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MICROMETEORIC INVESTIGATIONS IN THE NEAR EARTH SPACE ACCORDING TO OBSERVATIONS ON AES "KOSMOS-163"

II

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SUMMARY

Measurements of micrometeor streams were conducted in 1967 aboard AES "KOSMOS-163" with the aid of interference-proof acoustic detectors. The magnitude of the flux of particles with mass exceeding $7 \cdot 10^{-10}$g, constitutes $3.5 \cdot 10^{-6}$ particle/m^2·sec.

These data fully corroborate the results of measurements on AES "KOSMOS-135", the latter having rejected the hypothesis on the existence of a dust cloud around the Earth (ST-IM-10710).

The lengthy measurements, conducted during the action of the main yearly meteor streams, failed to reveal any manifestations of these fluxes' activity in the indicated region of masses of particles.

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* *

Measurements of particle fluxes of cosmic dust with the aid of piezoelectric detectors of collisions aboard AES "KOSMOS-135" [1, 2] and [ST—IM—10710] have shown that the earlier adopted values of the flux of micrometeors in the vicinity of the Earth, using the acoustic method, have been overrated by 10^3 to 10^4 times. The cause of such an overrating should be sought in the insufficiency of shielding in the instrumentations used from various kinds of interferences, and mainly from noises of thermic origin.

(*) MIKROMETEORY V OKOLOZEMNOM KOSMICHESKOM PROSTRANSTVE PO NABLYUDENIYAM NA SPUTNIKE "KOSMOS-163".

The new data, obtained on AES "KOSMOS-135" with the aid of interference-proof apparatus, were found to be in good agreement with the results of measurements of cosmic dust fluxes by the frequency of punctures of thin obstacles on AES "EXPLORER-16", "EXPLORER-23", "PECAS-1", "PEGAS-2" and "ARIEL-2" [4]. They constituted an experimental substantiation of the doubts in the reality of the existence of a dust cloud around the Earth [5, 6].

Since the new results and the conclusions derived therefrom were found to be quite substantial, having touched upon the numerous results of domestic and foreign experiments [7, 8], we pursued our investigations in 1967 aboard AES "KOSMOS-163" by conducting new investigations of micrometeor streams by means of an improved method.

The complete elimination of any danger of appearance of ghost signals at increase of sensitivity of the acoustic method of meteor registration is, apparently, quite complex a problem. In our opinion, a more rational way of method improvement is the utilization of two processes for the registration of a superfast microparticle impact; these processes must be appied simultaneously, for example, a mechanical impact and light flash or ionization. Several attempts are known by now of creating such a kind of combined detectors [9, 10].

For measurements on AES "KOSMOS-163" we constructed a detector of micrometeors, constituting a combination of an acoustic detector with a thin condenser. A simplified block-diagram of the apparatus is shown in Figure 1. The acoustic detector consisted of an aluminum plate in the shape of a rectangular panel of 0.24 m^2 area to which a piezoelectric element was fastened. The plate has been subjected to electrochemical treatment, as a result of which there was formed on its surface an electrically and mechanically dust-fast layer of aluminum dioxide of ~ 6μ thickness. A thin aluminum layer of ~ 0.4μ thickness was applied on both oxidized surfaces of the plate. In this way each plate surface constituted a separate thin condenser with sufficient capacitance and high electric strength, serving as independent micrometeor detector. At superfast micrometeor impact the destruction of detector material is attended by vaporization and intensive ionization of matter [11]. For a short time the condenser plates are found to be closed, and the condenser discharge, either total or partial, may then be registered by the electronic circuit.

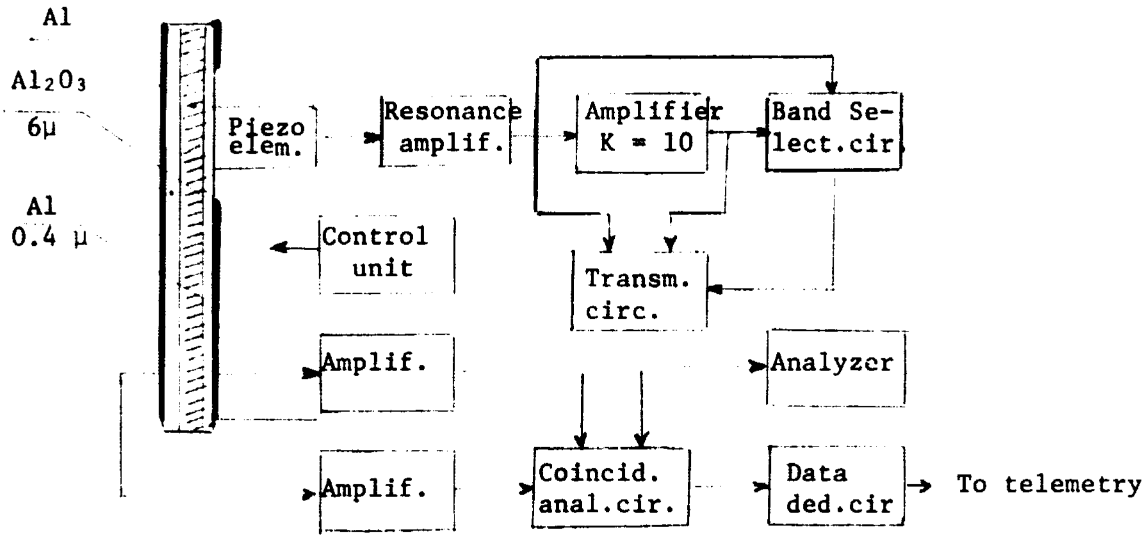

Fig.1

Block-diagram of the apparatus

In the processing of plates,requirements of assuring the necessary temperature regime of the detector were taking into account for the flight time of the satellite along the orbit.

The acoustic and condenser pickups exerted no influence upon one another in the course of operation. The acoustic characteristics of the system are not disrupted by the thin condenser on the plate's surface. The propagation of elastic perturbations along the plate is not attended by measurable variation of condenser capacitance. The condenser discharge does not result in the appearance of acoustic signal.

The electronic part of the apparatus, as compared with that utilized on AES "KOSMOS-135", underwent substantial variations [2]. However, the fundamental peculiarities of the electric circuit were preserved. From the piezoelement signal arrives to a selective amplifier with a 96 - 104 khz passband. An additional amplifier with an amplification factor of 10 serves for obtaining during amplitude analysis of two measurement ranges. Hitting the second amplitude range are signals arriving to the 10-channel amplitude analyzers through the transmission circuit, by-passing the second amplifier. Thus, the threshold response of the second amplifier is 10 times higher than that of the first one. The operation of the transmission circuit is controlled by the circuit of band selection as a function of signal level. As in the previous apparatus, when processing the signal, pulse selection is made by duration. The last channel of the second band is integral. The acoustic signal and those of condenser pickups arrive to the circuit of coincidence analysis, and then to telemetry through the data lead-out circuit. At transcription the number of analyzer channel, the presence of coincidences and the time of the event are registered. The control unit realizes a periodic rigorous verification of the continuity of apparatus' operation in flight. A special piezoelectric sensor simulates a meteor impact with a given signal amplitude. Simulated also is the puncture of condenser pickups. The control unit includes also a system designed for the elimination of possible condenser plate closing during its defects. A current pulse is periodically fed to detector, which in case of defect, must bake out a small area in the external thin aluminum layer around the place of defect, and restore the condenser. The plate with detectors is acoustically isolated from the satellite frame; the attenuation of acoustic noises proceeding from the frame constitutes in the operational frequency band more than 60 decibels. The total area of two operational sides of the plate is 0.48 m^2. The shadowing of panels by satellite parts constitutes about 20 percent of the total solid angle.

The calibration of the apparatus was conducted by low-velocity impacts at free fall on detector of metallic balls from 50 to 1000 μg in weight. The threshold response of devices by the transmitted pulse was established for the first band at level $6 \cdot 10^{-4}$ dyne·sec.* When estimating the masses of particles we limit ourselves to assumptions on linear dependence between the detector signal and particle pulse [2]. For the average collision velocity $V = 30$ km/sec the minimum registered mass constitutes $2 \cdot 10^{-10}$ g.

Temperature tests of the devices were also performed. Fully mounted operational panel samples with installed pickups, connected with the device's electronic unit, were subjected to multiple heating and cooling cycles in a temperature range from 100° to 0° C. During cooling cycles from 75° to 15°C with rates ~ 1 deg/min., temperature noises with intensity ~ 1 pulse/cycle were observed; their amplitudes were small and lay in 1 - 3 channels of analyzer I range. In the presence of condenser pickups of micrometeors, switched on to coincide with the acoustic ones, we estimated as admissible such an intensity of ghost signals.

(*) for the second band it was correspondingly 10 times higher: $6 \cdot 10^{-3}$dyne·sec.

Two identical devices, further denoted as No.1 and No.2, were installed on the satellite.

AES "KOSMOS-163" was launched on 5 June 1967 and put into orbit with the following parameters: range from the Earth's surface at apogee 616 km, at perigee 260 km; orbit inclination 48.5°, revolution period 93.1 min.

The obtained data have shown that, unfortunately, faults emerged in condenser pickups. Closing of condenser plates took place over the escape or lead-out sector. Apparently a number of minor failures occurred, each of which having a sufficiently high drag, with the result that the power of the regeneration system, whose current was distributed over numerous places of disruption, was found to be insufficient for their elimination. The leaks that do not lend themselves to elimination resulted in that the voltage in condenser pickups dropped below the operational level and was found to be insufficient for the effective registration of small particles. Obviously, these disruptions have in no way reflected upon the operational capability of the system of acoustic registration, whose normal functioning is corroborated by analysis of the operationl system of the control flights.

The rate of detector temperature variation in flight did not exceed 0.3°C/min. But since at temperature tests of the devices, even though in harder conditions, only scarce noise pulses of low amplitude, lying in 1-3 channels of the amplitude analyzer, were observed, the readings of the first three channels during subsequent analysis, corresponding to $6 \cdot 10^{-4} - 2.2 \cdot 10^{-3}$ dyne·sec, were not taken into account. The minimum registered mass of particles then constituted $7 \cdot 10^{-10}$ g.

The observations on AES "KOSMOS-163" were conducted during the period from 5 June to 10 October 1967. The results of measurements fully corroborate the main conclusion of the experiment on AES "KOSMOS-135", which consisted in that the magnitude of the flux of particles of cosmic dust in the near-Earth space, measured by the acoustic method with the aid of interference-proof apparatus, is 10^3 - 10^4 times lower than the previous microphone data.

The results obtained are compiled in Table 1 (next page). During the entire observation time, 11 events were registered by the sensors of two devices.

Compiled in Table 1 are the values of article flux $F_{2\pi} = \pi I$ through a plane unitary area, proceeding from the solid angle 2π (I being the intensity of particles passing through the unitary area perpendicularly to the direction of observation and related to the unit of solid angle).

TABLE 1

RESULTS OF MEASUREMENTS ON AES "KOSMOS-163" AND "KOSMOS-135"

DEVICE	Measurement time T, sec.	Exposure TS, m^2 sec.	Threshold Response			
			$P = 2.2\cdot10^{-3}$ dyne·sec; $m = 7\cdot10^{-10}$ g		$P = 6\cdot10^{-3}$ dyne·sec; $m = 2\cdot10^{-9}$ g	
			Number of coll.	Flux F par/$m^2\cdot$s	Number of col	Flux $F_{2\pi}$ par/$m^2\cdot$s
AES "KOSMOS-163" No.1	$5.2\cdot10^6$	$2.5\cdot10^6$	6	$3.0\cdot10^{-6}$	3	$1.5\cdot10^{-6}$
AES "KOSMOS-163" No.2	$2.9\cdot10^6$	$1.4\cdot10^6$	5	$5,5\cdot10^{-6}$	2	$1.8\cdot10^{-6}$
AES "KOSMOS-163" (average)	$8.1\cdot10^6$	$3.9\cdot10^6$	11	$3.5\cdot10^{-6}$	5	$1.6\cdot10^{-6}$
AES "KOSMOS-135"	$2.3\cdot10^6$	$1.1\cdot10^6$	-	-	4	$4.5\cdot10^{-6}$

The shielding by the Earth was not taken into account. Corrections for satellite detector shielding were introduced. The values of fluxes are given for two sensitivity (threshold) response, of which the second coincides with that of the detectors installed aboard "KOSMOS-135". The results of the latter are also compiled for the sake of comparison. The number of events registered during a prolonged measurement time, is quite small; the probability that they are spurious signals can not be entirely excluded. This is why the statistical reliability of the results brought out can not be determined quite precisely, and they must be considered as an upper limit of the measured quantity.

Utilizing the data of amplitude analysis, one may estimate the exponent γ in the integral distribution of particles by masses $F \sim m^{-\gamma}$. These estimates lead to the value $\gamma = 0.7 \pm 0.1$, i. e., to a significantly weaker dependence of the flux on the mass of particles than was assumed by Alexander and McCraoken [12]. Our measurements agree well in both the absolute magnitude of the flux and in the form of distribution with measurements of fluxes of dust particles by puncture frequency of thin-walled cells with gas and thin condensers on satellotes "EXPOLRER-16, -23" and "PEGAS" [3]. These data are presented in Fig.2 in the form of particle flux as a function of mass. The Bjork criterion of penetration was utilized at transition from equivalent thickness of the punctured aluminum obstacle toparticle mass. (Refer to [13]).

We already pointed out earlier [2], that no particularly great weight should be attributed to such a close coincidence of our data with the data on the frequency of punctures, as the uncertainty concerning the values of particle mass to which measurements are referred, which is linked with differences in the calibration methods. However, the general agreement of results obtained by distinct methods, and the closeness to the estimates, based upon observation of zodiacal light [14, 15], shows that the scale of the event is determined correctly.

A series of works were published in 1967-1968, the results of which clearly attesting to the erroneousness of former microphone measurements and measurements based upon extra-atmospheric collection of dust on rockets.

Devices were installed aboard AS "ORBITER", which are analogous to detectors of "EXPLORER-16 and -23". Measurements completed on five crafts in the course of 17 months [16], yielded magnitudes of fluxes $1.8 \cdot 10^{-6}$ particle/ $m^2 \cdot$sec, i. e. by a factor of 2 lower than those obtained by EXPLORER-16 near the Earth.

Micrometeoric investigations were conducted in 1966 on manned spacecrafts "Gemini-9 and -12". Several groups of investigators took part in the experiments [17]. Metallic and film surfaces were used for the detection of cosmic particles which were investigated in laboratory upon return with the help of different methods. These experiments failed to confirm high values of the fluxes of micrometeors in the vicinity of the Earth. Particles with dimensions 1 - 5 μ were not revealed, although dozens and even hundreds of particles could have been expected to register with the attained exposure and experiment response [18-21].

Measurements on AES "KOSMOS-135 and -163" were conducted in 1966-1967, in the period of activity of nearly all main meteor showers: Gemini, Ursides..... ... etc.

We therefore may conclude that, according to counter readings, no manifestation of flux activity of any kind was observed in the the region of particle masses ~ 10^{-9} g. Nor were meteor streams revealed during prolonged observation on EXPLORER-16, -23 , "PEGAS-1", "PEGAS-2" and on five satellites of the "ORBITER"

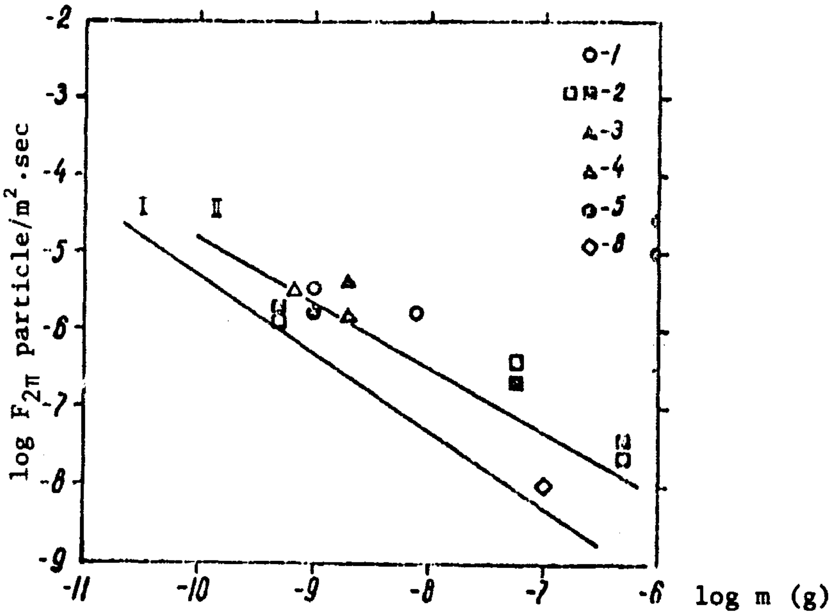

Fig.2

Integral Flux of Micrometeors:

1) "EXPLORER-16" and "EXPLORER-23" [3];
2) "PEGAS-1" and "PEGAS-2 [3];
3) "KOSMOS-135" [1, 2];
4) "KOSMOS-163" ;
5) "LUNAR ORBITER" [16];
6) RADIOMETERS [28].

Observations of Zodiacal Light:

1) INGHAM [15];
2) BEARD [1].

../..

series. The only exception is the increase in the counting rate of events on "PEGAS-2" in June 1965, during the activity of Arietides and ζ-Perseides meteor streams. However, this result has little statistical reliability and is not corroborated by simultaneous measurements on "PEGAS-1" [3]. During the flight of "MARINER-4" toward Mars, no meteor streams were even observed [22].

Therefore, the combination of experimental data shows that even the most intense ground-observed meteor showers are not singled out in the particle region of low mass 10^{-10}- 10^{-9}g against the background of sporadic micrometeors constituting 10^{-6} - 10^{-5} particle/m^2·sec.

In connection with this it is interesting to note that attempts to obtain information on particles of sub-μ dimension of 10^{-15} · 10^{-12} g mass were undertaken within the framework of the "LASTER" rocket program. In 1965-1967, during the activity of Leonides, Orionides, Arietides and Perseides meteor streams, four rocket launchings were performed, with apparatus for collecting cosmic dust particles having decelerated in the upper layers of the atmosphere. These experiments failed to indicate any significant discrepancy in the number of particles detected in the operational and control surfaces [23] Moreover, it was ascertained that even the threshold estimates of the number of particles of presumably cosmic origin were found to be substantially below the earlier admitted values based upon previous experiments on collecting dust, as well as on satellite data of [24, 25].

The measurements having yielded high values of collision frequencies and the observations of meteoric condensations of known and unknown meteor streams are described in the works by T. N. Nazarova [8]. Evidently, these data must be currently the object of reviewing. However, in a communication by Nazarova et al [26], it is pointed out that temperature tests of pickups not detecting noises were conducted. On that basis, the authors corroborate all their previous findings.

In this connection we may formulate the following remarks.

The acoustical method of meteor registration requires a careful screening from interferences of thermic, acoustic and electric origin. It was also shown experimentally the inadmissibility of installation of acoustic sensors directly on satellite frame or in the form of separate devices without sufficient acoustic insulation [2]. In the communication [26] attention is given only to one aspect of the problem, namely, the thermic noises in the pickupes themselves. But such noises are manifest at high apparatus' response, i. e. 10^{-2} - 10^{-3} dyne.sec and higher. The sensitivity according to the transmitted pulse of devices used in the Nazarova works constitutes only 1 dyne·sec [8, 27], i. e. it is 10^2 - 10^3 times lower than the response of apparatuses used by other researchers. At such level of sensitivity the thermic noises in pickups can easily be missed. Nevertheless, the counting rate registered by the devices appears to be immeasurably high. Even the agreement of Nazarova data with previous American microphone data appears to be imaginary, for at their comparison various representations were utilized on the dependence of detector sensitivity on the parameters of particles. The dependence of micrometeor flux on their mass was constructed by Alexander <u>et al</u> [12] in the assumption of pick-up's signal proportionality to particle pulse I ~ mv. In the work by Nazarova the relation I ~ mv^2 was used, which lowers considerably the computed value of particle mass by comparison with the first assumption [27]. In the region of particle masses ~ 10^{-7} g, accessible to observations with low-sensitivity devices, there are available data of ground measurements of the number of weak meteors by radar methods. Friichtenicht et al [28] have experimentally determined the ionization yield for artificially accelerated particles, and, on the basis of these data they refined the value of the mass ~ 10^{-7}g for weak radiometeors, whose flux constitutes 10^{-8} particle/m^2·sec. Comparison shows that the Nazarova data depart from the results of ground radar observations by 10^4 times for the very same region of particle masses.

In conclusion it is interesting to note that new data on micrometeor lead to the revision of representations on the extra-terrestrial origin of tiny dust particles of spherical, as well as of regular shape, collected on the Earth's surface, in polar ices and in the atmosphere [29].

***** THE END *****

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