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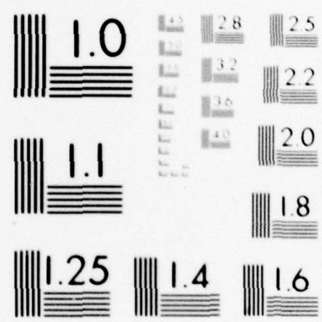


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# FOREIGN TECHNOLOGY DIVISION

METEOR RADIO ELECTRONICS

by

Ye. I. Fialko

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# UNEDITED MACHINE TRANSLATION

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METEOR RADIO ELECTRONICS

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

| Block | Italic | Transliteration | Block | Italic | Transliteration |
|---|---|---|---|---|---|
| А а | *А а* | A, a | Р р | *Р р* | R, r |
| Б б | *Б б* | B, b | С с | *С с* | S, s |
| В в | *В в* | V, v | Т т | *Т т* | T, t |
| Г г | *Г г* | G, g | У у | *У у* | U, u |
| Д д | *Д д* | D, d | Ф ф | *Ф ф* | F, f |
| Е е | *Е е* | Ye, ye; E, e* | Х х | *Х х* | Kh, kh |
| Ж ж | *Ж ж* | Zh, zh | Ц ц | *Ц ц* | Ts, ts |
| З з | *З з* | Z, z | Ч ч | *Ч ч* | Ch, ch |
| И и | *И и* | I, i | Ш ш | *Ш ш* | Sh, sh |
| Й й | *Й й* | Y, y | Щ щ | *Щ щ* | Shch, shch |
| К к | *К к* | K, k | Ъ ъ | *Ъ ъ* | " |
| Л л | *Л л* | L, l | Ы ы | *Ы ы* | Y, y |
| М м | *М м* | M, m | Ь ь | *Ь ь* | ' |
| Н н | *Н н* | N, n | Э э | *Э э* | E, e |
| О о | *О о* | O, o | Ю ю | *Ю ю* | Yu, yu |
| П п | *П п* | P, p | Я я | *Я я* | Ya, ya |

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

| Russian | English | Russian | English | Russian | English |
|---|---|---|---|---|---|
| sin | sin | sh | sinh | arc sh | $\sinh^{-1}$ |
| cos | cos | ch | cosh | arc ch | $\cosh^{-1}$ |
| tg | tan | th | tanh | arc th | $\tanh^{-1}$ |
| ctg | cot | cth | coth | arc cth | $\coth^{-1}$ |
| sec | sec | sch | sech | arc sch | $\text{sech}^{-1}$ |
| cosec | csc | csch | csch | arc csch | $\text{csch}^{-1}$ |

| Russian | English |
|---|---|
| rot | curl |
| lg | log |

Page 445.

# METEOR RADIO ELECTRONICS (Composition, History, Problems).

Ye. I. Fialko.

Is given determination of meteor radio electronics. Are described its component parts.

Is given the short outline of the history of the formation of meteor radio electronics. Are characterized the fundamental periods of its development. Are enumerated the main problems and the problems, confronting contemporary by meteor radio electronics.

Is presented brief information about meteors.

## Determination of meteor radio electronics.

The use of methods and means radio electronics determines to a considerable extent level and result of many branches of science and engineering. A characteristic example in this respect is the application/use of radar in the investigation of meteor phenomena in the atmosphere of the Earth. Successful study by radio aids, and then also the use of the ionized education/formation, created by meteoric bodies during their intrusion into high layers of the atmosphere, led to very rapid shaping of the specific section of radio electronics.

It should be noted that the most important Soviet scientist-specialists in the region of radio electronics, only did not rate/estimate the prospect of the use of radar methods for the investigations of meteors in the interests of astronomy, geophysics and radiophysics, but also in many respects they contributed to the realization of this direction. In the period 1953-1957 the academician A. I. Berg rendered great aid scientific collectives, which were being occupied by the development of radar equipment for meteor observations. In the middle of the 50's, academician A. L. Mints, attaching much importance to the development of radio methods in meteor investigations, and noting the prospect of the use of meteor ionization of the realization of long-distance communication in the range of VHF, introduced term radio-meteoritics.

Actually this was the first acknowledgement of that fact that the new branch of radio electronics is located in the stage of successful formation. Term radio-meteoritics - figurative, laconic and large-capacity, but needs insignificant refinement in connection with the taking root terminology in astronomy.

Radio aids are utilized, mainly, for recording or using the meteor ionization, produced by meteoric bodies, while by meteorites are understood only those, relatively few very large/coarse, meteoric bodies, which reach the surfaces of the Earth. Therefore more precise will be term meteor radioelectronics.

Page 446.

Meteor radio electronics - section of radio electronics, dedicated to study of meteor phenomena by radio aids and to their use for transmission of information with the aid of radio waves.

Before passing to the expansion/disclosure of the content, problems and problems of meteor radio electronics, and also to the presentation of its history, let us pause briefly at the fundamental special feature/peculiarities of meteors.

Brief information about meteors.

Meteoric bodies, meeting the Earth's atmosphere, generate meteor phenomena (meteors). The overwhelming majority of meteoric bodies (in the vicinities of the earth's orbit) belongs to the solar system and it moves over elliptic orbits; only a few meteors are generated by the meteoric bodies of interstellar origin. The meteoric bodies, which move by clusters, generate the meteor showers, and the others - create sporadic meteors (sporadic von). The meteors of flows, during their observation, seem escaping of one point of celestial sphere (radiant). The geocentric speeds of the meteoric bodies whose orbits intersect with the orbit of the Earth, are included virtually within the limits of 11-74 km/s. The masses of meteoric bodies they are distributed according to the inverse exponential law, beginning with certain minimum mass $m_0$ (meteoric bodies with smaller masses of $m<m_0$ are virtually "swept" by light pressure on the periphery of the solar system). The overwhelming majority of the meteoric bodies, which meet the Earth, brakes in upper levels of atmosphere, even without having melted. Significant part breaks down itself in range of height/altitudes from 70 to 120 km, creating the ionized meteor trails. Only the relatively insignificant part (large/coarser) of meteoric bodies reaches height/altitudes in several ten kilometers above ground level, forming very bright traces (bolides). And the entirely insignificant part of meteoric bodies does not manage completely to destroy itself in the atmosphere; the remains of these meteoric bodies, that drop out to the surface of the Earth, they are called meteorites.

Size/dimension and mass of the suppressing number of meteoric bodies is very small.

For the illustration of this position, let us give the following example. Let us assume that hardly the seen with the naked eye meteor is formed by the meteoric body, which has mean geocentric speed ($\approx 40$ km/s); in this case the mass of meteoric body is approximately 0.5 mg.

Having a small mass, but enormous geocentric speed, meteoric body it possesses considerable kinetic energy which is expend/consumed in the ablation process (destruction) of meteoric body. Interaction of meteoric body with the particles of "incident" air flow occur/flow/lasts as follows. "Being deepened" in the atmosphere of the Earth, meteoric body increasingly more intensely is bombarded with the particles of air. At first meteoric body is heated, then occurs its fusing which follows the boiling. The evaporating atoms of meteoric body encounter the molecules (and by atoms) of air, moreover the relative speed of these collisions differs little from the geocentric speed of meteoric body. Elastic collisions cause the heating of gas column, and inelastic - glow and ionization. Ionizations undergo, mainly, the meteor atoms the ionization potential of which is lower than in the particles of the air.

Page 447.

Extent and transverse size/dimensions of the ionized meteor trail depend, mainly, on speed and mass of meteoric body. The initial radius $r_0$, depending on the mean free path of ions, increases with height/altitude; on the average $r_0$ order of meter, and the length of trace - several ten kilometers. The ionized trace under appropriate conditions can effectively scatter radio waves. This is allowed, controlling the processes of formation and destruction of the ionized meteor trail (on recordings of meteor radio-echoes) to judge both properties and parameters of meteoric bodies and about the characteristics of the atmosphere in the region of meteor zone. So, observing the behavior of the formed trace, it is possible to study wind conditions/mode, intensity of concentration diffusion, processes of recombination, adhesion, etc., and also turbulent phenomena in the ionosphere. For this purpose, together with the radar methods, which realize a normal-recurrent sounding of meteor trail, is utilized the inclined irradiation of meteor trails with the considerable separation of the betraying and receivers. Use of the meteor ionized trace as passive re-emission of the electromagnetic waves gives possibility to carry out remote radio communication in the range to VHF. This radiolink system transmits information by "machine gun bursts" in the presence (on route) of the ionized meteor trail. The integral effect, produced by meteors, it affects the state of the ionosphere, especially on some forms of sporadic layer $E_s$. The equipment, intended for radar of meteors (and also communication gear), possesses the row/series of the specific special feature/peculiarities, caused by the specific character of interaction of radio waves with the ionized meteor trails. Thus, for instance, radar of meteors is realized usually in the range of the ultrashort waves, most frequently on $\lambda$=8-10 m.

Radar surveillance of meteors are most effective ones in comparison with other methods of meteor observations (photographic, telescopic, visual, magnetic, etc.). However, the most complete information about meteor phenomena is obtained during the composite observations of meteors. Development, together with the classical methods of the meteor observations (photo, visual) of radar method, contributed to the successful development of the science of meteors.

Meteor radio electronics; its place in the composition of the science of meteors.

Meteor radio electronics is the component part of two contemporary sciences: science of meteors and radio electronics. The science of meteors, which established in the past century, was initially represented by one section - meteor astronomy. In proportion to the study of interaction of meteoric body with the

Earth's atmosphere, was form/shaped physics of meteors. The development of the indirect method of studying upper levels of atmosphere, instituted on meteor observations, lay as the basis of meteor geophysics. The use of radio aids for recording the meteor phenomena made it possible to sharply raise the effectiveness of meteor observations. The radio methods of the observation of meteors very successfully are developed in recent 20 years. In connection with this will arise number of the radiophysics and radio engineering problems whose solution led to the formation of the independent section of radio electronics - meteor radio electronics, which is youngest part of the science of meteors[1].

FOOTNOTE [1]. Let us note that by examining meteor radio electronics relative to the science of meteors, in it it is possible to isolate three parts. The first - directly enters into the science of meteors. The second - is the method of studying the meteor phenomena. The third - does not refer to the study of meteor phenomena, but it is based on the use of meteor ionization for radio communication. ENDFOOTNOTE.

Page 448.

Thus, into the science of meteors enter meteor physics, meteor astronomy, meteor geophysics, meteor radio electronics.

As already mentioned meteor radio electronics is the independent section of radio electronics.

Sections of meteor radio electronics.

Into meteor radio electronics, enter meteor radiophysics, meteor radar, meteor radio communication and meteor radio engineering. Let us note that here there is in form radio engineering in the narrow sense of the word, i.e., mainly, the complex of equipment questions. To avoid discordance in terminology, let us note that the concept "radio engineering" in different historical stages corresponded to different content. In A. S. Popov's times by radio engineering, was understood the radio communication. Classical radio engineering includes seven sections: radio communication, broadcasting, radar, radio navigation, television, radio remote controls and radiotelemetry. Contemporary radio engineering, which encompasses the row/series of new sections, was called radio electronics. In our case, as was noted above, is in form meteor radio engineering in the narrow sense of the word.

It should also be noted that the framework of meteor radio electronics are not limited to the enumerated four sections. It adjoins the application/use of methods of electronics for an increase in the effectiveness of the optical investigations of meteors (as, for example, the use of superorthicons for an increase in the sensitivity of telescopic method, etc.).

Let us pause at the content of the main divisions of meteor radio electronics.

Content of the sections of meteor radio electronics.

1. Meteor radiophysics.

Meteor radiophysics studies, mainly, the processes of ionization and deionization and interaction of radio waves with the ionized meteor trail. The fundamental questions, which are determining meteor radiophysics's content, can be brought several groups:

education/formation and destruction of the ionized meteor trail;

the meteor contribution to the ionization of the ionosphere;

its own (primary) the radio emission of the ionized meteor trail;

interaction of radio waves with the ionized meteor trail;

meteor propagation of the radio waves, re-emitted by the ionized meteor trail;

the simulation of the ionized trace.

All noted questions are related to the ionized meteor trail (formed by meteoric body). At the same time is of great interest interaction of laser beam with meteoric body.

Page 449.

Meteor radiophysics's fundamental and most laborious problem is the theoretical and experimental study of scattering radio waves on the real ionized meteor trail (in the process of its formation and destruction).

In the solution of meteor radiophysics's problems, are reached the specific successes. This made it possible to supply investigations in the fields of meteor radar, radio communication and radio engineering, and also after the creation of effective equipment to begin the productive observations of meteors.

2. Meteor radar.

Meteor radar is dedicated to the study of meteor phenomena by radar means.

The content of meteor radar composes a number of theoretical and experimental problems:

the establishment of the dependence of intensity and duration of echo signal from the parameters of meteoric body, atmosphere and radar (this problem is to a considerable extent common with meteor radiophysics);

the measurement of the coordinates (among other things height/altitude) and of the parameters of meteor trail (including the initial radius $r_0$, linear electron density $\alpha$);

the establishment of the communication/connection between the statistical characteristics meteor radio-echoes and the statistical characteristics of meteoric bodies;

development and application of the methods of measuring the parameters of meteoric bodies (speeds $v$, of radiants, cell/elements of orbits, and also masses);

development and application of the methods of measuring the drift of meteor trails, and also turbulent phenomena in the ionosphere;

the selection of the optimum parameters of meteor radars of different designation/purpose.

One of the component parts of the meteor radar is setting and conducting of observations according to the appropriate programs.

Let us note that, together with radar of the ionized meteor trail, is possible also radar of meteoric bodies.

3. Meteor radio communication.

Meteor radio communication is instituted on the use of the ionized meteor trails as passive reemitters for the transmission of information.

The use of meteor ionization for purposes of radio communication places number of the problems of similar ones to some problems of meteor radar; to them it is related, first of all:

the determination of the relation between the parameters of that scattered forward signal and parameters of meteor trails, and also meteoric bodies;

the expansion/disclosure of the communication/connection between the statistical characteristics of scattered forward signals and the parameters of traces and meteoric bodies.

This gives the possibility to examine number of the most important problems:

the analysis of capacity, interference shielding and specific special feature/peculiarities of the meteor communication line;

the selection of the optimum parameters of the meteor communication line.

Meteor radiowave propagation can be used also for other target/purposes, namely:

the standardization of the standard of time and transmission of picture signals.

Page 450.

Meteor radar and radio communication advance the row/series of the specific equipment problems whose solution is the object/subject of meteor radio engineering.

4. Meteor radio engineering.

The fundamental problem of meteor radio engineering is the equipment provision (and the solution of connected with this theoretical and experimental problems) for meteor radar, meteor radio communication, etc.

The main directions of meteor radio engineering include following:

the creation of equipment with the optimum parameters (wavelength, repetition frequency, etc.), sufficiently high power and sensitivity; this problem is closely related with the problem of the selection of the optimum parameters, solved both in meteor radar and in meteor radio communication;

the provision for an interference shielding of installations;

the automation of recording and processing the results of observations.

The specific special feature/peculiarity of meteor radars is high effectiveness (caused by the short duration of object).

One of the most most difficult problems is the creation of a precise phase altimeter.

Radar surveillance of meteors, and also investigation of the meteor propagation of radiowaves made it possible to obtain the row/series of the results, representing interest from astronomical and geophysical point of view.

Contribution of meteor radio electronics to meteor astronomy and meteor geophysics.

The successful development of meteor radiophysics, radar, radio engineering, and partially also the investigations, connected with meteor radio communication, they made it possible to make a significant contribution to astronomy and geophysics. Let us note the fundamental investigations of this kind:

1) the study of meteor substance in the solar system;

2) the estimate/evaluation of the increment of the mass of the Earth because of meteor substance;

3) the investigation of atmosphere circulation in meteor zone;

4) the estimate/evaluation of the meteor contribution to the ionosphere. This problem is to a considerable extent common/general/total both for meteor radiophysics and for meteor geophysics;

5) the study of structure and atmospheric parameters in meteor zone.

Besides this, meteor radio electronics makes it possible to solve number of questions, which relate to meteor physics (especially in combination with other methods of observing the meteors).

The development of the radio method of the study of meteors is connected with the development of theory, procedure of observations, equipment and setting up and conducting meteor observations.

Development stages of meteor radio electronics.

On the basis of theoretical representations, experimental investigations, applied procedure, utilized equipment, character and scale of observations, and also use of meteor ionization for a communication/connection, it is possible to isolate following development stages of meteor radio electronics.

Page 451.

the 1st stage - from end/lead of 20's to the middle of the 40's (the "pre-radar" stage). In this period information about meteors, very incomplete, was obtained (since discussion deals with radio method) in connection with conducting of ionospheric observations and studying the radiowave propagation. N. A. Ivanov [1] (almost simultaneously with Skellett [2]) arrived at conclusion about the fact that the meteors, falling into the ionosphere, lead to a short-term increase in the ionization. Let us note that it is somewhat earlier than Nagaoka [3], correctly associating short-term anomalies in layer E with meteor phenomena, it gave the incorrect interpretation of the mechanism of education/formation and character of this ionospheric heterogeneity: it assumed that the meteoric body "clears out" on its path electrons (while in actuality, as a result of colliding the vaporized meteor atoms with the molecules of air it is formed the column of ionized gas).

At the start of the 30's, M. A. Gnevyshev [4] established the influence of the meteor shower on the conditions of radiowave propagation.

At the end of the 30's I. S. Astapovich [5], and then in the beginning of the 40's Yu. N. Khlyustov [6] reveal/detected the change in the intensity of radio signal and the onset of noises at the onsets of bright meteors. However, the conditions, favorable for the setting of the goal-directed systematic radio observations of meteors, were created only after the appearance of radars.

The 2nd stage (stage of the formation of meteor radar) - from the middle of the 40th to middle 50's. The use of radars of the type "P-2M" [7, 8], which worked in metric range, made it possible to supply in the USSR radar surveillance of meteors. I. S. Astapovich one of the first in the USSR focused attention on the possibility of applying radar equipment for recording meteors [7]. The first radar surveillance of meteors in the USSR pertain to the year 1946 - under B. Yu. Levin's management/manual with participation of P. O. Chechik and N. I. Kabanov observed the flow of Draconids [8] on wave $\lambda=4$ m. Radar surveillance of the flow of Draconids of 1946 in the USSR and abroad [9, 10] served as powerful/thick "jerk/impulse" in the development of the radar method of observing the meteors. In the USSR, and also in England, Canada and USA at the end of the 40's are created the first groups, which are occupied by questions of radar of meteors and by more or less systematic observations. To the second stage perptain also the attempts to realize meteor ionization for radio communication [14]. The rapid development of the radar method of observing the meteors in the USSR was begun in connection with preparation for international geophysical year (MGG).

The 3rd stage - preparation for MGG; conducting MGG and MGS (international geophysical collaboration) - from 1955 through 1959. In this period in the USSR were created the collectives, which consisted of radio specialists and astronomers. The common/general/total management/manual of preparatory works, and then also by observations according to program of MGG was realized by a board for comets and meteors of the astro-council of the AS USSR (chairman V. V. Fedynskiy) and by head institution - AO of Odessa university (director V. P. Tsesevich). Conducting observations according to single program to scale of the country made it possible to obtain data about meteor activity, about the statistical characteristics meteor of the radio echo and meteoric bodies, about flow pattern, about the intensity of the processes of deionization in meteor zone and so forth [15, 11, 16-28, etc.].

Page 452.

In this same period was made the row/series of theoretical works [11, 16, 29-37], which, together with the works of Kaiser, Mitra, Lovell, Herlofson, McKinley, etc. [38-45], and also the fundamental works of B. Yu. Levin [46], I. S. Astapovich (47), V. V. Fedynskiy [48], O. V. Dobrovol'skiy, L. A. Katasev, P. B. Babadzhanov et al. made it possible to give the scientific substantiation of the radar method of observing the meteors. The third period includes also the realization of meteor radio communication (in Canada) [49, 50]. By most successful during this period were the investigations, made the Kharkov collective, which, mention fundamental programmed observations, carried out also observations of the winds on the drift of meteor trails. This (together with data of Greenhow [51]) made it possible to supply programmed observations in the period of the international year of quiet sun (MGSS).

The 4th stage - 1960-1965 - preparation and conducting of MGSS. During this period in the row/series of point/items, was created the special equipment, intended for observing the drift of meteor trails and study of wind picture. During this period continued also the investigations of an initial radius of meteor trail [52, 53], was developed the statistical theory of radar of meteors [54, 55, 56], they were examined the simulation of meteor trails [57], resonance effects in meteor trail [58, 59], meteor contribution to ionosphere [60], were investigated the processes of deionization in meteor trail [61, 62], the theoretical questions, connected with the study of wind conditions/mode [63, 64], by turbulent processes in meteor zone [65], by diffusion [66, 67], meteor radiowave propagation [18, 68, 69]. In this same period are acquired data on the orbits of meteor showers [70], on mass distribution of meteoric bodies with the use of traces of different types (including intermediate type traces [71-73]), about the meteor increment of the mass of the Earth [74], about the distribution of meteoric bodies according to kinetic energies [73, 75, 76], etc.

This stage includes successful investigation and use of meteor radio communication in the row/series of countries [77][1].

FOOTNOTE [1]. See also [90]. ENDFOOTNOTE.

The 5th stage, which was begun following with the termination of MGSS (i.e. since 1966), was characteristic by the tendency to improve the procedure of the measurement of speed and wind direction in meteor zone, to develop the method of the precise measurement of the height/altitude on which were arrange/located the section of meteor trail, that diffuses of radio wave, and to also utilize identical (or close) operating frequencies and increase the effectiveness of equipment. In connection with this is of interest the phase-difference method of measuring the angular coordinates, which possesses the row/series of advantages in comparison with amplitude [78] and amplitude-phase [79] methods.

The for the first time direction-finding-ranging method of determining the coordinates of meteor with the use of a phase goniometer and spaced antennas was proposed by the author as early as 1950. Station "TPI-2", created under author's leadership, contained, besides range finder, also the channel of angular coordinates [11, 80]; the measurement of the height/altitude of meteors by phase-difference method was realized first in 1958, and then 1959 [81]. The phase-difference method of measuring the height/altitude was more lately realized with obtaining of higher accuracy in the row/series of others city country [82, 83, 84]. The creation of the improved equipment, for meteor investigations is successfully conducted by at present many scientists.

Page 453.

Contemporary meteor radio electronics is located in the stage of intense development.

Let us examine the problems, connected with the prospects for the development of meteor radio electronics.

Problems and problems of meteor radio electronics.

1) Meteor radiophysics.

a) it is necessary to refine the processes of forming the ionized meteor trail: the process of ionization (and "ionization probability" $\beta$) during interaction of meteor atoms with the particles of air, the dependence $\beta$ on the speed of meteoric body; a change in the linear electron density $\alpha$ along trace in dependence on the parameters and the composition of the meteoric body and atmosphere; a change in bulk density n along a radius of the ionized trace n(r) and its height dependence; the quantitative estimate/evaluations of the initial radius $r_0$, its high-altitude and high-speed/velocity dependences. There is special interest in the study of radial and axial distribution of electron energy n(r) and $\alpha$ taking into account the fragmentation of meteoric body.

b) follows the more thorough to study the processes of destroying the ionized meteor trail and, in particular, to obtain the common picture of change in the function of the time of linear and volumetric electron density taking into account all "deionizing" factors, concentration diffusion and turbulent diffusion.

c) one should also refine form and structure of the ionized meteor trail taking into account the action of the "destructive" factors in the process of track condensation, without disregarding the process of the fragmentation of meteoric body.

d) is in prospect to refine the meteor contribution to the ionosphere, namely: to refine the correlation between meteor phenomena, education/formation and condition of some types of sporadic layer $E_s$; to develop the mechanism of the education/formation of some types of layer $E_s$ of meteor origin; to refine the portion of the meteor contribution to layer E (both into the daytime and in night time).

e) there is a definite interest in the investigation of its own (primary) radio emission of the ionized meteor trail.

f) meteor radiophysics's most essential problem is the fundamental investigation of interaction of radio waves with the ionized meteor trail. To this problem one should relate: the refinement of theory for the case of the ideal infinite ionized cylinder (and, in particular, obtaining the analytical expressions of the intensity of the scattered signal for the case of traces of mongrel, i.e., from $\alpha$ on the order of $10^{12}$ el/cm); the essential refinement of theory for the case of imperfect trace taking into account the processes of formation and destroying the trace (for a monolithic body); the creation of the theory of scattering radio waves by the real ionized meteor trail (taking into account the possible mechanisms of fragmentation).

g) together with the careful examination of a normal-recurrent and inclined re-emissions and radiowave propagation in the classical case (monolithic meteoric body), it is necessary to consider also the presence of the fragmentation of meteoric bodies.

h) it is possible to expect the new theoretical and experimental data on resonance effects (especially for the case of transient and overdense types, and also upon consideration of fragmentation).

Page 454.

i) being promising is the simulation of the ionized meteor trails (both static with the use of gas-discharge tubes and dynamic - with the aid of "pools").

j) above discussion dealt with interaction of radio waves with the ionized trace. Becomes at present actual/urgent the setting of the theoretical and experimental studies of interaction of laser beam with meteoric bodies (different compositions, structure, forms and size/dimensions) for purpose of the study of the possibilities of radar detection of meteoric bodies and prevention of meteorite problem.

The solution of these problems, important by itself, is necessary for the progress of other sections of meteor radio electronics, and, first of all, meteor radar and meteor radio communication.

2) Meteor radar detection.

a) First of all, it is necessary to refine the dependences of intensity and form meteor of the radio echo on the parameters of meteoric body (ionized meteor trail), medium, equipment, "geometry" and the like in the process of formation and destroying the meteor trails in the presence and absence of fragmentation.

b) There is special interest in obtaining these data in the particular case when $\alpha$ is of the order of $10^{12}$ e /cm, i.e., for traces of transient type.

c) One should explain, under what conditions it is necessary to consider the effect of fragmentation with radar of meteor trails.

d) Useful both in theoretical and applied ratio/relations will be the refinement of the statistical characteristics meteor of the radio echo in the random position of "mirror" point on the meteor trails of different types (taking into account the presence of the transition region in which α it is of the order of $10^{12}$ e./cm) in the case of the nonfragmenting meteoric body. This will make it possible to refine the analytical dependence of the statistical characteristics meteor radio-echoes on the statistical characteristics of meteoric bodies. The solution of this problem taking into account the fragmentation of meteoric bodies will be the significant contribution to meteor radio electronics.

e) Special interest (and great difficulties) is of the development of a precise radar method of determining the mass of meteoric body.

f) Very promising is the improvement of the methods of measuring of initial radii of the ionized meteor trails and the realization of sufficiently prolonged meteor observations at several wavelengths.

g) One of the most urgent problems is the improvement of the methods of observing the drift of meteor trails and construction of wind picture in meteor zone. This will make it possible to carry out a dialing/set of statistical material for refining the global atmosphere circulation in meteor zone.

h) This problem adjoins improvement of the radar methods of studying the turbulent phenomena in meteor zone and obtaining sufficient the space statistics.

i) An increase in the effectiveness of meteor radars is connected with the development of the new methods of determining the parameters of the ionized meteor trails which would make it possible to obtain (for the limited time of observations) the sufficiently large number of precise measurements.

Page 455.

Here is related the improvement of the method of determining radial component drift velocities of meteor trails because of the use of very short-term meteor radio-echoes.

j) The expansion of the possibilities of meteor radar requires the development of the radar methods of measuring the parameters (among other things orbits, radiants, speeds and the like) of very weak meteors.

k) The need for the "joining" of recordings to height/altitude is connected with the improvement method determination of the height/altitude of "mirror" point.

l) In connection with the diversity of the functions, fulfilled by the contemporary radio installations, utilized for observations, is in prospect to carry out a selection of the optimum parameters of meteor radars of different designation/purpose.

To a considerable extent these problems are characteristic not only for a normal-recurrent, but also for oblique radio transmission.

3) Meteor radio communication.

a) First of all, is expedient to conduct further investigation of the parameters of radio signals during "forward scattering" as function of the parameters of the ionized meteor trails (and of their generating meteoric bodies), medium, equipment and geometry of routes (for monolithic and that crushing meteoric bodies).

b) This will make it possible to carry out refinement of statistical characteristics "scattered forward" radio signals and their communication/connections with the statistical characteristics of meteoric bodies, the parameters of medium, equipment and so forth (without account and taking into account fragmentation).

c) Great theoretical interest and applied value have studies of transmission ability, freedom from interference and specific special feature/peculiarities of the meteor communication lines.

d) Special importance has a selection of the optimum parameters of the system of meteor radio communication.

e) The meteor radio communication includes also the standardization of the standards of time (instituted on the use of meteor radiowave propagation).

f) This section of meteor radio electronics adjoins the study of the possibilities of the transmission of picture signals because of scattering of radio waves in meteor trails, i.e., the study of hyperdistant television because of meteor propagation (meteor television).

4) Meteor radio engineering.

Meteor radiophysics, radar and radio communication present the row/series of specific requirements for radio equipment. Let us recall that the discussion deals with radio engineering in the narrow sense of the word, i.e., there is in form a complex of equipment questions, connected with meteor radio electronics. Basic ones of them they are:

a) the creation of meteor radar station with high power and sensitivity (for observing the very weak meteors).

b) the creation of radar complex for the simultaneous sounding of the ionized meteor trails on several (the 3rd and more) frequencies.

Page 456.

c) the creation of the highly efficient meteor radar, which radiates coherent oscillations on the 2nd (and more) frequencies (for the experimental study of initial radii, etc.).

d) the creation of highly efficient altimeter (goniometer).

e) An increase in the freedom from interference of meteor radars, connected and other systems.

f) An increase in the effectiveness of installations.

g) The automation of perfecting result observations.

h) An increase in the accuracy of processing the results of observations.

i) Mastery/adoption, together with the range of VHF, "left boundary" of skip band, and also optical range of radio waves.

j) The creation of the amplitude-phase analyzer of the pulse of a meteor radio echo.

Besides the noted questions, connected with the development of the main divisions of meteor radio electronics, there are other problems, the solution of which will raise the effectiveness both of the "old" methods of the study of meteors and composite study of meteor substance and meteor phenomena.

5) The application/use of methods of radio electronics for an increase in the effectiveness of the optical methods of observing the meteors.

Discussion deals with an essential increase in the sensitivity of the telescopic method of observing the meteors. This, as is known, it can be reached because of obtaining of the television image of very weak meteor with the use, for example, of a superorthicon, arrange/located in the focus of optical telescope.

6) The application/use of meteor radio electronics during the composite study of meteors.

Most likely by most promising and fruitful/successful is the composite study of meteor substance and meteor phenomena radar method, method of "inclined sounding", by photoelectric, and also photographic, visual and telescopic methods in combination with direct methods.

In other words, the combination of direct/straight and indirect methods (radio-electronic, optical, etc.) with the methods of simulation (including the simulation of the ionized meteor trails) will make it possible to most completely get to know both meteor substance and generated it meteor phenomena.

In connection with this appears the problem of the development of theoretical base and procedure of this type of the comprehensive investigations (including observations) of meteors and meteoric bodies.

It is quite obvious tnat the development of meteor radio electronics, and first of all, radiophysics, imposes serious requirement on meteor physics.

Page 457.

7) Some questions of meteor physics and problem of applied character.

1. Meteor physics.

The progress of meteor physics is connected, first of all, with the development of the physical theory of meteors. As showed some investigations [85], development classical of the physical theory of meteors, studying the meteor phenomena, caused by monolithic meteoric body, can give the new data, which to a considerable extent explain the disagreement between theory and experiment. Therefore development the classical physical of the theory of meteors is extremely necessary and in any way hopeless.

However the account of the process of the fragmentation of meteoric bodies must be thoroughly studied and taken into account during development physical of the theory of meteors. Last/latter works [86-89] make it possible to rely on the possibility of the fundamental solution of this problem. But this, in turn, it will make it possible to introduce clarity into number of the problems of meteor radiophysics, radar and radio communication.

2. On the contribution of meteor radio electronics to astronomy. geophysics and physics of meteors.

The fundamental problems of applied character, placed before meteor radio electronics, are reduced to following:

a) The refinement of the "visible" and "true" distributions of radiants.

b) The supplement of the obtained previously distributions of the orbits of the meteor showers and associations [70].

c) Study of the properties of the "meteoric dust".

d) The estimate/evaluation of "meteorite problem".

e) The construction of the picture of global atmosphere circulation in meteor zone.

f) The refinement of the meteor contribution to the ionosphere.

g) The refinement of structure, form, size/dimensions of the ionized meteor trail.

Conclusion.

Thus, in last/latter two decades was formed the new branch of radio electronics - meteor radio electronics, object/subject of which is the investigation of meteor phenomena by radio aids and the use of meteor ionization for the transmission of information by the means of radio waves. Meteor radio electronics continues to be developed in the row/series of the countries, and first of all, in the USSR, USA, England, Canada, Czechoslovakia. In the USSR it was formed and conducts investigation a whole series of the collectives. The equipment, created by these collectives (and also by foreign centers), is utilized for observations according to international programs. Investigations in the region of meteor radio electronics are conducted on high scientific level, to which, in particular, testifies considerably a quantity of doctoral and candidate dissertations, made based on materials of these experiments. At the present time in world literature, in spite of the youth of meteor radio electronics, are counted tens of monographs and collections and many hundreds of periodical articles.

The row/series of problems and problems, which wait their solution, emphasizes the prospect of meteor radio electronics.

Pages 459-460.

REFERENCES

1. Иванов Н. А., Астрономич. ж-л, 1931, 8, № 3—4, 240.
2. Skellett, Phys. Rev., 1931, 37, 1668.
3. Nagaoka H., Proc. Imr. Acad., Tokyo, 1929, 5, 223.
4. Гневышев М. А., «Климат и погода», 1934, 10, № 2, 17.
5. Астапович И. С., Изв. Туркм. филиала АН СССР, 1946, № 3—4, 163.
6. Хлюстов Ю. Н., Бюллетень Всесоюзного астрономо-геодезического общества (ВАГО), 1951, № 10 (17), 37.
7. Астапович И. С., Изв. Туркм. филиала АН СССР, 1946, № 1, 100.
8. Левин Б. Ю., Астрономич. циркуляр, Астросовет АН СССР, 1946, № 57, 2.
9. Hey J. S., Parsons S. J., Stewart G. S., Mon. Not. Roy., Astron. Soc., 1947, 107, 176.
10. Lovell A. C., Banwell C. J., Clegg J. A., Mon. Not. Roy. Astron. Soc., 1947, 107, 176.
11. Фиалко Е. И., Некоторые проблемы радиолокации метеоров, Изд. Томского унив-та, 1961.
12. Костылев К. В., Астрономич. циркуляр, Астросовет АН СССР, 1955, № 163, 17.
13. Костылев К. В., Астрономич. ж-л, 1958, 35, № 4, 643.
14. Eshleman V. R., Manning L. A., PIRE, 1954, 42, № 3, 530.
15. Сб. «Результаты исследований по программе МГГ», Ионосферные исследования (метеоры), АН СССР, 1962, № 8.
16. Кащеев Б. Л., Лебединец В. Н., Радиолокационные исследования метеорных явлений, Изд-во АН СССР, 1961.
17. Фиалко Е. И., Радиолокационные наблюдения метеоров на волне λ = 10 м, Изд-во «Наука», 1967.
18. Сб. «Метеорное распространение радиоволн», Изд-во Казанского унив-та, 1963.
19. Сб. «Метеоры», V раздел программы МГГ, Изд-во Харьковского унив-та, 1960, № 1.
20. Сб. «Метеоры», V раздел программы МГГ, Изд-во Харьковского унив-та, 1963, № 2—3.
21. Фиалко Е. И., Радиолокационные методы наблюдения метеоров, Изд-во «Советское радио», 1961.
22. Фиалко Е. И., Изв. Томского политехнич. ин-та, 1962, 100, 4.
23. Саенко А. В., Фиалко Е. И., Тр. Томского ин-та Радиоэлектроники и электронной техники, 1964, 3, 36.
24. Кащеев Б. Л., Лебединец В. Н., Астрономич. ж-л, 1956, 36, №, 629.
25. Кручиненко В. Г., Мойся Р. И., Байраченко И. В., Сб. работ по МГГ, Изд-во Киевского унив-та, 1961, № 1, 26.
26. Байраченко І. В., Мiсернюк А. Г., Мойся Р. І., Вiсник Київського унiв-ту, 1960, № 3, 47.
27. Байраченко И. В., Мойся Р. И., Кручиненко В. Г., Информац. бюлл. «Геофизика и астрономия», АН УССР, 1963, № 5, 298.
28. Бибарсов Р. Ш., Брудный Л. Г., Колмаков В. М., Бюлл. ин-та Астрофизики АН Тадж. ССР, 1962, № 32, 32.
29. Лощилов Ю. А., Изв. АО Одесского унив-та, 1959, 5, №1, 39.
30. Лощилов Ю. А., Изд-во АО Одесского унив-та, 1959, 5, № 1, 35.

31. Фиалко Е. И., Тр. Сибирского физико-техннч. ин-та, 1959, № 37, 229.

32. Перегудов Ф. И., Характеристика метеора как радиолокационной цели, Изд-во Томского унив-та, 1960.

33. Лебединец В. Н., Лагутин М. Ф., Лысенко И. А., Сб. статей, Изд-во Харьковского унив-та, 1960, № 1, 21.

34. Дудник Б. С., Кащеев Б. Л., Лебединец В. М., Доповіді АН УРСР, 1961, № 3, 299.

35. Кручиненко В. Г., Мойся Р. И., Байраченко И. В., Информац. бюлл. «Геофизика и астрономия», АН СССР, 1963, № 5, 293.

36. Дерюгин И. А., Мойся Р. И., Сб. работ по МГГ, Изд-во Киевского унив-та, 1961, № 1, 37.

37. Перегудов Ф. И., Некоторые вопросы радиолокации метеорных следов, Канд. диссертация, Томский политехнич. ин-т, 1959.

38. Mitra S. K., The upper atmospher, Galcutta, 1951.

39. Lovell A. C. B., Clegg J. A., Radio astronomy, London, 1952.

40. Mckinley D. W. R., Can. J. Phys., 1951, 29, № 5, 403.

41. Lovell A. C. B., Meteor astronomy, Oxford, 1954.

42. Kaiser T. R., Radio—echo studies of meteor ionization, Phyl. Mag., Suppl, 1955, 2, № 8, 495.

43. Kaiser T. R., Closs R. L., Phil. Mag., 1952, 43, № 336, 1.

44. Herlofson N., Arkiv för Fysik, 1951, 3, 247.

45. McKinley D. W. R., Meteor sci. end Eng., 1961.

46. Левин Б. Ю., Физическая теория метеоров и метеорное вещество в солнечной системе, Изд-во АН СССР, 1956.

47. Астапович И. С., *Метеорные явления в атмосфере Земли*, Физматгиз, 1958.

48. Федынский В. В., Метеоры, Гостехиздат СССР, 1956.

49. Forsyth P. A., Vogan E. L., Hanser D. R., Hines, PIRE, 1957, 45, № 12, 1642.

50. Davis G. W. L., Glodys S. J., Lang G. R., Luke L. M., Taylor M. K., PIRE, 1957, 45, № 12, 1666.

51. Creenhou J. S., Phil. Mag., 1954, 364, 471.

52. Байраченко И. В., «Геомагнетизм и аэрономия», 1965, 5, № 3, 460.

53. Мойся Р. І., Байраченко І. В., Вісник Київського унів-ту, 1967, № 9, 111.

54. Белькович О. И., Бескин Л. Н., «Геомагнетизм и аэрономия», 1964, 4, 706.

55. Белькович О. И., Статистическое решение некоторых задач радиолокации метеоров, Канд. диссертация, Казанский унив-т, 1964.

56. Глазов Г. Н., Тр. Томского ин-та Радиоэлектроники и электронной техники, 1964, 3, 18.

57. Байраченко И. В., «Геофизика и астрономия», Информац. бюлл. Изд-во «Наукова думка», 1966, № 9, 153.

58. Немирова Э. К., Изв. Томского политехнич. ин-та, 1962, 100, 75.

59. Немирова Э. К., О роли резонансного рассеяния при радиолокационных наблюдениях метеоров. Канд. диссертация, Томский политехнич. ин-т, 1962.

60. Рубцов Л. Н., Некоторые вопросы метеорной ионизации атмосферы, Канд. диссертация, Астрофизич. ин-т АН Тадж. ССР, 1966.

61. Фиалко Е. И., Изв. вузов СССР — Физика, 1962, 5, № 2, 51.

62. Бибарсов Р. Ш., Бюллетень ин-та Астрофизики АН Тадж. СССР, 1964, № 37, 34.

63. Кащеев Б. Л., Лысенко И. А., Ионосферные исследования, Изд-во АН СССР, 1961, № 9, 7.

64. Сидоров В. В., Радиометеорные методы и аппаратура для наблюдения движения верхней атмосферы, Канд. диссертация, Каз. ун-т, 1963.

65. Делов И. А., Сб. *«Проблемы космической физики»*, Изд-во Киевского унив-та, 1966, № 1, 126.

66. Бабаджанов П. Б., Кащеев Б. Л., Крамер Е. Н., Цесевич В. П., Геофизич. бюлл. АН СССР, 1964, № 14, 83.

67. Фіалко Є. И., Байраченко І. В., Чумак Ю. В., Вісник Київського унів-ту, Астрономія, 1965, № 7, 64.

68. Сб. «Метеорное распространение радиоволн», Изд-во Казанского унив-та, 1964, № 2.

69. Чепура В. Ф., Кащеев Б. Л., Бондарь Б. Г., «Электросвязь», 1962, № 11, 3.

70. Кащеев Б. Л., Лебединец В. Н., Лагутин М. Ф., Метеорные явления в атмосфере Земли, Изд-во «Наука», 1967.

71. Фиалко Е. И., Физика комет и метеоров, Изд-во «Наукова думка», 1966, 100.

72. Фиалко Е. И., Мойся Р. И. и др., «Геофизика и астрономия», Информац. бюлл., Изд-во «Наукова думка», 1966, № 9, 157.

73. Фиалко Е. И., Радиолокация метеоров, Изд-во «Советское радио», 1967.

74. Лебединец В. Н., Астрономич. ж-л, 1963, 40, № 4, 719.

75. Фиалко Е. И., Астрономич. ж-л, 1965, 42, № 2, 409.

76. Фиалко Е. И., Романюк В. Ф., Астрономич. циркуляр, АН СССР, 1966, № 301, 1.

77. «Метеорное распространение радиоволн», сб., Изд-во Казанского унив-та, 1966, 3—4.

78. Clegg J. A., Davidson J. A., Phil. Mag., 1950, 41, № 312, 77.

79. Дудник Б. С., Сб. ст. «Метеоры», V разд. программы МГГ, Изд-во Харьковского унив-та, 1963, № 2—3, 22.

80. Золотарев И. Д., Изв. Томского политехнич. ин-та, 1960, 105, 72.

81. Фиалко Е. И., Перегудов Ф. И., Немирова Э. К. и др., Изв. Томского политехнич. ин-та, 1962, 100, 16.

82. Дудник Б. С., Метод измерения угловых координат метеорного радиоэхо, Геофизич. бюллетень, 1966, № 17, 62.

83. Сидоров В. В., Угломерное устройство метеорной станции КГУ-М2, «Метеорное распространение радиоволн», Изд-во Казанского унив-та, 1964, № 2.

84. Колмаков В. М., Измерение угловых координат метеорных следов фазовым методом, Бюлл. Астрофизич. ин-та АН Тадж. ССР, 1968, № 49.

85. Коломиец А. Р., Некоторые вопросы физики метеорных явлений и метеорный вклад в ионизацию атмосферы, Канд. диссертация, Киевский унив-т, 1967.

86. Бабаджанов П. Б., Крамер Е. Н., Предварительные результаты фотографирования метеоров по методу мгновенной экспозиции, Астрономич. ж-л, 1965, 42, № 3.

87. Лебединец В. Н., Физическая теория метеоров и метеорное вещество в окрестностях орбиты Земли по результатам радионаблюдений, Докторская диссертация, ИПГ АН СССР, 1967.

88. Кручиненко В. Г., О дроблении метеорных тел, Канд. диссертация, Киевский унив-т, 1967.

89. Симоненко А. Н., Дробление метеорных тел в атмосфере Земли, Канд. диссертация, Институт физики Земли, АН СССР, 1968.

90. Бондарь Б. Г., Кащеев Б. Л., Метеорная связь, Изд-во «Техніка», 1968.

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