°
50°
40°
30°
20°
10°
20
21
22
23
α[h]
I
II
III
IV
4.5h
0.5h
20.5h
16.5h

Fig.3

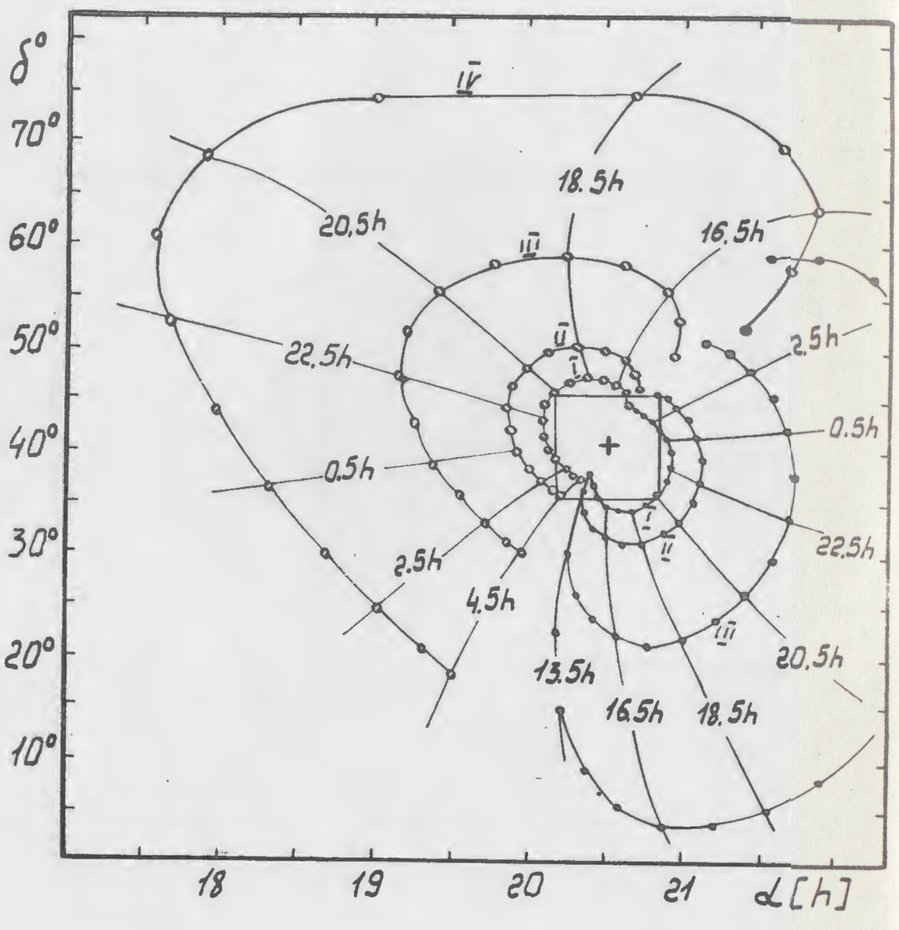
δ°
70°
60°
50°
40°
30°
20°
10°
18
19
20
21
α [h]
IV
III
II
I
18.5h
20.5h
16.5h
22.5h
2.5h
0.5h
4.5h
13.5h

Fig.4

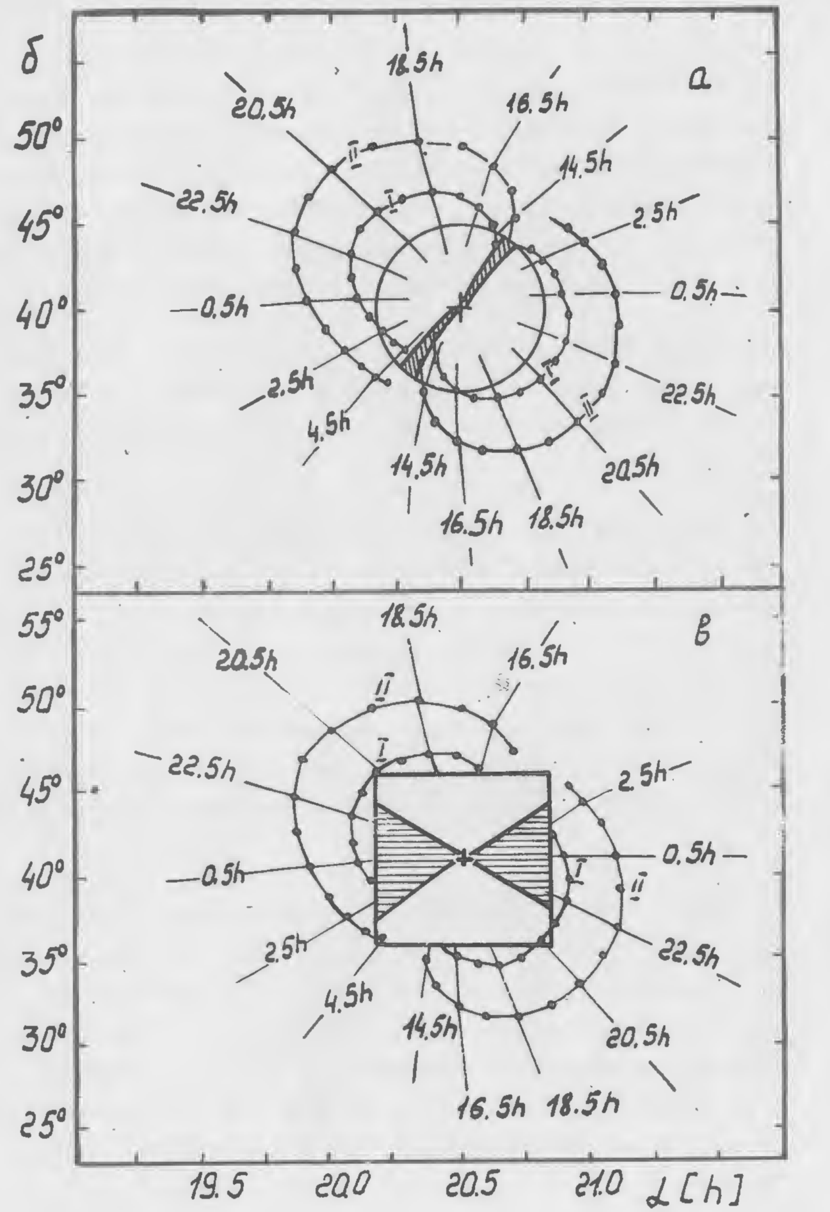
δ
50°
45°
40°
35°
30°
25°
55°
a
в
18.5h
20.5h
16.5h
14.5h
22.5h
2.5h
0.5h
4.5h
II
I
19.5
20.0
20.5
21.0
α [h]

Fig.5

FIGURE CAPTIONS

Fig.1 Relative position of the observer's coordinate system at t(oxy) and $t+\Delta t(o'x'y')$ moments of time. The wavy line OS is the path of photons, the solid line O'S is the path of massive particles. Δt is the massive particle time lag relative to photons on the way from the source to the observer. λ is the rotation angle of the coordinate axes for Δt.

Fig.2 Relative position of the source S and the horizontal coordinate system of the observer at ψ latitude at t(oxyz) and $t+\Delta t(o'x'y'z')$ moments of time in the equatorial coordinate system OXYZ.

Fig.3 The distribution of the false image of Cyg X-3 on the celestial sphere relative to its real position (denoted by a cross) as a function of observation time and lag time. The curves I, II, III, IV pass through the coordinates of the source at time lags 20^m, 30^m, 1^h, 2^h. The full circles on these curves denote the coordinates corresponding to hourly intervals of the local observation time The points corresponding to 4.5^h, 0.5^h, 20.5^h and 16.5^h times of observation are connected by lines.

Fig.4 The distribution of the false image of Cyg X-3 in case of $\Delta t_0<\Delta t<86400+\Delta t_0$. The curves I, II, III, IV correspond to the values of $\Delta t_0=20^m$, 30^m, 1^h, 2^h, respectively. Open circles denote the source's coordinates at the moment of observation at a lag of $\Delta t>86400-\Delta t_0$; the full circles - at $\Delta t<86400+\Delta t$. The real position of Cyg X-3 is denoted by a cross. The square shows the cell with $\Delta\alpha\times\Delta\delta=10^o\times10^o$ centred on Cyg X-3.

Fig.5 The curves I, II correspond to $\Delta t_0=20^m$ and 30^m lags. The cross (×) shows the position of Cyg X-3. a) The circle shows the cell with a radius of 5^o chosen in the FREJUS experiment. The shaded area is the region where the events registered in the FREJUS experiment should have been projected in the observation time intervals $10.5^h<t<14^h$ and $5^h<t<6.5^h$. b) The square shows the $10^o\times10^o$ cell chosen in the BAKSAN experiment. The shaded area corresponds to the observation time interval $21.8^h<t<3.2^h$.

REFERENCES

1. Владимирский Б.М., Гальпер А.М., Лучков Б.И., Степанян А.А. УФН, 1985, т.145, с.255.
2. Bonnet-Bidaud J.M., Chardin G, Phys. Rep., 1988, v.170, p.326.
3. Weekes T.C., Phys. Rep., 1988, v.160, p.2.
4. Battistoni G., Bellotti E., Blouse C. et al., Phys. Lett., 1985, v.155B, p.465.
5. Aharonian F.A., Avakian V.V., Mamijanian E.A., Martirossian H.S., Proc. 21st ICRC, Adelaida, 1990, v.2, p.87.
6. Vladimirsky B.M., Stepanian A.A., Fomin V.P., Proc. 13th ICRC, Denver, 1973, v.1, p.465.
7. Fomin V.P., Stepanian Yu.I., Stepanian A.A., Proc. 17th ICRC, Paris, 1981, v.1, p.28.
8. Chadwick P.M., Dipper N.A. Dowthaite J.C. et al. in: Further Evidence for the Emission of 1000 GeV Gamma Rays with 12ms Periodicity from Cygnus X-3. Very High Energy Gamma Astronomy, 1987, ed. Turner K.E. (Dordrecht: Reidel), p.115.
9. Fegan D.J., Cawley M.F., Gibbs K.G. et al., in: Search for a 12.59ms Pulsar in Cygnus X-3 at E>400GeV, Very High Energy Gamma Astronomy, 1987, ed. Turner K.E. (Dordrecht: Reidel), p.111.
10. Resvanis L., Learned J., Stenger V. et al., Very High Energy Gamma Rays from Cygnus X-3, Very High Energy Gamma Astronomy, 1987, ed. Turner K.E. (Dordrecht: Reidel), p.105.
11. Rawat H.S., Senecha V.K., Rannot R.C. et al., Proc. 20th ICRC, Moscow, 1987, v.9, p.129.

12. Alekseenko V.V., Chudakov A.E., Gulieva E.N. et al., Proc. 20th ICRC, Moscow, 1987, v.1, p.229.
13. Ayres D.S., Preprint ANL-HEP-CP-86-39, 1986.
14. Bionta R.M., Blewitt G., Bratton C.B. et al., Phys. Rev. D, 1987, v.36, p.30.
15. D'Ettorre Piazzoli, Preprint LNF-87/1(P), 1987.
16. Baltrusaitis R.M., Cassiday G.L., Cooper R. et al., Proc. 20th ICRC, Moscow, 1987, v.1, p.233.
17. Cudell J.R., Halzen F., Hoyer P., Preprint MAD/PH/339, 1987
18. Marshak M.L., Bartelt I., Courant H. et al., Phys. Rev. D, 1985, v.55, p.1965.
19. FREJUS Collaboration, Phys. Lett., v.174B, p.118.
20. Андреев Ю.М., Когай И.М., Козяривский В.А., Чудаков А.Е., Письма в ЖЭТФ, 1986, т.44, с.401.
21. Oyama Y., Arisaka K., Kajita T. et al., Phys. Rev. Lett., 1986, v.56, p.991.

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