28. COMMISSION DES GALAXIES

Reports of Meetings

PRESIDENT: R. Minkowski.
SECRETARY: E. Holmberg.

The Commission met on 23, 24, and twice on 29 August. The successive sessions dealt with (1) business matters, (2) stellar composition of galaxies, (3) presentation and discussion of a series of papers on extragalactic research, and (4) reports of Working Groups and presentation of a second series of papers. The second session was a joint meeting with Commission 45.

A Joint Discussion on X-Ray Astronomy was held under the sponsorship of Commissions 28, 33, 34 and 44, a Joint Discussion on Extragalactic Radio Sources under the sponsorship of Commissions 28, 40 and 45.

Business Meeting, 23 August 1967

The Draft Report was adopted by the Commission subject to minor editorial corrections.

On page 571, *line* 6,

for $Q \propto M^{5/3}$ read $Q \propto M^{7/4}$

for $Q \propto M^{5/3}$ read $Q \propto M^{3/2}$.

The President proposed, and the Commission approved, that the following list of names should be sent to the Executive Committee of the Union as those of persons who should form the Organizing Committee of the Commission: D.S. Evans, D.S. Heeschen, E. Holmberg, B.E. Markarjan, M. Schmidt. At the final General Assembly on 31 August, this list was approved, with the addition of R. Minkowski as past President, and the following appointments were made: President: G.C. McVittie. Vice-President: E.M. Burbidge. The new President appointed E. Holmberg to continue as Secretary of the Commission.

The Commission discussed and rejected by vote the proposal submitted to the Executive Committee by the National Committee of the DDR to form a new IAU Commission for Relativistic Astrophysics and Cosmology and a proposal, submitted by the President following a suggestion by the Secretary General, to create a Working Group on Cosmology. A proposal by the President to change the name of the Commission to 'Commission for Galaxies and Cosmology' was rejected by a vote.

A recommendation, adopted at the IAU Symposium no. 29 at Burakan and approved by the Executive Committee (see IAU Information Bulletin, no. 17), was discussed and rejected by the Commission. Instead, the following resolution was submitted by the President and approved by a vote of the Commission: 'Commission 28 recommends that the services of the Central Bureau of Astronomical Telegrams be used to announce without delay significant events and changes in quasistellar sources and objects in order to achieve effective coordination of observations in all frequency ranges'.

A resolution concerning the definition of radio magnitudes at different frequencies had been submitted by J. Heidmann to Commissions 28 and 40. It was decided that Commission 28 should refrain from discussing this matter, and that the Commission would concur with the resolution adopted by Commission 40. The resolution subsequently was withdrawn.

Following the wishes of a number of members of the Commission, a proposal had been sent by the President to the Assistant Secretary General to hold a Symposium on Extragalactic Research in 1970 immediately before or after the XIVth General Assembly. The Commission endorsed this proposal by vote, and authorized and requested the new President to take all necessary steps for the arrangement of the Symposium.

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1st Scientific Meeting on the Stellar Composition of Galaxies, 24 August 1967

In this joint meeting with Commission 45, R. Minkowski acted as chairman, and V. Reddish as secretary. Two invited papers with the common title 'On the Stellar Composition of Galaxies' were given by *W. W. Morgan* and by *H. Spinrad.* A number of commission members, among them W. Baum, G. de Vaucouleurs, R. Minkowski, and T. Page, participated in the following discussion.

2nd Scientific Meeting: Presentation of Papers, 29 August 1967

The following 24 papers had been submitted by members of the Commission for presentation and discussion at the Commission meetings:

1. *Abell, G.O.*, Luminosity Functions and Structures of Several Clusters of Galaxies.
2. *Bertola, F.*, Variations of the Mass to Light Ratio within the Galaxies.
3. *Bottinelli, L., Gouguenheim, L., Heidmann, J., and Heidmann, N.*, 21 cm Observations of Small Galaxies.
4. *Burbidge, E.M., and Burbidge, G.R.*, Velocity Fields in NGC 1808 and an Anonymous 'Integral Sign' Galaxy.
5. *Carranza, G., Courtès, G., Georgelin, Y., and Monnet, G.*, Interferometric Studies of Ionized Hydrogen in M33.
6. *Demoulin, M.H.*, NGC2685.
7. *Gallouët, L., and Heidmann, N.*, Optical Positions of Brightest Galaxies.
8. *Heidmann, J., and Heidmann, N.*, The Mean Optical Emissivity of Galaxies.
9. *Hodge, P.W.*, The Distribution of H II Regions in Galaxies.
10. *Iskudarjian, S.G., Kalloghljan, A.T., Sahakjan, C.A., and Tovmassjan, H.M.*, The Burakan Classification of the Central Parts of Galaxies.
11. *Kalinkov, M.*, Autocorrelation Functions in the Surface Distribution of Galaxies (by the Palomar Atlas).
12. *Kwast, A., Zonn, W., Neyman, J., and Scott, E.L.*, Characteristics of Galaxies Forming a Pair.
13. *Markarjan, B.E.*, A Survey of the Spectra of Faint Galaxies.
14. *Page, T.*, Line Intensities in Galaxy Spectra with an Image Tube.
15. *Polikarov, A., and Kalinkov, M.*, A Possible Classification of Quasi Hypotheses.
16. *Richter, N.*, The Variability of Blue Objects as a Test of Their Galactic or Extragalactic Nature.
17. *Rubin, V.C., and Ford, W.K. Jr.*, Image Tube Spectra of Extragalactic Objects.
18. *Sěrsic, J.L.*, The Formation of Galaxies by Fragmentation.
19. *Souffrin, S.*, Remark about a Possible Variation in the Spectrum of the Nucleus of the Seyfert Galaxy NGC3516.
20. *Veleva, B., and Kalinkov, M.*, Results of Counting of Galaxies on the Palomar Atlas.
21. *Whitrow, G.J., and Thompson, I.H.*, On Radial Gravitational Motions, Including Collapse, of Spherically Symmetrical Bodies of Perfect Fluid.
22. *Wild, P.*, 'Superexplosions' and Supernovae.
23. *Zelmanov, A.*, On the Differential Criterion of Homogeneity in Cosmology.
24. *Zwicky, F.*, Classification of Clusters of Galaxies.

Since the limited time available did not permit the presentation of all papers at the sessions of the Commission, the papers to be presented were selected by the Organizing Committee. The papers no. 1; 3; 5; 9; 14; 17; and 20 were read at the 2nd Scientific Meeting. In the short discussion periods following each paper remarks and comments were made by G.O. Abell, V.A. Ambarcumjan, E.M. Burbidge, T. Kiang, W.W. Morgan, T. Page, M.S. Roberts, E.L. Scott, P. Wild, F. Zwicky.

3rd Scientific Meeting: Reports of Working Groups and Presentation of Papers, 29 August 1967

A report on the activities of the Working Group for Research on Supernovae was read by F. Zwicky. The membership of the Group has been reconstituted and now consists of the following:

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V.A. Ambarcumjan, Ch. Bertaud, A.A. Bojarčuk, L. Detre, E.A. Dibaj, G. Haro, B.V. Kukarkin, H. Lambrecht, L. Rosino, K. Rudnicki, J.L. Sěrsic, A.D. Thackeray, B.E. Westerlund, P. Wild, F. Zwicky (chairman).

The Working Group on Supernovae expressed its support to a request by K. Rudnicki for endorsement of his project to assemble a catalog of essential characteristics of supernovae. The Commission gave its approval to this project.

B.E. Westerlund summarized the report of the Working Group on the Magellanic Clouds. The reconstituted list of membership includes the following: J. Landi Dessy, Ch. Fehrenbach, S.C.B. Gascoigne, E.M. Lindsay, B.Y. Mills, C.H. Payne-Gaposchkin, A.D. Thackeray (chairman), P.A. Wayman, B.E. Westerlund.

The Working Group on Galaxy Photometry submitted a brief report. The reconstituted list of membership includes the following: H.D. Ables, F. Bertola, J. Bigay, W. Bronkalla, G. de Vaucouleurs (chairman), S. D'Odorico, C. Fraser, N. Heidmann, I.R. King, D. Koelbloed, G.E. Kron, B.E. Markarjan, P. Pishmish de Recillas, N. Richter, H. Rood, C.D. Shane, R.R. Shobbrook, S. Simkin, D.W.N. Stibbs, E.Vandekerkhove, S. van den Bergh, B.A. Voroncov-Vel'jaminov, F. Zwicky.

V.A. Ambarcumjan reported on work at the Burakan Observatory, including the papers no. 10 and 13. The papers no. 2; 16; 19; 22 and 23 also were presented in this session. In the discussion periods remarks and comments were made by V.A. Ambarcumjan, A. Elvius, E. Holmberg, I.R. King, T. Page, and V.C. Rubin.

APPENDIX. SUMMARY OF WORK DONE IN USSR ON COSMOLOGY AND RELATED TOPICS OF GENERAL RELATIVITY

(Prepared by A.L. Zelmanov)

I. GENERAL PROBLEMS

I.M. Halatnikov (**1**) found a class of solutions of gravitation equations with a time singularity in energy density; the singularity is due to scale contraction for one of the space coordinates. These solutions are not contained in that, found earlier by E.M. Lifšic and I.M. Halatnikov, which describes an anisotropic collapse and contains a physical singularity both in presence and in absence of matter. The behaviour of electromagnetic fields under anisotropic collapse is also discussed.

V.A. Belinskij and I.M. Halatnikov (**2**) proposed a solution for empty world with a fictitious singularity in a synchronous (semi-geodetic) coordinate system, attained in all points of the space simultaneously, the solution depending on the largest number (four) of physically arbitrary functions of three variables. L.P. Griščuk (**3**) showed, that for the space, filled with dust-like matter, the solution of gravitation equations depending on the largest number (eight) of physically arbitrary functions of three variables had a true (physical) time singularity.

According to H. Keres (**4**) there exist two kinds of solutions of Einstein equations, Newtonian and non-Newtonian. Solutions of the first kind in non-relativistic approximation do satisfy the Newtonian gravitational theory (invortical fields), while those of the second kind do not satisfy it (vortical fields). The last ones are characterized not only by the Newtonian scalar potential, satisfying the Poisson equation, but also by a vector potential, satisfying Laplace equation. All solutions of Einstein equations for empty space were found which satisfy in a suitable chosen coordinate system also the equations of the Newtonian theory (**5**). A conclusion is also made according to which Petrov's classification of gravitational fields has no analogue in the Newtonian theory.

Proceeding from the fundamental character of the symmetry properties, G.I. Naan (**6**) assumed that the Universe was completely symmetrical and consisted of the world and anti-world. The Naan anti-world differs from the world not only by replacing the particles by anti-particles, but also by the space reflection and by the time inversion. Mass, energy and other integral quantities in the world and respectively in the anti-world can vary, but each of these quantities remain equal to zero

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in summary, i.e. in the whole Universe composed of the world and anti-world. The interaction (in its usual sense) between the world and anti-world is absent. G. I. Naan suggested that in connection with the possibility of the appearance of the mass and energy in each of the two parts of the Universe, all phenomena which are characterized by an enormous energy-output (cosmic rays, supernovae, quasars, nuclei of some galaxies, radio-galaxies), as well as the beginning of the expanding of Metagalaxy were of interest from the point of view of the proposed hypothesis.

According to Y. P. Terleckij (**7**) macroscopic violations of thermodynamics do not contradict Gibbs statistics. In particular, the existence of a thermodynamic machine of the second kind is possible with heat sources possessing negative energy and negative temperature. The causality principle can become invalid, and the existence of macroscopic systems with negative time direction can be possible. Particles can exist not only with positive, but also with negative and even imaginary masses. These general ideas were applied by Y. P. Terleckij also to the problem of quasars, radiogalaxies and other phenomena. The essence of these applications is an appeal to such processes, the possibility of which follows from these ideas. In particular, it was indicated that the idea of the existence of a new type of energy sources (such as the thermodynamic machine of the second kind) can be used for explaining the energy emission by radiogalaxies and quasars.

E. B. Gliner (**8**) suggesting a physical interpretation of some algebraic structures of the energy-momentum tensor, assumed that a kind of matter is possible, for which this tensor is equal to the metrical one, multiplied by a constant (μ). This matter called 'μ-vacuum', macroscopically possesses the properties of vacuum. The supposition was considered according to which the real vacuum was a μ-vacuum. The homogeneous μ-vacuum world possesses the de Sitter metrics. Further (**9**) E.G. Gliner proposed a generalized gravitation law, expressed by a system of 20 equations (in partial derivatives of the second order) in accordance with the fact that the space-time curvature is described by 20 quantities. Einstein gravitation law, expressed by a system of 10 equations, is a consequence of the generalized law.

B. L. Altšuler (**10**) suggested a method for presenting the Einstein equations in an integral form with the aid of a covariant Green function. Under a definite choice of the equation for these function the integral form appears to be a covariant expression of the Mach principle. This principle becomes equivalent to the requirement that the Einstein equations should be valid in the integral rather than in the differential form. It is shown in particular that the homogeneous isotropic cosmological models are incompatible with the proposed form of the Mach principle.

K.P. Stanjukovič (**11**) assumed the existence of stable particles—planckeons—with modern values of mass, radius and density ($1{\cdot}1 \times 10^{-5}$ g, $1{\cdot}3 \times 10^{-33}$ cm, 10^{95} g cm^{-3} respectively). Connecting this hypothesis with his version of the theory of the universal constants variability, K. P. Stanjukovič supposed the existence of closed particles also with other definite values of mass, radius and density. K. P. Stanjukovič's ideas (on the radiation by elementary particles and others) caused the polemics between him on the one hand and Y. B. Zeldovič and Y. A. Smorodinskij on the other (**12**), (**13**).

M. A. Markov (**14**) considered characteristic masses $m_0 = (\hbar c/\gamma)^{1/2}$ and $m_1 = e/\gamma^{1/2}$ as possible largest values of elementary particles masses (maximons). These masses are of the order of 10^{-5} g and 10^{-6} g respectively.

The ratio of masses of electron and neutron is approximately equal to that of electromagnetic and strong interactions constants. Proceeding from this empiric correlation, D. F. Kurdgelaidze (**15**) introduced the universal mass (equal to $1{\cdot}25 \times 10^{-25}$ g) and the mass, connected with the gravitational interaction (equal to 4×10^{-66} g). Using them, he considered the known empiric correlations between microphysical constants and metagalactic parameters. The connection between symmetry properties of elementary particles and cosmology was considered by D. Ivanenko and D. Kurdgelaidze (**16**).

G. M. Idlis (**17**) developed the idea of analogy between the Metagalaxy and a certain particle, which is elementary from the outer side. He considered also the problem of the causal determinacy of the three-dimensional character of space and of the universal nature of the gravitation law.

II. HOMOGENEOUS ISOTROPIC UNIVERSE AND ITS PHYSICAL EVOLUTION. ORIGIN OF GALAXIES

A. D. Černin (**18**) obtained exact solutions of the gravitational equations (without the cosmological constant) for homogeneous isotropic cosmological models, filled with a non-interacting mixture of dust-like matter and radiation, and found for these models expressions for the red shift, for amount of matter till the given red shift, for apparent brightness and for apparent angular dimension.

K. P. Stanjukovič (**19**) considered geodetics in homogeneous isotropic models. (See also (**69**)).

The investigation of the problem on angular dimensions of distant objects in the Universe with discrete distribution of the mass (i.e. with mass, concentrated in the galaxies), executed earlier by Y. B. Zeldovič and by V. M. Dashevsky and Y. B. Zeldovič was generalized by V. M. Daševskij and V. I. Sliš (**20**) for the case, in which, besides the matter concentrated in galaxies, the matter distributed continuously (radiation, intergalactic gas) does exist also. The authors came to the conclusion according to which in this case the curve of the dependence of angular diameter on distance must always have a minimum.

A. D. Černin (**21**) considered homogeneous isotropic cosmological models with a chaotic magnetic field. He derived exact solutions of the gravitation equations for such models and investigated the gravitational stability of these models.

Considering the possibility for determination of the metagalactic mean matter density from quasars observations V. M. Daševskij and Y. B. Zeldovič (**22**) analyzed the shortcomings of usual methods, based on observations of distributions by the apparent magnitude or by the red shift, and proposed a new method. It consists of the calculation of the number of objects with a given red shift and with apparent magnitude, brighter (not greater) than some given one. It was pointed out that the conclusions depend so much on the proposed evolution law of the observed objects, that the observational data can be conformed with any cosmological model by accepting a suitable supposition.

A. V. Zasov (**23**) examined for homogeneous isotropic models general correlations, connecting the metrical and luminosity distances, red shifts and aberrational time.

Y. B. Zeldovič, L. B. Okun' and S. B. Pikelner (**24**) examined the fate of quarks in the hot and the cold models of the Universe and in stars. They suggested, that at present the concentration of quarks in relation to nucleons in the hot and the cold models must be of the order of respectively 10^{-10}–10^{-13} and 10^{-18}.

E. M. Lifšic's relativistic theory of gravitational instability was completed in the work by E. M. Lifšic and I. M. Halatnikov (**25**). Examining the possibility of the formation of stars and galaxies as a result of the gravitational instability of the homogeneous Universe I. D. Novikov (**26**) obtained a positive answer by the supposition, that small density fluctuations, accompanied by small metrics fluctuations, arose at a sufficiently early stage of the expansion of the homogeneous Universe, i.e. under densities much greater that the nuclear one. According to this author, it is possible in this way to explain the formation of cosmical objects of various sizes including galaxy clusters with dimensions of the order of hundreds of megaparsecs. A. D. Saharov (**27**) assumed (in the limits of the cold model), that the initial inhomogeneities arose as a result of the quantum fluctuations of cold baryon-lepton matter at densities of the order of 10^{98} baryons (i.e. 10^{74} g) per 1 cm^3. It is supposed also that at such densities gravitational effects are of decisive importance in the equation of state and as a result of this fact at a certain baryon density the energy density vanishes. A theoretical estimation results in such initial non-homogeneities, which can explain the origin of clusters with masses of the order of 10^5—10^6 solar masses, that is close to the masses of globular clusters. (Hence the dimensions of initial non-homogeneities are deduced from some initial positions, and are not selected as usually in order to bring the results in accordance with the empirical data). According to A. D. Saharov's hypothesis the gravitational collapse of these primary stellar clusters led to the appearance of gas, possessing non-homogeneities in the motion and distribution. An increase of these non-homogeneities led to the formation of galaxies. According to the proposed hypothesis the spherical component of galaxies consists mainly of clusters of primary stars, captured

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by the gravitational field of the rotating gas cloud, while the stars of the flat component are formed from the gas.

V. A. Ambarcumjan (**28**) continued to develop his cosmogonic ideas, based on the analysis of the observational data, concerning processes occurring in galaxies and systems of galaxies and on the interpretation of these data as an evidence of non-stationarity of the systems of galaxies. According to these ideas the cosmical objects arise directly from the superdense matter, the processes of their formations (including the formation of galaxies and their systems) continuing at present. The community between the non-stationarity of the system of galaxies on one hand and the expansion of Metagalaxy on the other is supposed.

I. D. Karačencev (**29**), counting the galaxies up to different angular diameters, came to the conclusion, that the result of this counting gives an independent confirmation to the idea of the continuous formation of new galaxies. I. D. Karačencev (**30**) found also, that the degree of non-stationarity (i.e. the virial mass-luminosity ratio) of different systems of galaxies (pairs, triple systems, groups and clusters of galaxies) is the higher, the greater is the luminosity of the system, and that this correlation includes the Metagalaxy also. The last result was interpreted as a confirmation of V. A. Ambarcumjan's idea on the connection between the non-stationarity of systems of galaxies and the expansion of the Metagalaxy. A hypothesis conforming to V. A. Ambarcumjan's idea on the formation of cosmical objects immediately from superdense matter with the relativistic cosmological theory, was proposed by I. D. Novikov (**31**). According to this hypothesis, quasars are core-parts of the expanding homogeneous isotropic Universe, delayed in their expansion. The primary linear dimensions of such cores were smaller than their gravitational radius. In the proper time of the cores the delay in the expansion is absent. For an external observer the appearance of the cores can occur at different times. The author of the hypothesis derived an exact solution of the gravitational equations, describing a cosmological model with delayed cores. The possibility of formation of such cores on the contraction stage which could precede the expansion stage was considered. See also (**35**).

In the work devoted to computation of the spectrum and of the intensity of metagalactic radiation produced by stars and by radio-sources in a homogeneous isotropic universe (**32**) A. G. Doroškevič and I. D. Novikov suggested, that observations in the region 0·06–30 cm could give a possibility to check the hypothesis of the 'hot' Universe.

Accepting the interpretation of the black-body radiation with $T=3\,°K$ (background) as a confirmation of the hot Universe hypothesis, Y. B. Zeldovič and I. D. Novikov (**33**) showed that another explanation of the origin of the detected black-body cosmic radiation, according to which this radiation resulted finally from the energy release in cosmic bodies in a late stage of the cosmological expansion, is very incredible because it requires a rapid release of a considerable part of the nuclear energy—in the supposition of its further re-emission in the form of equilibrium radiation. To confirm the correctness of the interpretation of the detected radiation by means of the 'hot' universe hypothesis Y. B. Zeldovič (**34**) suggested observations of neutrino: relict neutrinos should reach us from the early expansion stage with the matter density of 35 orders higher than the modern one. But for their detection the experiment precision must be million times higher than the present one. Proceeding from the hot Universe hypothesis Y. B. Zeldovič and I. D. Novikov (**35**) presented critical comments on the hypothesis on cores delayed in the expansion (see (**31**)). According to these comments the existence of bodies with dimensions smaller than their gravitational radius at the early stages of expansion of the Universe led to a strong accretion of radiation by these bodies. If further calculations confirm that the accretion is catastrophically high, the hypothesis of cores delayed in expansion would contradict the observational data.

L. M. Ozernoj (**36**) examined the development of perturbations in the hot cosmological model. It is obvious that for explaining the formation of such condensations as galaxy clusters resulting from the gravitational instability of a gaseous medium, it is necessary to assume it to be of a very high temperature. This condition is valid for the earlier stages of expansion of the 'hot' Universe. But then the gas was almost fully ionized, its density was high, and it strongly interacted with the radiation, which was of a still higher density. Hence, adiabatic perturbations under which the matter contracted together with the radiation, did not increase because of the great elasticity of the mixture of the matter and radiation, due to the radiative pressure which was greater than that of the matter (the critical mass was too great). Even isothermic perturbations, under which only the matter contracts (the critical mass for them was much smaller) increased slowly. The interaction of the metagalactic matter with the radiation became insignificant, when the ionized gas recombined. A theory of the thermal balance of expanding metagalactic gas for different variants of heating and cooling is also given. The idea is proposed of the heating of the recombined gas due to the dissipation of turbulent motions and to explosions of rapidly evolving objects of the quasars type (see also (**41**)). The role of initial conditions in the formation of galaxies of different morphologic types is considered.

A.G. Doroškevič, Y.B. Zeldovič and I.D. Novikov (**37**) studied the formation of clusters and galaxies due to gravitational instability after the recombination of the metagalactic gas. This gas was cold and the critical mass was of the order of 10^6 solar masses. According to the authors' hypothesis, cosmic objects with such masses—'parent stars'—were formed, and they heated the gas so, that the critical mass became of the order of 10^9-10^{10} solar masses. As a result metagalactic objects of the second generation arose. These objects lead to the formation of non-uniformities of the order of $10^{13}-10^{14}$ solar masses. These non-uniformities lead to the isolation of clouds, from which galaxy clusters formed.

The problem on parent stars explosions was considered by G.S. Bisnovaty-Kogan (**38**). The necessity of the epoch of neutral hydrogen in the evolution of the Universe was studied by R.A. Syunjajev (**39**). The distribution function of the appearing cosmic objects by the moment and by the mass was examined by A.G. Doroškevič (**40**). Assuming the intergalactic matter to be composed of gas (mainly of hydrogen) V.L. Ginzburg and L.M. Ozernoj (**41**) analyzed its thermal regime. The authors took into account both cooling of the gas due to emission and cosmological expansion and heating of it due to the dissipation of energy of the plasma waves originated by cosmic rays, formed under the explosions of galaxies and radiogalaxies. At present the main mechanism of cooling is the adiabatic expansion. According to the authors conclusions the gas is almost fully ionized. This fact explains why the greatest part of the intergalactic matter yet avoids observations.

An attempt of detecting the ultraviolet radiation of the metagalactic ionized hydrogen and helium with the aid of the apparatus mounted at Soviet interplanetary automatic stations in 1964–1966, was made by V.G. Kurt (**42**). According to V.G. Kurt and R.A. Syunjajev (**43**) it can be deduced from the negative result of this attempt, that metagalactic density, in any case (if special assumptions concerning the gas temperature are not made) is less than the treble critical one.

M.S. Kardašov and G.B. Šolomickij (**44**) estimating the limiting distance and the corresponding value of the red shift (z), up to which observations of extragalactic objects are possible, came to the conclusion, that this value can be determined by Thomson dispersion of radiation in the intergalactic medium. This value, depending on the medium density and on the type of the model, lies between 3·5 and 7.

Y.B. Zeldovič, I.D. Novikov and R.A. Syunjajev (**45**) proposed methods for the investigation of the intergalactic helium and suggested the cosmological significance of the possible results, because the present helium content in the intergalactic medium, firstly, depends on the character of the expansion at its earlier stages and, secondly, influences strongly the thermal balance and the ionization state of the gas. Hence, the investigation of the intergalactic helium will allow to determine firstly, the degree of isotropy of the expansion at the earlier stages, i.e. at the mean density of the order of 1 g cm^{-3} (when the formation of hydrogen and helium occurs), and secondly, the present density and state of the intergalactic gas. R.A. Syunjajev (**46**) considered possible sources and methods of observation of helium and deuterium (its formation is an intermediate stage in the process of transforming hydrogen into helium). A.G. Doroškevič and R.A. Syunjajev (**47**) calculated the thermal balance of the intergalactic medium and pointed out the important role of helium in cooling the medium.

Assuming the existence of both matter and antimatter in the observed part of the Universe N.A. Vlasov (**48**) proposed an optical method for detecting the antimatter.

According to Y.B. Zeldovič and I.D. Novikov (**49**) the charge asymmetry of the Universe at the present epoch is due to a similar asymmetry at the contraction epoch (preceding to the present expansion) when under the density of the order of 10^{-30} g cm^{-3} and as result of common nuclear reactions (for instance, in cosmic bodies) an amount of energy of the order of 10^{16} erg g^{-1} was emitted. When approaching the singularity almost complete symmetry due to the creation of particles and anti-particles was reached. When the expansion began and hence the energy density declined the former antisymmetry of particles and anti-particles reappeared.

For explaining the observed charge asymmetry, A.D. Saharov (**50**) supposed that in the superdense state of the hot universe in particular baryon and muon conservation laws were broken (instead of them the conservation law is supposed to be valid for a combined baryon-muon charge).

III. ANISOTROPIC MODELS

The work by I.R. Pijr (**51**) is devoted to the static axial-symmetrical solution of the problem of many particles in general relativity and to clarifying the physical meaning of these solutions.

A.S. Kompaneec and A.S. Černov (**52**) derived solutions of the Einstein equations for a non-stationary homogeneous axial-symmetric model of the Universe in two limited cases: for the dust-like matter and for the ultrarelativistic gas. The solutions possess a singularity at a certain moment of time. A solution for a non-relativistic gas with a constant isentropy index is also derived.

Generalizing the ideas by S.B. Pikelner (**53**), J.H. Piddington *et al.* on existing of intergalactic magnetic fields, Y.B. Zeldovič (**54**) assumed the existence of a primary homogeneous magnetic field in the Universe. Solutions for a homogeneous, but anisotropic axially symmetrical Universe were considered, the anisotropy being due to the presence of a magnetic field. This magnetic field turns out to be frozen into the medium. Its strength at present is, suppositionally, less than 3×10^{-9} gauss. The vortical electric field, created by the variation of the magnetic field, is absent for an observer co-moving with the matter.

A.G. Doroškevič (**55**) considered a series of exact solutions of the gravitation equations for anisotropic homogeneous cosmological models with the magnetic field (to be more precise, homogeneous axial-symmetric models with magnetic field, oriented along the symmetry axis) and without it. The properties of the solutions near the singularity and in the late stages of the expansion were studied. It was found that the magnetic field can strongly influence the behaviour of the model near the singularity (i.e. in the initial stages) under any equations of state, but in the later stages of the expansion this influence becomes inappreciable. It is pointed out that the well known objection by F. Hoyle (according to which the ratio of the magnetic field energy to the full matter energy increases infinitely when approaching the singularity) against including the magnetic field in cosmological solutions is wrong.

Homogeneous axial-symmetrical models with a magnetic field, directed along the symmetry axis, were considered also by I.S. Šikin (**56**).

The gravitational instability of anisotropic homogeneous cosmological models was considered briefly by A.G. Doroškevič (**57**). It is shown that in such models the amplification factor of the initial inhomogeneities is much greater than that of the homogeneous isotropic models. The influence of the magnetic field is discussed also. It is shown, that the account for the possible anisotropy of the expansion can turn out to be important for the theory of cosmic objects formation not only in the cold universe, but in the hot one also.

A.G. Doroškevič, Y.B. Zeldovič and I.D. Novikov (**58**) showed that in an anisotropically expanding Universe the weakly interacting particles (neutrinos, gravitons) moving in different directions, change their momentum in different ways and this, in its turn, strongly influences the picture of the anisotropic expansion. In particular, a higher (than in case of isotropic Universe) neutrino density turns out to be possible.

I. M. Halatnikov (**59**) considers a stationary cylindric-symmetric model, filled with matter obeying the equation of state $p = n\rho c^2$, and with a magnetic field. In connection with this model the question was discussed concerning the possibility of considering quasars as magnetogravitational formations.

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IV. SPHERICAL SYMMETRY

R.I. Hrapko (60) considered various co-ordinate systems applicable for describing the semi-closed world, in connection with the Lichnerowich continuity conditions. He (61) also solved analytically the problem of the sight of the emitting surface of a gravitating sphere, expanding with parabolic velocity from inside of its Schwarzschild sphere. The same author (62) investigated the structure of the world of a special type with spatial spherical symmetry, including the Schwarzschild, de Sitter, Kottler and Nordström metrics, as particular cases.

V.S. Brežnev (63), V.S. Brežnev, D.D. Ivanenko and B.N. Frolov (64) considered solutions of Einstein equations, describing spherically symmetrical fields of condensations in the expanding universe and possessing Friedmanian asymptotics at infinity. Spherically symmetrical motions of the matter were considered in general relativity also by K.P. Stanjukovič and S.M. Kolesnikov (motions of the dust-like matter (65) and adiabatic motions of non-dust matter (66)), by K.P. Stanjukovič, O. Šaršekejev and V.Z. Gurovič (automodel motions of relativistic gas (67)), by K.P. Stanjukovič and V.Z. Gurovič (ultra-relativistic gas scattering (68)).

K.P. Stanjukovič and O. Šaršekejev (69) transformed Schwarzschild and Friedman line elements to a form, in which the metrics of spatial sections, non-orthogonal to the time lines, is euclidean.

V. COLLAPSE, ROTATION, QUASARS

A. G. Doroškevič, Y.B. Zeldovič and I.D. Novikov (70) considered the gravitational collapse of non-symmetric and rotating masses. It was shown that, as P.A. Bergman had supposed, the characteristic picture of gravitational selfclosing, true for the spherical case, is the same for the general case. In the case of collapse of a non-rotating body the quadrupole and higher field moments (which are due to asymmetry), decrease for an external observer inversely to the time elapsed. But in the case of collapse of a rotating body the deviations in metrics connected with the rotation when damping do not approach zero. Static non-spherical solutions of the Einstein equations were also considered, and in particular, the properties of the surface, analogous to that of Schwarzschild.

Y.B. Zeldovič and M.A. Podurec (71) considered the evolution of the system of heavy point particles. As effects, leading to the evolution, the following ones were taken into account: evaporation of particles, and gravitational radiation and capture. According to the authors' conclusion the system, evolving slowly, passes the sequence of quasi-equilibrium states, the evolution being inevitably terminated in a collapse. The applicability of the results to astronomical objects was also discussed.

Considering the behaviour of an electrically charged dust-like sphere, I.D. Novikov (72) came to the conclusion, that its contraction inside the Schwarzschild surface is followed by the expansion, both the preceding contraction stage, forecoming before the sphere is plunged inside the surface, and the following stage of expansion occuring after the sphere appears outside this surface, taking place in similar, but not coinciding space-time regions, disconnected in time, and euclidean on spatial infinity. The maximal mean density is of the order of c^6m^4/ε^6, where m is the mass, ε the charge. The infinite density is reached in the center only. It was supposed that the increase of perturbations or quantum effects must lead to a similar behaviour of a non-charged material sphere.

In contradiction to the abovementioned views, M.E. Gercenštein (73) considered the gravitational collapse as a stage in an oscillatory process with passage through the center, the maximal radius of the central body exceeding the gravitational one. Such an oscillatory process is regarded as a behaviour of a quasar. According to this author, oscillatory collapse, in principle, is visible for an outer observer and does not exclude the emission of large amounts of energy. M.E. Gercenštein and Yu.M. Ajvazjan (74) considered the picture of the oscillatory collapse from the point of view of an external observer, and came to the conclusion that in this picture the symmetry of the contraction and expansion is not disturbed.

Criticizing F. Michel's idea concerning the role of neutrino emission in the phenomenon of quasars, Y.B. Zeldovič (75) pointed out that the gravitational collapse considerably extinguished not only the energy output through electromagnetic emission, but also that through the neutrino one. So establishing the impossibility of a sufficient output of the energy under a spherically symmetric collapse, Y.B. Zeldovič simultaneously pointed out the significance of non-symmetric motions of the matter in the process of the transformation of the gravitational energy of a collapsing star into the energy of radiation and cosmic rays, and in other processes accompanying the collapse.

In connection with the collapse phenomena I. S. Šklovskij and N. S. Kardašov (**76**), Y. B. Zeldovič and I. D. Novikov (**77**) considered energy emission in the form of gravitational waves, arising as a by-product in the case of non-symmetric motions of matter. L. M. Ozernoj (**78**) considered gravitational emission due to non-symmetric motions of the matter under explosion phenomena.

Y. B. Zeldovič (**79**) pointed out the process of liberation of gravitational energy in non-symmetric accretion through the glow of gas in a shock wave, arising under its falling in the gravitation field of a collapsed star. Observations of this phenomenon should particularly be a method for detecting collapsed stars. Another method of their detection (among spectral binaries with invisible companions) was suggested by O.H. Gusejnov and Y. B. Zeldovič (**80**).

Y.B. Zeldovič and I.D. Novikov (**81**) assuming that in the quasar atmosphere the radiative pressure is balanced by the gravitation, found the mass of the quasar core to be of the order of 10^8 solar masses. A disturbance of the equilibrium in outer layers leads to their ejection. The accretion of the matter from the atmosphere (about three solar masses per year) to the near vicinity of the collapsed core is suggested as a possible mechanism of energy generation by the quasar.

Y. B. Zeldovič (**82**) showed that, because of the dependence of the gravitational field of a body on its rotation, a gravitational analogue of Zeeman-effect in the field of the rotating star must exist. As it is shown by A.G. Doroškevič (**83**) the dependence of the gravitational field of a body on its rotation acts also in the process of accretion: the moment of momentum of a rotating body decreases during the accretion of the matter, free of the moment of momentum. The decrease of the moment is found to be most rapid for collapsed stars.

V. L. Ginzburg (**84**) proposed a hypothesis, according to which quasars are radiation belts around large collapsing magnetic protostars. V. L. Ginzburg and L. M. Ozernoj (**85**) investigated the gravitational collapse of a spherically symmetrical mass of gas with zero pressure, possessing a magnetic moment. According to the drawn conclusions the magnetic moment of a star decreases for an exterior observer as a power function, and the increasing magnetic field draws to the Schwarzschild surface.

I. D. Novikov (**86**) considered the variation of the magnetic field during the collapse of a magnetic star as a possible mechanism of electromagnetic waves emission by quasars. N.S. Kardašov (**87**) considered the strengthening of the magnetic field of a rotating plasma cloud under the gravitational contraction as the cause of the observed features of powerful sources of the non-thermal emission.

L. M. Ozernoj (**88**) proposed the theory of the magnetoid – a massive plasma quasi-stationary configuration, its equilibrium being supported by the ordered circular streaming of plasma, and came to the conclusion that it is possible to explain the properties of a quasar within the limits of the magnetoid model.

Massive configurations stabilized by the rotation under the slow loss of the matter from the equator, were considered by A.S. Bisnovaty-Kogan, Y.B. Zeldovič and I.D. Novikov (**89**).

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