FOR ~~OFFICIAL USE ONLY~~

№ 183

SCIENTIFIC INTELLIGENCE REPORT

SOVIET QUANTUM FIELD THEORY

IPS FILE COPY
DO NOT REMOVE
20 May 59

CIA/SI 15-59
4 May 1959

CENTRAL INTELLIGENCE AGENCY

OFFICE OF SCIENTIFIC INTELLIGENCE

FOR ~~OFFICIAL USE ONLY~~

WARNING

Laws relating to copyright, libel, slander, and communications require that the dissemination of part of this text be limited to OFFICIAL USE ONLY. Exception can be granted only by the issuing agency. Users are warned that non-compliance may subject violators to personal liability.

~~FOR OFFICIAL USE ONLY~~

Scientific Intelligence Report

SOVIET QUANTUM FIELD THEORY

NOTICE

The conclusions, judgments, and opinions contained in this finished intelligence report are based on extensive scientific intelligence research and represent the final and considered views of the Office of Scientific Intelligence.

CIA/SI 15–59
4 May 1959

CENTRAL INTELLIGENCE AGENCY

OFFICE OF SCIENTIFIC INTELLIGENCE

~~FOR OFFICIAL USE ONLY~~

PREFACE

Quantum field theory is a comparatively new branch of physics that deals with complex mathematical representations and basic physical concepts (those of quanta and fields) in order to explain and predict properties of the fundamental elementary particles, such as the familiar electron and proton and the less familiar mesons and hyperons. The former concept, which held that material particles obey the relatively simple laws of classical mechanics, proved completely inadequate for use in interpreting the behavior of microscopic particles. The concept of quantum entities alone without further refinements was also inadequate. Only quantum field theory, which combines the notions of quanta and fields (e.g. electromagnetic fields), has given promise of satisfactorily explaining certain physical phenomena, such as the creation and annihilation of particles, and the existence of newly discovered elementary particles (at present over 30 different types are known). This branch of physics, in spite of its relative newness, is marked by a rapidly growing scientific literature and is occupying the attention of many of the world's best mathematical physicists.

Quantum field theory represents the frontiers of modern theoretical researches into the mathematical relationships governing the basic constituents of nature. As the theoretical adjunct of experimental-particle physics, which is a large and growing branch of modern physics, quantum field theory is called upon to interpret and predict the results of cosmic-ray and particle-accelerator experiments where very-high-particle energies are involved. According to world scientific literature, these experiments and their theoretical interpretation by quantum field theory are being actively pursued in close conjunction.

Because of its very basic and tentative nature, this comparatively new branch of physics is confronted with many difficulties. These are mainly mathematical problems that involve the formal manipulation of limiting quantities,* the nonconvergence of mathematical series, and the extension of the region of applicability of mathematical functions into regions that have no known physical significance. Other difficulties concern the determination of how many independent postulates must be established, how certain newly discovered particles should be fitted into the theory, and whether mathematical rigor and correspondence with reality are possible simultaneously.

---

* Limiting quantities that owe their existence to the extremely small dimensions of the elementary particles and to the extremely large numbers and energies of these particles.

The solution of these problems could lead to a revision of present-day theories about the nature of space, time, and matter. The basic concepts of quantum field theory are fundamental to the physicist's understanding of nature. His mathematical techniques in certain areas of modern physics, such as solid-state physics and low-temperature physics, are closely related to those used in quantum field theory. A deeper understanding of the basic particles and of their forces of interaction will be reflected in enhanced knowledge of general nuclear phenomena and hence in the strengthening of the theoretical bases underlying the technological utilization of the energy of the nucleus.

The present report is based on available information from January 1953 to September 1958. The work was carried out under an external contract. The judgments expressed in this paper represent the immediate views of the Office of Scientific Information, Central Intelligence Agency.

CONTENTS

TABLES

SOVIET QUANTUM FIELD THEORY

PROBLEM

To assess the status and trends of Soviet research in quantum field theory.

CONCLUSIONS

1. The Soviet research effort in quantum field theory is roughly comparable to the related U.S. effort; and the work of the best Soviet mathematical physicists who are active in quantum field theory is quite comparable to that of the best U.S. physicists in the field.

2. The number of physicists of "next-best" competence in quantum field theory who could be considered as a reserve pool of future "bests" is considerably larger in the USSR than in the West. Although the results of research efforts in this field by the "next-best" group are at present often of only moderate interest and sometimes mediocre, they are expected to increase gradually in quality with no loss in quantity.

3. The number of Soviet publications in quantum field theory is increasing at a greater rate than is the number of U.S. publications, and in the near future will exceed the number of U.S. publications.

4. The Soviets who have been intimately associated with the theory from its beginning are fully aware of its general significance in pure and applied fields of science and are capable of making basic contributions to this theory. In the USSR, research efforts in quantum field theory are closely allied with pertinent research efforts in cosmic-ray, solid-state, and high-energy physics. The Soviets are fully aware of the applicability of the quantum field theory to other areas of physics and to nuclear technology.

5. Although the Soviets are fully engaged in work on the outstanding problems confronting quantum field theory, there is no indication of any imminent major advance in their research.

6. Within the next decade, the Soviets probably will take the lead over the West in quantum field theory.

SUMMARY

Considerable Soviet scientific effort is expended in quantum field theory. Research in this area of modern physics requires great mathematical capabilities, which are possessed by many Soviet physicists, because of the strong traditional emphasis on mathematical disciplines in Soviet schools. Soviet interest in such a high-level subject as quantum field theory is completely in line with the familiar Soviet preference and aptitude for the theoretical aspects of physical research. Many versatile Soviet physicists and mathematicians who are active mainly in other areas have produced one or more papers in quantum field theory, indicating a large potential of Soviet capabilities in this area of modern physics. As clearly indicated by a survey of the world's scientific literature, a large and growing portion of quantum field theory papers are by Soviet physicists and mathematicians. Such works regularly appear in the well-known Soviet journals *Reports of the Academy of Sciences in the USSR* (*Doklady Akademii Nauk SSSR*) and the *Journal of Experimental and Theoretical Physics* (*Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki*), as well as in many other high-level physics journals, both Soviet and Western. Many of the Soviet works are being translated into English.

The world-famous physicists L. D. Landau and N. N. Bogolyubov are the most outstanding Soviet scientists working in quantum field theory. Their work can easily be compared with that of leading U.S. physicists J. S. Schwinger and F. J. Dyson. Landau and Bogolyubov, who are extremely versatile, are competent both as mathematicians and physicists. Landau, whose name is associated with low-temperature phenomena of superfluidity and superconductivity and with numerous topics in theoretical physics, has often been called "the world's best physicist." Bogolyubov's mathematical ability is comparable to that of the late John von Neumann (U.S. physicist). Bogolyubov's paper on dispersion relations, important in quantum field theory, was considered by many to be the most outstanding paper given at the International Conference on Theoretical Physics, held in Seattle, Washington, in September 1956. Since then he was awarded a Lenin Prize for his works in theoretical physics.

Soviet physicists have been associated with the development of the newest physical concepts in quantum field theory. They include V. A. Fok, Landau, I. Ye. Tamm, Ya. I. Frenkel' (deceased), D. I. Blokhintsev, and Ye. M. Lifshits. In 1953, A. I. Akhiyezer, who is well known for his work in cosmic-ray physics, and V. B. Berestetskiy did the first comprehensive work on quantum electrodynamics, which may be described as an early form of quantum field theory.

Important Soviet contributions to quantum field theory include the Tamm-Dancoff scheme, developed by Tamm; field (second) quantization, further developed by Fok; new mathematical representations of Landau; and the rigorous mathematical proof of dispersion relations (relating to the scattering of high-energy particles) by Bogolyubov.

The Soviets are fully conversant with Western efforts in quantum field theory. They have published papers in such Western journals as *Physica, II Nuovo Cimento,* and *The Physical Review.* Soviets who are working in quantum field theory have appeared at various international conferences and are exchanging preprints of works on quantum field theory with their Western counterparts. For example, U.S. researchers are receiving preprints from the Joint Institute of Nuclear Research, Dubna, USSR.

Many Soviet works on quantum field theory clearly relate to nuclear phenomena observed in high-energy accelerators and cosmic rays. Such phenomena as the scattering of high-energy particles, nuclear forces of interaction, spin of particles, radiation from fast moving particles, and creation and annihilation of particles are often discussed. Bogolyubov, the chief Soviet worker in quantum field theory, is the head of the Laboratory of Theoretical Physics at the Joint Institute of Nuclear Research, where the world's largest particle accelerator — 10 billion electron volts (Bev) — is located and where extensive experimental research on all phases of high-energy particle physics is being conducted. This indicates close cooperation between theorists and experimentalists at this center. Most of the authors of the quantum field theory papers are doing research related to cosmic-ray and high-energy physics at well-known Soviet universities.

Soviet physicists are pursuing research in quantum field theory along two main lines. The first, an older one, involves field equations and perturbation methods, and represents a direct outgrowth of the still older quantum mechanics. The second and newer approach, which involves so-called axiomatic

---

methods c
factory fe
mines the
of the ge
restricting
position c
(axioms)
such as s
These tw
with the
respective

On the
pendices
to show
done in
4, and 5
2 summa

NUMBEI
PA

BEFORE
1953 *
44

* "Befo
that were
reviewed

NUMBE
LISHEI

1953
91
(61) *

* Figu
that are
report.

Table
pers p
field th
throug
Table
typical

methods developed to overcome the unsatisfactory features of the first approach, determines the ultimate mathematical properties of the general field equations by gradually restricting their generality through the imposition of certain mathematical conditions (axioms) corresponding to physical reality, such as symmetry and casuality conditions. These two approaches are closely associated with the work of Landau and Bogolyubov, respectively. In some cases, pertinent studies were initiated in the West and further developed in the USSR. In other cases, studies were initiated by Soviets and carried further by Westerners. In general, Soviet and Western research in quantum field theory closely parallel each other and rely on one another for ideas and clarification. There are as yet no indications of any radically new developments in or departures from present trends in Soviet and Western quantum field theory research.

DISCUSSION

On the basis of the detailed data in appendices D and E, tables have been prepared to show the quantity of work that has been done in quantum field theory. Tables 1, 3, 4, and 5 represent Soviet activity, and table 2 summarizes U.S. work.

TABLE 1

NUMBER OF QUANTUM FIELD THEORY PAPERS WRITTEN BY SOVIETS

Before 1953 *	1953	1954	1955	1956	1957	Early 1958	Total
44	51	49	91	128	91	11	465

* "Before 1953" indicates the number of papers that were published before 1953, but they were not reviewed or abstracted until after 1953.

TABLE 2

NUMBER OF FIELD THEORY PAPERS PUBLISHED IN THE U.S. *PHYSICAL REVIEW*

1953	1954	1955	1956	1957	Early 1958	Total
91 (61) *	102 (68)	114 (76)	93 (62)	93 (62)	56 (38)	549 (367)

* Figures in parentheses represent the articles that are on the type of research considered in this report.

Table 1 presents the total number of papers published by the Soviets in quantum field theory. The papers have been located through a survey of the Soviet literature. Table 2 gives a comparable breakdown for a typical U.S. publication, *The Physical Review*. The figures of table 2 can be compared with those of table 1 only in a very rough way. They represent the number of articles listed under field theory in the subject index of *The Physical Review*. The term "field theory" as used by the Soviets has a much broader meaning than U.S. usage and includes many articles that might more properly be placed under another subdivision. In table 2, only about two-thirds of the numbers listed (those in parentheses) would be articles on the type of research considered in this paper. The figures in table 2 represent the papers in only one U.S. journal in which U.S. scientists publish research in quantum field theory, but this journal publishes a large percentage of the U.S. reports in the field.

According to tables 1 and 2, the quantity of Soviet work in quantum field is about equal to the U.S. effort alone, although probably less than the total Western effort, especially if Japan is included.

Table 1 indicates that the Soviet effort is growing at a more rapid rate than that reflected in table 2. The Soviet papers of 1957 and 1958 are still being translated and are not all included, so that those numbers in table 1 will be subject to revision upwards. It is believed that this rate of Soviet growth is probably a real one, not reflecting simply the increasing availability of Soviet works. If this rate continues, the quantity of Soviet work in this field will probably equal and then exceed the Western effort in the near future.

TABLE 3

NUMBER OF TOP QUANTUM FIELD THEORY PHYSICISTS AT SOVIET INSTITUTIONS AND NUMBER OF PAPERS PUBLISHED BY THEM

		NUMBER OF PUBLICATIONS							
INSTITUTE	No. of Physicists	Before 1953	1953	1954	1955	1956	1957	Early 1958	Totals
Moscow State Univ	33	12	13	11	13	26	19	4	98
Physics Inst imeni P. N. Lebedev, Acad of Sciences, USSR	19	2	4	6	18	14	12	4	60
Various Institutes of Physics of the Acad of Sciences, USSR	18	2	4	6	18	14	12	4	60
Leningrad State Univ imeni A. A. Zhdanov	11	3	1	6	9	7	4	3	33
Joint Inst for Nuclear Research	13					1	6	6	13
Inst for Nuclear Problems	8	1	1	3	3	6	7	1	22
Totals	102	20	23	32	61	68	60	22	286

Table 3 presents data pertaining to physicists and institutions. In some cases, authors publish from several institutes. In other cases, it was not possible to ascertain the author's institution. Thus, the table presents incomplete statistics and only represents a trend. Furthermore, the Academy of Sciences, USSR, is not strictly an institution, but many papers are published with its designation. The tabulation indicates that there are only a few institutions of dominating importance both in quantity and quality of their output.

TABLE 4

NUMBER OF PAPERS WRITTEN ON QUANTUM FIELD THEORY BY ONE OR MORE SOVIET AUTHORS

No. of Authors	No. of Papers
1	342
2	95
3	26
4	2
5	0

Table 4 presents a breakdown of the Soviet work by number of authors. The number of papers with only one author exceeds the number of those with more than one. Some of the very best men, e.g., Landau and Bogolyubov, almost invariably publish with others in this field. Their counterparts in the United States, Schwinger and Dyson, almost invariably publish alone, but many very good physicists in the West also usually publish jointly, e.g., T. D. Lee and C. N. Yang. The overall percentage of single and multiple authorships is probably about the same for the Soviet Union as for the West.

Table 5 lists the top producers of papers on quantum field theory, and the numbers of papers are a fairly good reflection of the general relative importance of the men in this branch of physics. Some of the men, for instance Pomeranchuk and Landau, are more productive than the numbers of publications show, since they also do a great deal of work in other areas of research.

TABLE 5

PAPERS WRITTEN BY TOP SOVIET PHYSICISTS IN QUANTUM FIELD THEORY RESEARCH

No. of Papers	Author
24	Bogolyubov, N. N.
20	Sokolov, A. A.
16	Ivanenko, D. D.
15	Shirokov, Yu. M.
15	Khalatnikov, I. M.
14	Fradkin, Ye. S.
12	Galanin, A. D.
12	Abrikosov, A. A.
11	Medvedev, B. V.
10	Landau, L. D.
10	Novozhilov, Yu. V.
10	Pomeranchuk, I. Ya.
9	Zaytsev, G. A.
9	Barashenkov, V. S.
Total 187	14

Moreover, there are about 200 additional men (see appendix D) who have written only a few papers on this subject. In all, this represents a large reservoir of potential workers in the quantum field theory, who presumably at present are working in other branches of science.

The number of physicists listed in table 5 who might be considered the best in the field is smaller than a comparable list of Western physicists would be. On the other hand, the list of physicists in appendix D, which includes men who probably work in other fields of science, but who still have published in quantum field theory in the last 5 years, is perhaps somewhat larger than a comparable Western list would be and presumably will grow in the future. This latter fact represents a significant difference between the USSR and the West, or at least between the USSR and the United States, in attracting young scientists to this field of research. In the last 5 years or so, the West has been discouraged with the difficult problems of quantum field theory. As a result, fewer good graduate students have been encouraged to enter this field. Students have probably been reluctant to enter this work in the United States because of the mistaken impression that such recondite research is not as rewarding financially as other less fundamental work might be.

The total number of men qualified to work in this field is probably about the same in the United States as in the USSR. The Soviets appear to have produced many new workers during the last few years. Financial support for this type of fundamental theoretical research may be obtained more easily in the USSR than in the United States.

The overall type of research in quantum field theory done in the USSR is much the same as in the West. They have worked in a large number of different areas in quantum field theory, with only a few of particular interest.

The Soviets seem to be doing quite a bit of work in the area of the strong-coupling meson theory. They have attempted to work out such a theory for π-mesons (the mesons of interest in nuclear-force problems) without too much success. Some work along the same lines has been done in the West, but by and large, the feeling has been that such an approach to the nuclear-force problem was too much like perturbation theory and would not be too fruitful.

Another such example of comparative Soviet concentration is the application of the Tamm-Dancoff scheme of approximation. This is related somewhat to the strong-coupling theories. This scheme represents a slightly different approach to perturbation theory, wherein the quantities of interest are not expanded in powers of the interaction, but rather in the number of particles in the intermediate states. Of course, it is natural that much of this work is being done in the USSR, since Tamm was one of the founders of this technique. Again, quite a bit of work along these lines has also been done in the West, notably by Bethe's group at Cornell and by Dyson at Princeton. In recent years, this method has been virtually abandoned by the West in favor of other approaches.

One such Western approach to the nuclear force problem has been that of Chew and Low. This was originally a semiphenomenological attack on the problems of low-energy π-meson scattering data. By the use of this approach, Western scientists were moderately successful in correlating these types of experiments, and were particularly successful in explaining the resonance behavior observed in π-meson-nucleon scatterings. Subsequently, the approach was refined to the point where it became of more fundamental interest, because many of its ideas and conclusions were of a more general nature than they were originally thought to be. These early successes of the Chew approach, and the subsequent theoretical refinements by Low, Wick, and others contributed a great deal in reviving the somewhat flagging interest in quantum field theory.

Very little, if any, work on the Chew approach has been done in the USSR. This is probably just a counter-example to the Western reaction to their work in strong-coupling theory, or, more appropriately, to the recent work of Landau. A great deal of work on the Landau approach has been done in the USSR, whereas almost none has been done in the West. Western physicists have felt that this approach contained basic mathematical errors which made its results inconclusive. Notwithstanding this Western reaction, many Soviet papers along these lines continue to be published.

A final point to be considered here is a general impression concerning the level and effectiveness of Soviet training in this field. This, of course, can only be an impression, based on a few text books, their general work, and some conversations with physicists who have visited the USSR.

In general, the level of training in the USSR in field theory seems to be very high. For example, there seems to be official support or encouragement for their best workers to write textbooks. These textbooks are written and published very quickly, so that they have timely interest. Since they are written by top men and reasonably priced, they probably are influential in enticing young worker into this field and in retaining those who are already in it. Just within the last few years, the following books have been written: *Quantum Theory of Fields* by Bogolyubov and Shirkov; *Quantum Electrodynamics* by Akiezer and Berestetskii; *Foundations of Quantum Mechanics* by Blokhintsev; *Classical Field Theory* by Ivanenko and Sokolov; *Classical Theory of Fields* by Landau and Lifshits; *Quantum Mechanics'' Non-Relativistic Theory* by Landau and Lifshits; and *Problems in Dispersion Relations* by Bogolyubov, Medvedev, and Polayamov.

The books themselves, or their proofs or translations, indicate that not only are they written by the best men available, but, as textbooks, they are generally excellent. As a consequence some of the very best books in field theory available in English or German are translations of these Soviet works, many published by American houses. Thus, these books are becoming standard and in many cases they are the only textbooks in this field in many American universities, notwithstanding the high cost of the translated versions.

The particular quality of some of the better Soviet work in quantum field theory is best illustrated by the work of Landau and Bogolyubov, which represents the only lines of Soviet research of special importance during the past few years. (See appendices B and C.)

APPENDIX A

EXPLANATION OF QUANTUM FIELD THEORY

Basic research in modern physics can conveniently be broken down into subdivisions or steps according to the size of the object under study. The first step is the study of very large objects -- the universe as a whole, including the galaxies, stars, and planets. Studies on the universe lean heavily on the ideas of special and general relativity, magnetohydrodynamics, classical mechanics, and thermodynamics.

The next step is the study of matter in bulk of every-day size. This is the physics of solids, liquids, gases, and plasmas. In the last few decades, this phase of physics has made tremendous strides, as evidenced directly by the sudden growth of advanced technologies. The great strides in the fundamental understanding of the properties of matter in bulk can be traced to contributions originally made in the study of the next smaller stage.

The third step embraces the constituents that make up matter in bulk -- the molecules and their constituents, the atoms. It was at this stage that the revolutionary ideas of quantum physics were first found necessary and introduced in the early decades of this century. These ideas and theories, linked with scientists such as Bohr, Planck, Einstein, and Dirac, have gradually permeated physics, until today, the concepts of quantum theory are considered fundamental to understanding of nature in general. Not only have these concepts filtered up to the next higher step, the study of matter in bulk, but they lead directly to the next lower step, the study of the elementary particles.

Thus, the ideas of quantum theory must be used in the study of constituents of the atoms themselves, the protons, neutrons, and electrons. In attempting to understand the interactions between these fundamental "building-blocks" of matter in the universe, and their nature and structure, the most modern versions of quantum theories must be called into play.

The fundamental particles and the various interactions between them are described in terms of quantized fields, so that there is a one-to-one correspondence between a quantum field and a particle or family of particles, such as the proton and neutron. The interaction itself, for example, between two neutrons, is represented by another quantized field, which in this case corresponds to another real particle, first predicted by Yukawa, the π-meson. It is the study of these various quantized fields and their behavior under different conditions that is called quantum field theory.

Still another way to place quantum field theory in relation to the rest of theoretical physics is to consider the energies involved in the interactions or forces between the particles making up molecules, atoms, and nuclei.

The unit of energy generally used in discussing atomic and nuclear physics is the electron volt. This is defined as the energy acquired by one electron in falling through an electric potential difference of one volt. The thermal kinetic energies that molecules in the air have at ordinary temperatures, just for their random motions, are about one-fortieth of one electron volt.

The interaction energies between ions or molecules in a solid* is about a few tenths to a few electron volts. This is the same order of magnitude as those energies that bind the constituent atoms of molecules, and represents the energies of general interest in chemistry.

The energies involved in binding the electrons within the atom itself range from about tens of electron volts, in the lightest elements, to some thousands of electron volts in the heavier elements. It is this order of magnitude of energies that is involved in atomic transitions responsible for the emission of light in flames or light from the sun and in the emission of X-rays in a X-ray machine.

On the next level, within the nucleons of an atom, the interaction energies are very much larger, and are of the order of 10 Mev. (million electron volts). This is why so much more energy is released in an atomic explosion, which involves the release of these interaction energies, compared with a chemical explosion, such as TNT, which involves the molecular interaction energies.

All of the energies except the nuclear are quite small compared with elementary particle rest-mass energy, i.e., that energy E to which the mass m of a particle corresponds in the Einstein relation, $E=mc^2$. The rest-mass energy of an electron is one-half Mev; that of a π-meson, 140 million electron volts; and that of a proton is about 1 Bev. As long as the interaction energies are very small in comparison with the rest-mass energies, so that there is no question of having enough energy to create new particles, quantum field theory is not generally used, although ordinary quantum mechanics is. When the interaction energies become so large that elementary particles might be created, as they do in the nucleus, then quantum field theory is essential, for it treats these interactions not so much in terms of indivisible particles, but rather in terms of fields wherein the number of particles can change by creation or annihilation.

---

*The strength of these energies determines whether the substance is a solid rather than a liquid or gas.

Thus, quantum field theory is necessary in that region of energy extending from about 1 million electron volts (creation of electron pairs) through nuclear energies of 10 to 100 Mev to the highest available. These are from high-energy particle accelerators* and cosmic rays.** At these energies, all sorts of particles are created. These include some, called K-mesons, whose mass is between that of the π-meson and the proton; others called hyperons, whose mass is greater than one proton mass, but less than two proton masses; and perhaps as yet undiscovered new particles.

Quantum field theory can be divided into two approaches: (1) the older approach involving field equations and perturbation theory; and (2) the new or axiomatic approach.

The older approach was a direct outgrowth of the even older (about 1920-30) quantum mechanics. This approach attributes certain mathematical functions called wave functions or fields to such physical entities as elementary particles. These fields are assumed to obey certain mathematical equations, the form of which is determined by certain physical properties of the fields realized in nature - for example, its equations are Lorentz-invariant and have certain symmetry properties. The physical interaction between various particles (e.g. the Coulomb interaction between electrically charged particles) is described by a certain mathematical combination of the field functions of the interacting particles and this interaction term is inserted in the field equation in the appropriate place.

Thus the field equations, with the interaction terms, could be written down directly and should determine the form and behavior in space and time of the field functions. With the determination of these field functions, it is possible to calculate such interesting physical quantities as the energy of interaction between two interacting particles, such as two protons in a nucleus; scattering cross-sections, which are a measure of the probability of one particle scattering from another in a certain way in experiments that could be performed with high-energy accelerators; the life-time of unstable particles; the internal structure of such elementary particles as the proton; and many others.

While the field equations can be written down, their solutions can not, in general, be obtained. Only approximate solutions are possible, in practice, and these are obtained by an approximation procedure called "perturbation theory." This mathematical technique consists in first obtaining solutions to the field equations when the interaction term is neglected. This corresponds physically

---

*About 10 Bev, wherein proton pairs are created.

**Extremely high energies from a thousand to a million Bev.

to assuming the neglected interaction energies are quite small in comparison with other relevant energies, such as the kinetic energies. Having this "unperturbed" solution, one finds corrections to it in which the interaction is allowed to act only once (first-order perturbation theory). Corrections to this correction are then found, in which the interaction acts twice (second-order perturbation theory), and so on.

One of the decisions to be made in quantum field theory is whether or not such a perturbation-theory approach to these equations' solutions is valid. In using this approach, it soon became clear that it was formally meaningless. Mathematically infinite quantities appeared in the equations. A successful but not entirely satisfying method was developed for removing these quantities in the "renormalization" program when it was noted that they always appeared in relation to a few fundamental properties of the field, like its mass and charge. Thus, the original or "bare" mass and charge of the field put in the equations could be combined with these divergences to give, by definition, the real, or renomalized mass and charge of the particle. Actually, the equation changed the character of the so-called vacuum from being a state of nothingless, so to speak, to a quantum mechanical state in which no real particles were present, but in which virtual particles could continually be created and destroyed. Thus, in going from a particle's "bare" charge to its real or "renormalized" charge, the particle has essentially interacted with this vacuum in such a way that virtual pairs of particles surround it and alter its original charge. The prediction of this type of strictly quantum field-theoretical effect, confirmed by some extremely accurate experiments, was one of the great successes of quantum electrodynamics.

Nevertheless, although these effects are observed, the fundamental mathematical structure of the theory is still very unsatisfying.

In an attempt to by-pass these unsatisfying features of quantum field theory, a fairly new, axiomatic, approach has started to develop. This approach does not use field equations and the strictly dynamic properties of fields, but rather attempts to speak very generally about the ultimate mathematical properties that the field functions, or certain combinations thereof, must have.

Thus, certain physical properties of nature, like Lorentz-invariance, causality (roughly: no signal traveling faster than light, or no output before input), and certain invariances in space and time are translated into mathematical terms. These properties are used as restrictions on the functions themselves rather than to determine field equations that the functions must satisfy. This provides a very broad class of mathematical functions. Then, one by one, restrictions are placed on these functions by means of the basic axioms (which correspond to physical properties). These restrictions are represented by equations which the functions must satisfy, entirely different from field equations. In certain instances, the restrictions lead to equations called dispersion relations. If a set of restrictions that are an exhaustive and accurate reflection of nature can be successfully placed on these functions, it is hoped that the set of functions that are left will be so limited that they will constitute an answer to the original problem of obtaining mathematical field functions to represent the physical world.

The following questions still need to be answered:

(1) Can a set of restricted functions be obtained?

(2) If a set of restricted functions is obtained, will they be suitable?

(3) Are the axioms really restrictive?

(4) Are the axioms mutually contradictory? If they are, the present concept of nature must be changed.

Thus, both approaches in quantum field theory are beset by severe difficulties and require further research.

There have been several severe criticisms of this method, which probably accounts for the lack of Western interest in the Soviet work.

The first few, general criticisms, are made by Dyson. 16/ He points out that there is no justification, mathematically, for using cut-off procedures. Especially in the two-cut-off case, the method of taking the limits is arbitrary. Whether one can interchange limits like this with integrations is unknown.

The problem of the singularity in the proton propagator is shown in* equation 15, appendix B, part II. This appears at a momentum of

$$k^2 \approx e^{3\pi/a} \cdot m^2 \approx e^{1000} m^2$$

which is extremely high, but finite. What this means physically is not clear. In the case of the meson theory, equation 14, this singularity appears at experimentally observed energies M, where M is the nucleon mass. Besides this, the analytic form of equation 15 means that there is a double "ghost" state in the Lee model sense, a residue of the wrong

---

*All equations referred to in this section are in appendix B, part II.

sign, and at imaginary mass values. Again, this seems to make for problems in physical interpretation. 4/

Still more severe criticisms of a mathematical nature are made by Kallen. 17/ These criticisms are based on the approximations mentioned with reference to the equation for the vertex function, equation 6, and its solution. It is still not clear what effect the terms neglected there might have. In solving equation 6, one expands the integrand in a perturbation sum, integrates, and then takes the sums of the series again. For integrating, one replaces the terms by assumed asymptotic forms, and then assumes that the sum of these asymptotic terms is really the asymptotic limit of the original sum. There is always a cut-off. It is expected that a higher-order process does not become important until the energy is well above its threshold. Thus, for a given cut-off energy, the asymptotic value for a process is being assumed in an energy region where the process might still be small. In other words, if a given cut-off in the integral eliminates processes whose thresholds are above the cut-off, the resulting sum of integrated expressions is a limited one. When the cut-off then goes to infinity, asymptotic expressions for processes that have already been excluded should be included. Thus, the expression for the sum may not at all be its asymptotic form. Perhaps this explains why the presumably divergent sum of divergent terms gives such simple, convergent results. Kallen approaches the problem of summing the series of asymptotic terms from a different point of view, i.e., at high energy, a process is a multiple of the corresponding Born approximation. He gets an answer entirely different from that obtained by Landau and his co-workers.

The work in quantum field theory by Landau and his co-workers appears to be open to very serious questions on rigorous mathematical grounds. This should not be taken to imply, however, that this is true, in general, of Landau's work. Landau is probably one of the best physicists in the world. While work on quantum field theory is open to questions, it had the positive effect of again stimulating thoughts on these subjects throughout the world. This probably led to some of Kallen's more recent work as well as to some of the ideas in the axiomatic approach to quantum field theory.

In addition, Landau has made very significant contributions in many other fields. Most recent, and perhaps most spectacular, of these is his work on the two-component theory of the neutrino, and its connection with the parity experiments. Before that, he did very early and good work on the properties of liquid helium. He has contributed significantly to the theory of multiple production of mesons in cosmic rays. There are many other examples. Thus, this analysis of the Landau approach to quantum field theory should be taken merely as an example of one of many approache

While there are some questions as to the validity of this approach, it has not been proved incorrect. It may not be an example of Landau's better work, but it does demonstrate his versatility and the influence that his work has on other Soviet work.

APPENDIX B

PART I

THE QUANTUM FIELD THEORY WORK OF L. D. LANDAU

For many years, the problems of divergences plagued the perturbation approach to quantum electrodynamics. If certain simple corrections were computed straight forwardly, such as the effect of an electron's self-energy (mass) because of its interaction with the electromagnetic field, mathematically these corrections were infinite, rather than small, as they should be.

In 1947, Kramers observed that all such corrections to the mass of an electron, while they might formally diverge, were still only to be interpreted as changes in the particle's mass. Since a mass is observed physically, presumably of the electron interacting fully, the fictitious, original free electron mass together with all its corrections should be identified as the true, observed mass. Thus, these divergent quantities were to be absorbed with the original electron mass, and the result defined as the usual finite observable mass. This is the basic idea behind the renormalization program in quantum electrodynamics. When similar ideas were applied to other quantities, like the electric charge, it could be shown (see Dyson) that all divergences were thus removed from quantum electrodynamics. Similar considerations hold for some forms of meson theory: H. A. Bethe and F. de Hoffman.

With this successful removal of divergencies by renormalization and the subsequent experimental confirmation of the very precise theoretical predictions, it was hoped that the inconsistencies had been removed from quantum electrodynamics. It soon became clear that whether or not they had been removed was still open to question.

T. D. Lee gave a good example of a theory which could be renormalized and in which the S-matrix* is nonunitary. 4/ 5/ Such a situation corresponds to a physical situation in which states of negative probability occur; hence it is inadmissible.

Still another matter that had to be determined was the rather formal one of the nature and source of the divergences removed by renormalization. The problem was to determine whether these multiplicative constants were infinite because of an unwarranted usage of perturbation theory (e.g. the perturbation series perhaps diverges) or whether the infinities inherent in the theory were independent of perturbation series expansion.

---

*S-matrix - The scattering matrix - the quantity that contains all the information of the theory on scattering processes.

Kallen and Lehmann showed that at least some of the renormalization constants were inherently infinite. Thus, there still remains the question of the origin of these infinities. 6-8/ Gell-Mann and Low have attempted to investigate the high-energy (or, equivalently, very small distance) aspect of the functions involved in quantum electrodynamics, using perturbation theory as well as some group properties of these functions. 9/ Their results, while interesting, were rather inconclusive. Recently, Bogolyubov has refined the group theory approach to this matter, without essentially changing its inconclusiveness. 10/

Throughout these more recent doubts as to the inconsistency of electrodynamics, there has long been the question concerning the connection between the point-like nature of the interaction assumed in electrodynamics and the infinities that arise. It was felt that, while this problem was still somewhat puzzling, no fundamental questions were involved.

In quantum electrodynamics, this question of point interactions, of course, corresponds to very high-energy asymptotic behavior of the relevant functions. This whole question was reopened by Landau, who used a potentially very powerful technique not necessarily restricted to a perturbation-theory approach.

The approach adopted by Landau is based on the field equations derived by Schwinger and Fradkin. In principle, these equations are exact and independent of perturbation theory. In practice, certain approximations must be made in order to solve these equations and these approximations depend strongly on a perturbation approach. This approach gives much the same answers and conclusions for the meson theory and even for beta-decay types of coupling. The physical coupling vanishes in the point-interaction limit.

PART II

MATHEMATICAL DETAILS OF THE QUANTUM FIELD THEORY WORK OF L. D. LANDAU

In his work on quantum field theory, L. D. Landau used several field equations to determine "Green's functions." In this context, a Green's function* contains all the information necessary to find the behavior of the electron's wave function in space and time; i.e., in principle, it contains the information necessary to answer questions about scattering and other problems. The term "propagater" is used almost interchangeably with the term "Green's function." This usage reflects the fact that this function contains the information on how the particle propagates in space and time (or, more strictly, the Fourier transform of G(p) does).

As an example, the Dirac equation for a free electron in momentum space in terms of the corresponding free-electron's Green's function, $G^o(p)$ is given. This is

$$1.^{**} \qquad G^o(p)\ (\hat{p} - m_1) = 1$$

where m_1 is the electron's bare (in this case actual) mass. This equation is really symbolic, in that it is a matrix equation as well as a differential equation. The symbol $\hat{p}$ stands for the four-dimensional scalar product $\gamma \cdot p$, where the four-vector γ's are the Dirac matrices.

It is clear from equation 1 and the above explanation that there is no term in equation 1 referring to interaction (hence, $G^o(p)$ is designated as the "free" propagator).

If the electron is allowed to interact with the electron-magnetic field, then Schwinger's exact equation for the electron propagator becomes

$$2.\quad G(p)\left\{\hat{p} - m_1 - \frac{e_1^2}{\pi i}\int \Gamma_\mu(P, P-k; k)\cdot G(p-k)\gamma_\nu D_{\mu\nu}(k)d^4k\right\} = 1.$$

In equation 2, the third term in curly brackets is the effect of the electromagnetic interaction. e_1 is the bare electric charge (this equation is, of course, unrenormalized).[1] γ_ν is, as before, the Dirac matrices. $\Gamma_\mu(P, P-k; k)$ is known as the vertex function; it contains the information concerning the form of the interactions, and is to be determined from its equation. $D_{\mu\nu}(k)$ is the photon's Green's function, and it, too, is determined by its equation. It is also clear from equation 2 that we now

---

*For the electron, this is denoted as G(p), a function of the electron's four-momentum P.

**The summation convention on four-vector and tensor indices is used in all of these equations.

deal with complicated matrix equations of the integro-differential type (the differential operators in space-time being here just P; the integral equation form coming from the G(p-k) under the integral).

The corresponding equation for the photon propagator D   (k) is

$$3.\quad D_{\mu\nu}(k) = D^{0}_{\mu\nu}(k) - \frac{e_1^2}{\pi i} D_{\mu\sigma}(k) \times \cdots$$
$$\cdots \times S_p \left[\int G(p)\Gamma_\sigma(P,P-k;k)G(p-k)\gamma_\tau d^4p\right] D^{0}_{\tau\nu}(k) .$$

Here, $D_{\mu\nu}^{0}$ (k) is the "free", noninteracting photon Green's function, analogous to $G^0(p)$. Thus, where $G^0(p)$ satisfies the free Dirac equation 1, and has the solution

$$4.\qquad G^{0}(p) = \frac{1}{p - m_1} ,$$

$D_{\mu\nu}{}^{0}(k)$ satisfies the free Maxwell equation, and has the solution

$$5.\qquad D^{0}_{\mu\nu}(k) = \frac{\delta_{\mu\nu}}{k^2} .$$

The operation S_p means that one should take the spur, or trace, of the matrix quantity in the square brackets.

Finally, the equation that Landau uses for the vertex function is

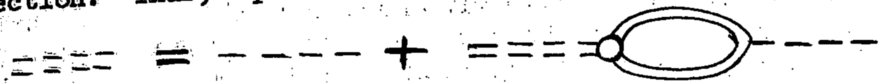
$$6.\quad \Gamma_\sigma(P,P-l;l) =$$
$$\gamma_\sigma + \frac{e_1^2}{\pi i}\int \Gamma_\mu(P,P-k;k)G(P-k)\Gamma_\sigma(P-k,P-k-l;l)\times\cdots$$
$$\cdots\times G(P-k-l)\Gamma_\nu(P-k-l,P-l;k)D_{\mu\nu}(k)\,d^4k .$$

This equation is the most complicated of the equations 2, 3, and 6, because it is a matrix, nonlinear integral equation. It is nonlinear because the unknown function Γ_μ (--) appears more than once under the integral.

In all equations, it is sometimes useful to think in terms of Feynman graphs. In a very rough way, these graphs show the electron and photon propagating in space-time. The electron is indicated by a solid line and the photon by a broken line. When G(p) appears, it corresponds to an electron; when $D_{\mu\nu}$ (k) appears, it corresponds to a photon; when Γ_μ(--) appears, it corresponds to a point of interaction between them; and $D_{\mu\nu}{}^{0}(k)$ or $G^0(p)$ corresponds to propagation with no interaction.

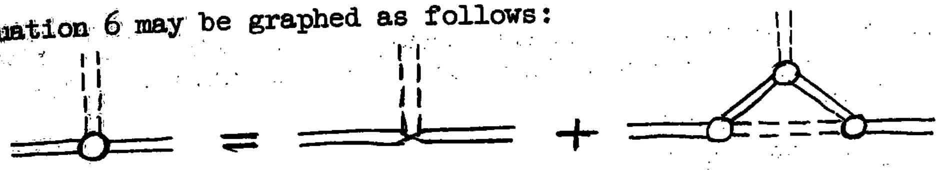
When the electron (photon) is complete with interaction, G(p), (D(k)), the solid (broken) lines are double. When the vertex is the complete one, Γ_μ (--), it will be represented by a circle at the line intersections. When it is only the "bare" interaction, it will be just the intersection. Thus, equation 3 can be graphed as follows:

7.



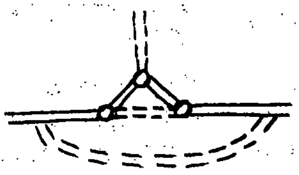
Equation 6 may be graphed as follows:

8.



It is clear from graph 8, that other possible topographical forms are excluded, for example

9.



The original equation of Schwinger includes these graphs and all other possibilities. Neglecting these is the approximation mentioned above that Landau makes in Schwinger's equations.

In all these equations, the integration variables (say p or k) correspond to the energy-momentum of intermediate-state particles (in terms of graphs, the internal lines). The investigation of the effect or point interactions is introduced as follows. The original interaction between the electron field and the electro-magnetic field was considered to occur at a mathematical point in space. This restriction is dropped, and it is considered that this interaction takes place in a small region of space-time, say of dimension a (presumably about 10^{-14} to 10^{-13} centimeters, from present-day experiments). In these equations, which are in momentum-space, this spread corresponds to an upper limit on the intermediate-state particles' momenta, i.e., the integrals in the above equations are cut off at an upper limit of momentum, of the order of $\Lambda \approx 1/a$. Thus these integrals are made finite. It is hoped that when a calculation is completed, the limit $a \to 0$, or $\Lambda \to \infty$, will correctly correspond again to a point interaction, and, in passing to this limit, something will be learned of the divergences. Thus, Landau's program is an attempt to solve the simultaneous integro-differential equations 2, 3, and 6, incorporating the upper limit on the integrals, and then passing to the point limit.

Since the divergences that occur in the perturbation solution of these equations are logarithmic with momentum, the major contributions to the integrals come from the high intermediate momenta. It is because the divergencies are logarithmic that Landau uses equation 6 rather than the complete equation. He feels that this equation contains all the terms contributing importantly to the divergence.

To solve these equations Landau assumes that when the momentum becomes very high, the Green's functions assume certain simple asymptotic forms.

10. $$G(p) = \frac{\beta(p^2)}{\hat{p}}$$

$$\Gamma_\mu(p,q;l) = \gamma_\mu \alpha(f^2)$$

$$D_{\mu\nu}(k) = \frac{1}{k^2}\left[d_t(k^2)\left(\delta_{\mu\nu} - \frac{k_\mu k_\nu}{k^2}\right) + d_l(k^2)\frac{k_\mu k_\nu}{k^2}\right]$$

where f^2 is any p^2, q^2, l^2 if they are of the same order of magnitude, and, if not, should be the largest. The functions of β, α, d_t and d_l are slowly-varying function of their arguments.

Substituting these expressions in equations 2, 3, and 6, he solves for the functions. In doing so in the equation for Γ_μ (p, p-k; k), Landau makes an additional assumption in finding the dependence on the second variable p when it differs from o in comparison with k. This is, that in finding the change in Γ_μ (--) in going from p=o to small p, he can consider the changes in the integral in equation 6 as the sum of the changes of the integrated expressions.

As solutions to these equations, Landau finds that within the approximations made in writing down equation 6, the functions α, β can be chosen as 1; i.e., there are no corrections to the electron-free Green's function or to the "free" vertex function γ_μ. However, the photon propagator is changed from its free value of $d_t = 1$ to

11. $$d_t(k^2) = \left[1 + \frac{e_1^2}{3\pi}\ln\left(\frac{\Lambda^2}{k^2}\right)\right]^{-1}$$

e_1^2 is the bare, unrenormalized electric charge. To put the propagator in renormalized terms, it must be written in such a way that it does not depend on the unphysical quantities e_1^2 and the cut-off Λ^2. To do this, the real, observed electric charge e^2 (=1/137) is defined in terms of e_1^2 in the following way:

12. $$e^2 = e_1^2 \lim_{k^2 \to 0} d_t(k^2) .$$

Physically, this corresponds to defining the electric charge as the charge seen in the Compton scattering of zero-energy photons (or, alternatively, that Coulomb's law gives the potential between two real charges at large distances). When equation 12 is used in equation 11, the following equations result:

13. $$e^2 = \frac{e_1^2}{1 + \frac{e_1^2}{3\pi} \cdot \ln\left(\frac{\Lambda^2}{m^2}\right)}$$

or,

14. $$e_1^2 = \frac{e^2}{1 - \frac{e^2}{3\pi} \cdot \ln\left(\frac{\Lambda^2}{m^2}\right)}$$

or,

15. $$d_t(k^2) = \frac{e^2}{e_1^2} \cdot \frac{\quad}{1 - \frac{e^2}{3\pi} \cdot \ln\left(\frac{\Lambda^2}{m^2}\right)}$$

and thus, if we multiply $d_t(k^2)$ by the renormalization constant e_1^2/e^2, the renormalized propagator does not depend on any unphysical quantities.

In all these equations, the point interaction limit is taken by letting $\Lambda^2 \to \infty$. Originally, Landau assumed that the bare charge $e_1^2 \ll 1$. From equation 14, it is clear that as Λ^2 increases, eventually $e_1^2 \gg 1$. This difficulty is eliminated by Pomeranchuk, who introduces two cut-offs, one for the intermediate bosons (photons) Λk, and one for the intermediate fermions (electrons) Λp, and $\Lambda p \gg \Lambda k \gg p, k$. [1] Results similar to those in equation 13 are obtained.

The conclusions to be drawn from equation 13 is somewhat startling. For, as long as $e_1^2 > 0$ (necessary for unitary S-matrix), irrespective of the variation of e_1^2 with Λ^2, we have the limiting conditions: as $\Lambda^2 \to \infty$ $e^2 \to 0$. Thus, choosing a point interaction corresponds to no physical interaction at all.

This work has been followed by many works in the USSR that apply the same analysis to other theories. 1/

It is essential to remember that in this analysis, Λ represents an upper limit to the momenta. If, for example, the photon momentum $k \gg \Lambda$, then Landau finds $\Gamma_\mu \to 0, \mu \to \infty$ rather than $\Gamma_\mu = \gamma\mu$. This is as it should be, because as the energy becomes very large, it is expected that the effect of the (presumably) small interaction will vanish. This result was also shown by Lehmann quite generally. 2/

APPENDIX C

Part I

THE QUANTUM FIELD THEORY WORK OF N. N. BOGOLYUBOV

N. N. Bogolyubov* is probably the most important Soviet contributor to quantum field theory at the present time. He has provided the first rigorous proof of the so-called "dispersion relations" for other than forward scattering and this work has greatly stimulated the most promising approach to quantum field theory at the present time.

In order to make a thorough appraisal of the work in quantum field theory of Bogolyubov and his collaborators, all available translated sources were read, including his published papers that are listed in Appendix E. The past year has seen an exchange arrangement under which preprints in quantum field theory and related topics are received from the Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna, USSR, in exchange for publications on the same general topics from comparable groups in the United States. Since Bogolyubov has recently been appointed director of the Laboratory of Theoretical Physics, this arrangement affords a good opportunity to follow his work. In addition to the exchange arrangement and published translations of Soviet articles, several other sources were used. For example, the page proofs of the first 428 pages of the forthcoming English version of the book Introduction to Quantum Field Theory by Bogolyubov and D. V. Shirkov have been obtained recently. Unfortunately, the page proofs from the entire book are not yet available, but those that have been received include the first 34 of the 52 sections of the book. When Bogolyubov visited the United States to attend the International Congress on Theoretical Physics at Seattle, Washington, in September 1956, he presented his findings on dispersion relations, which were definitely the most important presentation at this meeting. Because of the wide interest in his work, he left a manuscript on The Problems of the Thoery of Dispersion Relations (co-authors are Medvedev and Polivanov), which was subsequently translated and circulated. A revised version of the manuscript has also recently appeared in the Fortschritte der Physik. Bogolyubov later sent in an important mathematical supplement to this paper to the Congress and it was then translated. In view of the special importance of the paper, a careful study was made of the monograph of Bogolyubov and collaborators, and also of the mathematical supplement. Similar works by other authors have been studied. Thus a good background has been acquired to use in appraising the present work of Bogolyubov, even though not all of his works have been translated.

---

*This spelling is used to be consistent with the system of transliteration followed throughout this report even though the translations issued by the author spell the name Boboliubov and Bogolubov.

As is characteristic of many of the world's best mathematical physicists, Bogolyubov has made important contributions in several different fields. He is fundamentally a mathematician of great ability whose contributions to physics have been primarily the presentation of rigorous mathematical developments for conjectures or vague physical programs that were proposed by others. The nearest parallel among present Western workers might be Professor F. J. Dyson of the Princeton Institute for Advanced Study. He also began as a mathematician and has made contributions that are comparable quantitatively and qualitatively to those of Bogolyubov. Perhaps Bogolyubov's work is even more clearly mathematical than that of Dyson. An alternative Western parallel might be the late John von Neumann, although his contributions to mathematics are of a greater importance than those of Bogolyubov.

Bogolyubov first gained wide recognition for his work with N. Kryloff on nonlinear mechanics. A good summary of the basic work of Kryloff and Bogolyubov in this field is contained in the collection of papers translated by Solomon Lefschetz and published by the Princeton University Press in 1943 under the title: Introduction to Non-Linear Mechanics. This book gives a list of 40 references of the original Soviet papers of the authors. As Dr. Lefschetz stresses, this Soviet work introduced powerful new methods in nonlinear mechanics and gave new importance to this field. It also stimulated general developments in the theory of nonlinear differential equations.

Perhaps the next really outstanding contribution to Bogolyubov was in the general theory of the statistical methancis of interacting particles. In this field he contributed particularly to the problem of condensation of dense systems in approximate equilibrium. This field is too complex to review it here in great detail, but it should be mentioned that Bogolyubov did develop a hierarchy of differential equations usually called the BBGKY equations because they resulted from the work of the following people: Bogolyubov, Born, Green, Kirkwood, and Yvon. This hierarchy of equations replaces the Boltzmann equation of the more simplified presentations. Bogolyubov then showed a new approach of approximation to the solution of this hierarchy of BBGKY equations which depends primarily on classifying the various characteristic time intervals in the relaxation of a dense system. Much work still remains to be done in this field, but Bogolyubov's papers constitute the starting point for many investigations.

Bogolyubov has made some contributions to problems of the theory of the solid state. In 1950, he published an important paper on the polaron problem, which deals with the effects of the polarization of electrons within a crystal in such a way as to lead to a reduction in the electron's energy and possible localization of the electron through a "self-trapping" mechanism. The first approaches to this problem were made using a weak coupling expansion, i.e., an expansion in powers of the electron charge. Difficulties in this method of expansion occur that are similar to the difficulties of the perturbation theory of quantum electrodynamics, which have been discussed in this report. Bogolyubov developed a strong coupling limit, which involves expansion in inverse powers of the effective coupling constant. 1/ The approximation of Bogolyubov is still inadequate for an accurate treatment, and alternative approaches involving intermediate coupling have been developed by other workers (e.g., T. D. Lee and D. Pines). Much work remains to be done before a complete theory and quantitative agreement with experiment are obtained in this field, but the work of Bogolyubov was certainly an important contribution.

An even more important contribution by Bogolyubov to solid-state physics has been his recent contribution to the theory of superconductivity. Present theories of superconductivity, stemming from the theory of Frohlich, depend upon determining how the interactions between electrons can, under proper conditions, create a gap in energy between the lowest state of the system and the next highest state. Various workers have devised theories that predict this energy gap and a specific model was developed recently by Bardeen, Cooper, and Schrieffer. 2/ The theoretical results of Bardeen and his co-workers had many attractive features but artificially exclude many of the contributions that a general theory would predict. Bogolyubov developed a much more exact mathematical formulation, which returned to the original Hamiltonian of Frohlich rather than choosing an arbitrary model, and he showed how to obtain more rigorously an approximation that produced the same results as the theory of Bardeen. 3/ The problem of superconductivity is still not fully solved, but workers in this field generally agree that Bogolyubov's recent work has been a very important step.

It is not surprising that Bogolyubov has made outstanding contributions in statistical mechanics and in the theory of superconductivity as well as in quantum field theory, for there are many similarities in the mathematical treatment of these various fields of physics. In quantum field theory, the time dependence of relevant functions normally is given as $\exp[-iEt/h]$ where E is an energy. In statistical mechanical problems, the probability function depends upon the temperature through the function $\exp[-E/kT]$ where T is the absolute temperature. Thus we see that the time in the mathematical equations of quantum field theory correlates with an imaginary temperature in the equations of statistical mechanics. This analogy is only one of the similarities between statistical mechanics and field theory. Another is that the creation of field quanta can be made to correspond to a general excitation process in a statistical system. This mathematical similarity is in fact quite far-reaching and allows many statistical mechanical problems to be computed by the method of Feynman diagrams, which was developed for quantum field theory and is the principal technique for practical quantum-electrodynamical computations at the present time. Thus, many of the ablest physicists in quantum field theory (e.g., Feynman, Gell-Mann, Brueckner, T. D. Lee, C. N. Yang, and K. Watson) have recently made important contributions to statistical problems, just as Bogolyubov has done.

Functional Approach to Quantum Field Theory-Renormalization Group

Quantum field theory was originally developed by introducing non-interacting fields and then considering the coupling between these fields as a perturbation. This method of presentation has the advantage that the dependence of the original Lagrangian of the system on the field operators is usually given in a relatively simple form. However, these fields which correspond to "bare" particles without interactions do not describe the real physical particles, for even a real isolated particle interacts with the quantum fluctuations of the other fields in the vacuum. Thus, the renormalization problem had to be introduced so as to obtain the quantities corresponding to real quantities from those originally introduced in the theory. Because of the infinities involved in relating the real particles to "bare" particles, a new approach has been developed in recent years which attempts to define the basic theory entirely in terms of the quantities for real particles. Thus, it is assumed that the fields are already renormalized. In this case, one does not know explicity how the field operators enter into the Lagrangian or other important quantities, such as the scattering matrix S. Nevertheless, certain general mathematical relationships between these quantities can be determined. Bogolyubov has been one of the many people who have contributed to the development of these general mathematical formulations. One assumes that a quantity such as the scattering matrix is a general functional of the fields $\varphi(x)$ and introduces the concept of a functional derivative $\delta S/\delta\varphi(x)$. This functional derivative is a useful generalization of the idea of an ordinary derivative and it expresses the way in which S varies when the operator suffers a small alteration in the neighborhood of x. (This statement is nonrigorous but gives the general idea.) Bogolyubov published a paper in 1954 that contributed to the development of this formulation, and he and Shirkov have used it extensively in their work on the quantum theory of fields. Many quantities can be expressed very succinctly in terms of these functional derivatives, and Bogolyubov has used them to define the generalized currents of the theory and to reformulate the causality principle. In his work on the functional approach to quantum field theory, Bogolyubov was to a large extent simply stating the research results of other people in slightly different form.

Bogolyubov and Shirkov have also introduced the idea of a "charge renormalization group" in quantum field theory. This is a Lie group of transformations that can be introduced to clarify some of the ideas of the renormalization process and to remove some ambiguities in it. The technique has permitted the authors to clarify some of the steps in perturbation procedures and in particular to deal with some of the problems connected with the introduction of an artificial cut-off of large momenta. It is not felt that the work mentioned was of unusual importance, but it was certainly sound work that helped improve the formalism of quantum field theory and constituted the first appreciable contributions of Bogolyubov in quantum field theory.

Indefinite Metric

One of the major problems in quantum field theory is the introduction of infinities by the renormalization procedure. At first, workers in this field thought that these difficulties should be associated with the use of a perturbation procedure, but it was later proved by various theorists (principally Kallen of Sweden) that infinities must occur even if the theory is treated accurately without the use of the perturbation method. Kallen and Lehmann showed that the divergencies were a very essential property of the theory related to the singularities of the Green's functions.

In the case of the renormalized coupling constant, these functions are defined over all space-time, but become infinite on the light cone. It was hoped at first that these infinities in the Green's function might be removed, or at least decreased, by the normalization procedure. Kallen and Lehmann proved, by very general arguments, that the renormalized Green's functions must at least be as singular as the original functions. This result showed that it would be difficult to prove the logical consistency of quantum field theory. Furthermore, it seemed to prevent the construction of nonlinear theories of a satisfactory kind.

The Lehmann-Kallen theorem depended upon some very general mathematical postulates; one of these was that the appropriate space in which to describe the states of the quantum field is a "Hilbert space." This is a generalization of a vector space to an infinite number of dimensions. All of the states in this space have a positive norm, i.e., all vectors have positive length. Heisenberg and others suggested that the difficulties posed by the Lehmann-Kallen theorem could be avoided by introducing states of negative norm. These would correspond to states with a "negative probability." Such a space, in which the length of vectors can be either positive or negative, is said to have an "indefinite metric." These negative probabilities obviously have no direct physical meaning. Earlier, Gupta and Bleuler had used a theory with such an indefinite metric to carry out the quantization of the electromagnetic field in such a way as to properly eliminate the longitudinal photons, and they had shown how this indefinite metric does not need to lead to unphysical results if the real physical states are limited to the subspace of the states of positive norm. Bogolyubov and Shirkov considered in quite general fashion the usefulness of introducing such an indefinite metric. They find that there are difficulties with the use of indefinite metric and that its introduction does not appear to offer a particularly simple solution to the problems of nonlinear quantum field theories. Interest in the idefinite metric in quantum field theory stems now in great part from use of such a metric in the program of Heisenberg for a unified field theory for elementary particles. This program is still too indefinite to permit any clear appraisal. The publications by Bogolyubov and Shirkov as well as articles by their associates on the subject of the indefinite metric, such as a 1958 preprint by Medvedev and Polivanov entitled On a Classical Model of Indefinite Metric, indicate that Soviet workers are continuing their interest in this field.

Causality and Dispersion Relations

The work of Bogolyubov and collaborators on the rigorous derivation of dispersion relations in quantum field theory is believed to be the most important contribution that Bogolyubov has made in quantum field theory.

The work on the proof of the dispersion relations by Bogolyubov and his co-workers represented an outstanding piece of work which was extremely difficult from a technical standpoint. The most difficult part was the mathematical supplement, which appears to have been done by Bogolyubov alone. The methods that he used have since been simplified by Bremermann, Oehme and Taylor, who have restated his proof in terms of general theorems about the holomorphic envelopes of domains of many complex variables. However, some idea of the difficulty of Bogolyubov's theorem can be gained from the fact that it took these three expert workers over 6 months to restate Bogolyubov's proof; they agreed that it was very unlikely that they would have come to a proof of the theorem without Bogolyubov's theorem to guide them.

The essential step in these proofs, as has been clarified by Bremermann, Oehme and Taylor, is to extend functions which are originally proved to be analytic in a small domain, called D. Then by very general theorems it is proved that any function which is analytic in a domain D must also be analytic in a larger domain D, which is the pseudo-convex hull of D and is called the holomorphic envelope of D. While the domain D is by itself not large enough to prove the dispersion relations, the extended domain is.

The proof of Bogolyubov and his group stimulated many other workers. The current proofs for dispersion relations are found to be valid only for those values of Δ less than a certain maximum value of Δ_{max}.

As the proofs have been improved, the value of $\Delta_{\max}$ has been increased. This is done as better and better methods are found for approximating the holomorphic envelope. The Soviet workers' best value for $\Delta^2_{\max}$ was approximately $2\mu^2$ where μ is the pion rest mass. More recently an explicit representation has been found from the work of Dyson, Jost, and Lehmann, which allows one to extend the limit for $\Delta^2_{\max}$ to about $3\mu^2$. These last three workers have shown that the current methods of proof cannot be extended to greater value of $\Delta^2_{\max}$ because they have a counter example for which dispersion relations break down at this critical momentum transfer. This example is not sufficient to prove that the dispersion relation is not really valid for a great momentum transfer, for the current proofs do not make use of the unitary principle, which may easily extend the range of validity of the theorem.

Dispersion relations have now been proved for other processes in addition to pion-nucleon scattering. The methods of Bogolyubov, as extended to date by others, have not been sufficient to prove dispersion relations in many interesting cases. For example, dispersion relations for nonforward scattering of nucleons by nucleons cannot be proved rigorously. It is clear that the Soviets appreciate the great importance of Bogolyubov's achievement in this proof because it was cited as one of the major reasons that he was recently awarded the Lenin Prize.

Possible Future Work of Bogolyubov

Both in the USSR and in other countries, many applications of dispersion relations have been made. The Soviet workers have also applied dispersion relations to photo-production and scattering of pions by deuterons. The Soviets seem to be aware of the full potential of dispersion relations. They have begun considering relations in which Δ is varied and ω held fixed, which has recently shown promise of useful applications. All or nearly all the important work in the USSR on dispersion relations in quantum field theory is probably coming from the Laboratory of Theoretical Physics of the Joint Institute for Nuclear Research, Dubna, USSR; Bogolyubov is now director of this Laboratory and this work is presumably a result of his influence and interest in this field. Some idea of the amount of effort in this particular field in the USSR relative to the rest of the world may be indicated by the following comparison. A bibliography of all significant papers related to the development of dispersion relations in quantum field theory was found to contain a total of 187 papers of which 37 are by Soviets. 4/ The above comparison may be somewhat misleading because it is obviously easier to obtain papers of Western workers.

It is difficult to predict exactly what the future contributions of the Soviets will be in quantum field theory. The usefulness of the dispersion relations as such will probably decrease and emphasis will probably shift to other general consequences of the analytic properties of the scattering functions. Of course, this is a closely related field. Recent major achievements in this direction have been the proof of the "CPT theorem" in this way by the Swiss physicist Jost and a general proof of the connection between spin and statistics by Burgoyne and by Luders and Zumino. The Soviets have not as yet made an outstanding contribution in this particular direction, but there seems to be every reason to expect that they will do so. The Soviets are quite competent in the basic field of mathematics, which is most closely related to this particular field of physics; this is the theory of functions of several complex variables.

On a longer range basis, it is clear that new ideas are needed in quantum field theory and that a further development is very apt to require a combination of the methods already developed by Bogolyubov, the theory of functions of several complex variables, and a much more detailed understanding of such nonlinear relationships as the unitary principle. It appears that Bogolyubov will be as apt to make a fundamental contribution to this important field of mathematics as any other single worker in this field.

PART II

BOGOLYUBOV'S DERIVATION OF DISPERSION RELATIONS

The term "the assumption of causality", as used in current work in quantum field theory, refers to the physical assumption that "no effect can be observed before its cause." While this may seem to be a very obvious and trivial requirement, it actually places severe limitations on the mathematical properties of a theory that describes a linear scattering system. The nature of this mathematical correction and the need for it will be explained briefly. Assume that an input or source is introduced at the time $t=0$ and then removed almost immediately. Let $G(t)$ be a function that gives a time dependence of any resulting physical observable. This will be called an output scattered wave. The input at $t=0$ can excite many transients in the physical system and therefore an output $G(t)$ may continue to be observed for a long time after the input pulse has stopped. However, the output cannot occur before the input, and therefore $G(t)$ must equal 0 for $t < 0$. Let $g(\omega)$ be the Fourier transform of the output $G(t)$, which is given by

$$g(\omega) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} G(t)\, e^{i\omega t}\, dt .$$

Since $G(t)$ vanishes for $t<0$, the integration domain actually extends only from the time $t=0$ to $t=\infty$. The Fourier transform $g(\omega)$ is originally defined only for real frequencies ω. However, we can now extend this definition to complex values of ω using the property that

$$e^{i(\omega_r + i\omega_i)t} = e^{-\omega_i t} \cdot e^{i\omega_r t}$$

we note that the factor $e^{-\omega_i t}$ has absolute value less than 1 for all positive t and all positive ω_i; hence the factor depending on ω_i; only decreases the integral for $g(\omega)$. The damping factor is in fact a strong damping term since it is exponential, and it will therefore dominate any power of t that might be introduced by differentiating the expression for $g(\omega)$ with respect to ω under the integral sign. Using these properties, we can therefore show that the function $g(\omega)$ and all its derivatives are well defined for all values of ω such that $\omega_i > 0$. In this way, it can be proved that the function $g(\omega)$, originally defined only on the real ω-axis, can be extended into a function that is analytic in the upper half of the complex ω-plane. Furthermore, the presence of the damping factor $e^{-\omega_i t}$ implies that the values of the function in the upper half plane are always dominated by the values of the real ω- axis.

As is well known from the theory of complex variables, any function that is analytic in a region can be given by an integral formula around a contour about that region. This formula is called Cauchy's formula. Since the boundary of the upper half plane is the real axis, one can show in this way that the values of the function in the upper half plane are given by an integral around the real axis. Furthermore, as one lets a point in the upper half plane approach the real axis, one can prove in this way that the real part of the function g at any point on the real axis is given in terms of an integral involving only the imaginary part (except possibly for some constants if the function g is not properly bounded.) In this way, one sees that the causality function can be made equivalent to a "dispersion relation," which in the simplest cases takes the following form:

$$\mathrm{Re}\, g(\omega) = \frac{P}{\pi}\int_{-\infty}^{+\infty}\frac{\mathrm{Im}\, g(\omega')}{\omega'-\omega}\,d\omega' .$$

This simple dispersion relation is the type of mathematical relationship that is called a Hilbert transform. We have thus shown that the causality principle greatly restricts the function $g(\omega)$; once the imaginary part of this function is known for all frequencies, the real part can be determined by the above formula and the function $g(\omega)$ is analytic when extended into the upper half of the complex frequency plane. Furthermore, if both the real and the imaginary part of $g(\omega)$ are given only on a small interval of frequencies on the real axis, from the theory of analytic continuation it is known that the function $g(\omega)$ is then already determined at all other frequencies. If the physical function $g(\omega)$ at the low energy or low frequency region is known exactly, then it is known accurately at all other frequencies, including high frequencies where measurements might not otherwise be possible. Thus, from the causality principle relations are derived that permit the prediction of observable information on one kind from the exact knowledge of completely different observable information.

For example, if the function $g(\omega)$ is the forward scattering amplitude for the scattering of energy ω, then the imaginary part of g is determined by a measurement of the total absorption cross-section. This is the well known "optical theorem." Thus, the dispersion relation makes it possible to deduce the results of a forward scattering experiment from measurements on the total interaction cross-section. 1/

In application, the functions that occur in quantum field theory are complicated and depend on many parameters in addition to the time and frequency, but the assumption of causality leads to powerful restrictions on such quantities as scattering amplitudes, the scattering matrix, or the spectral representations of various expectation values of the physically important operators.

The causality assumption in quantum field theory is usually stated as the requirement that measurements at a space-time point **x** and at another space-time point x' cannot have any effect on one another if the two events are simultaneous with respect to some frame of reference. This is stated mathematically by the requirement that the field quantities at such points must commute. This is expressed by the following equation $\langle 2 | [A(x), B(x')] | 1 \rangle = 0$ for $(x-x')^2 < 0$, where A and B are any two local physical operators and $| 1 \rangle$ and $| 2 \rangle$ are any possible states of the system. A metric is used in which the space-time length is positive for time like directions and negative for special directions. 1/

The causality assumption alone is not enough for the derivation of dispersion relations in quantum field theory. In addition, we must use the following general limitations on our theory:

(1) Relativistic Invariance: The relativistic invariance of the theory demonstrates that the commutator expression written above must be Lorentz-invariant so that e.g., if $| 1 \rangle$ and $| 2 \rangle$ are both the vacuum state $| 0 \rangle$, this expectation value is a function of only the one 4-vector $(x-x')$ and not a function of both x and x' separately. Furthermore, such expressions can depend upon the four components of x-x' only through the Lorentz-invariants of these quantities when combined with the other vectors, tensors, etc., in the theory. Thus, the principle of relativistic invariance leads to a very large reduction in the number of variables of the theory and simplifies the form of many functions.

(2) Asymptotic Condition: It is assumed that each of the local field operators for the interacting system approaches (in a proper mathematical sense) a solution of the equations for a noninteracting system when the differences and times involved become infinite.

(3) Energy Spectrum: A natural assumption is made that a vacuum is the state of lowest energy, so that all other states have positive energy. Each operator of the theory then has a spectral representation in terms of the contributions from the states of different energy in the theory. These states include both discrete or bound states and continuum states.

One other very strong restriction that a true quantum field should satisfy is the unitary principle. This principle expresses the conservation of probability and is given mathematically by the requirement that the S-matrix must be unitary. This particular requirement has not been used fully in most of the proofs of dispersion relations that are discussed below.

Since the 1954 paper of Gell-Mann, Goldberger and Thirring, many workers have developed dispersion relations in quantum field theory. 2/ However, the original presentations lacked much rigor and the relations should properly have been considered as conjectures, although it was generally expected that they follow from very general principles. The relations were extremely valuable in theoretical physics; e.g., they allowed Anderson and his group to determine the Fermi-Yang ambiguity in the phase shifts for the scattering of pions. Furthermore, the dispersion relation for forward scattering allowed a general determination of the coupling constant between pions and nucleons. This was the first time that this basic coupling constant, which characterizes the strength of nuclear forces, could be determined in a manner free from the great difficulties of perturbation theory or other types of approximations. Many applications were made of the dispersion relations and they were found to be in good agreement with a wide variety of experimental results. However, there were many difficulties in proving the dispersion relations for particles with finite mass and for scattering in directions other than the exactly forward direction. The first rigorous proof of dispersion relations for the forward direction in field theory was given by the German physicist Symanzik. Only slightly later and independently Bogolyubov and his coworkers developed a proof of a dispersion relation for pion-nucleon scattering that was valid for all directions of scattering. The relation, which was conjectured earlier by Goldberger and others, involved relating scattering amplitudes for various energies ω, but all for the same value of the momentum transfer Δ.

This proof of dispersion relations was first shown to Western workers by Bogolyubov in Seattle and was then circulated in a paper entitled: The Problems of the Theory of Dispersion Relations by Bogolyubov, Medvedev, and Polivanov. While this proof is necessarily very intricate, it involves the following important parts:

(1.) The use of a particular representation for the scattering amplitude of pions of energy $A(\omega, \Delta)$ scattering of pions through momentum transfer Δ. This representation utilizes the spectral properties of vacuum operators in accordance with earlier investigation of Lehmann and others.

(2.) The expression for $A(\omega, \Delta)$ depends upon the rest mass M. When M^2 is positive, it is not possible to give an easy proof of dispersion relations. However, the relations are easily proved if the parameter M^2 is chosen less than $(-\Delta 2)$. The proof is therefore carried out first for such negative values of the M^2 and the necessary analytic properties of $A(\omega, \Delta)$ are proved in this case. Then an analytic continuation in the rest mass is made back to the physically meaningful real positive value.

In order to prove that this analytic extension is possible, use was made of a powerful theorem dealing with the analyticity domain of a certain generalized function of five complex variables and one real variable. The proof of the necessary properties of this function is provided in a mathematical supplement by Bogolyubov.

APPENDIX D

BASIC DATA LIST

The following list was extracted from the bibliography of appendix C, part II. It constitutes the basic data from which the tables in the discussion were drawn and upon which most of the conclusions are based.

The list gives the various authors, their institution, and the number of articles which they published, either alone, or jointly. The following data on Bogolyubov have been excerpted to use as an example in explaining the system:

		1953	1954	1955	1956	1957	1958
Bogolyubov, N. N.	Leningrad State Univ.	1:	2½	2 8/2	5/2		2/3 ¼

(1) Numbers appearing in any given column represent articles originally published in that year (usually in Russian), although abstracts and/or previews appeared at a later time.

(2) Numbers appearing to the left of the dotted vertical line under the 1953 column refer to articles found abstracted, etc., in 1953, but originally published before 1953.

(3) Whole numbers, or integers, refer to papers published by the man alone.

(4) Fractions refer to joint authorships.

<u>The denominator</u> indicates how many authors wrote the article (including the author opposite whose name the number appears).

<u>The numerator</u> indicates to how many distinct articles of that number of authors the particular author contributed.

Thus the 1 in the 1953 column opposite Bogolyubov's name indicates that he published one paper alone in 1953. In 1954, he published two alone and collaborated with another author on one article. In 1958, he collaborated with three authors on two separate articles; and he collaborated with four other authors in one more article.

~~FOR OFFICIAL USE ONLY~~

		1953	1954	1955	1956	1957	195
Abrikosov, A. A.	Inst of Physical Problems imeni S. I. Vavilov, Acad of Sciences, USSR		5/3 ½	1½	2 2/3		
Adirovich, E. I.	Physics Inst imeni P. N. Lebedev, Acad of Sciences, USSR		½				
Afrikyan, L. M.	Physics Inst imeni P. N. Lebedev, Acad Sciences, USSR				1	2	
Akhiyezer, A. I.	Ukrainian Physico-Technical Inst, AS, Ukrainian SSR	2/2		1/3		1	
Alekseyev, A. I.	Moscow Engineering Physics Inst					1	
Aleksin, V. F.	Ukrainian Physico-Technical Inst, AS, Ukrainian SSR			1/3 ½		½	
Arzhanykh, I. S.	Inst of Math and Mechanics imeni V. I. Romanovskiy, AS, Uzbek SSR				2		
Asanov, A. R.	Electrophysical Labs, AS, USSR				1		
Askaryan, G. A.	Physics Inst imeni P. N. Lebedev, AS, USSR		1				
Averbakh, V. L.	Physics Inst imeni P. N. Lebedev, AS, USSR	1½					
Avrorin, Ye. N.	Physics Inst imeni P. N. Lebedev, AS, USSR				½		

~~FOR OFFICIAL USE ONLY~~

~~FOR OFFICIAL USE ONLY~~

1958

		1953	1954	1955	1956	1957	1958
Barashenkov, V. S.	Chief Administrator, Main Administration for Utilization of Atomic Energy			1	2	3	2½
Baldin, A. M.	Physics Inst imeni P. N. Lebedov, AS USSR	½	1		1		
Bayer, V. N.	Inst of Physics, AS, Ukrainian SSR				½		
Bazarov, I. P.	Moscow State Univ				1		
Belenkiy, S. Z. (deceased 1956)	Physics Inst imeni P. N. Lebedev, AS, USSR			1½	1		
Belyayev, S. T.	Inst Atomic Energy, AS, USSR				½		
Berestetskiy, V. B.	Physics Inst imeni P. N. Lebedev, AS, USSR			3	½	½	
Bilenkiy S. M.	Joint Inst for Nuclear Research						1/3
Blank, V. Z.	Moscow State Univ			1	2½	1 1/3	
Blokhintsev, D. I.	Joint Inst for Nuclear Research	½		2		2	1
Bogolyubov, N. N.	Leningrad State Univ imeni A. A. Zhdanov	1½	2½	2 8/2	5/2		2/3/¼
Bonch-Bruyevich, V. L.	Moscow State Univ	1½	½	1	1	1/3	
Borgardt, A. A.	Dnepropetrovsk State Univ imeni 300th Anniv of Union of Russia and Ukraine	11		1	4	1	
Borovikov, V. A.					1		

~~FOR OFFICIAL USE ONLY~~

~~FOR OFFICIAL USE ONLY~~

		1953	1954	1955	1956	1957	
Brodskiy, A. M.	Moscow State Univ	1½+1/3		2/3	2	1	
Budker, G. I.	Inst of Nuclear Physics Siberian Dept, AS, USSR				1		
Buymistrov, V. M.	Inst of Physics, AS, Ukrainian SSR					½	
Bychkov, Yu. A.	Acad of Sciences, USSR					1	
Chavchanidze, V. V.	Inst of Physics, Acad Sciences, Georgian SSR			2	1		
Chernavskiy, D. S.	Moscow Mining Inst imeni I. V. Stalin		½				
Chang-Lee	Leningrad State Univ imeni A. A. Zhdanov					1	
Chou Kuang-Chao	Joint Inst for Nuclear Res (Lab of Theor Phys)						½
Chernavskiy, D. S.	Physics Inst imeni P. N. Lebedev, AS, USSR			½	½		
Cytovic, V.	Moscow State Univ		½				
Demkov, Yu. N.	Leningrad State Univ imeni A. A. Zhdanov		1				
Dolginov, A. Z.	Leningrad State Univ imeni A. A. Zhdanov				1	1	
Duan-I-Shi	Joint Inst for Nuclear Research				1	1	

~~FOR OFFICIAL USE ONLY~~

~~FOR OFFICIAL USE ONLY~~

		1953	1954	1955	1956	1957	1958
Dyatlov, I. T.	Leningrad Physico-Technical Inst, AS, USSR				½	1/3	
Dykman, I. M.	Inst of Physics, AS, Ukrainian SSR	½:					
Faddeyev, L. D.	Leningrad State Univ imeni A. A. Zhdanov				1		
Faynberg, V. Ya.	Physics Inst imeni P. N. Lebedev, AS, USSR			1½ 1/3	1½		
Fedorov, F. I.	Inst of Physics and Math, AS, Belorussian SSR				1		
Feynberg, Ye. L.	Physics Inst imeni P. N. Lebedev, AS, USSR			½	½		
Filimonov, G. F.	Moscow State Univ					½	
Fradkin, Ye. S.	Physics Inst imeni P. N. Lebedev, AS, USSR		2	6	1 2/2	2½	
Frenkel', Ya. I.	Deceased 1952	1:					
Galanin, A. D.	Inst Physical Problems imeni S. I. Vavilov, AS, USSR	3:	3 2/3	1/3	½	2	
Geylikman, B. T.	Moscow Pedagogical Inst imeni V.I. Lenin	5		2			
Gel'fand, I. M.	Moscow State Univ		½		1/3		
Ginzburg, I. F.	Moscow State Univ				1		
Ginzburg, V. L.	Physics Inst imeni P. N. Lebedev, AS, USSR	½:					½

~~FOR OFFICIAL USE ONLY~~

~~FOR OFFICIAL USE ONLY~~

		1953	1954	1955	1956	1957	1958
Gol'fand, Yu. A.	Physics Inst imeni P. N. Lebedev, AS, USSR			1	1	1	
Golubenkov, V. N.					½		
Gor'kov, L. P.	Inst of Physical Problems imeni S. I. Vavilov, AS, USSR			1½	1 2/2	2	
Grigoryev, V. I.	Moscow Petroleum Inst imeni I. M. Gubkin	½:2			1	2	
Gurevich, A. V.	Moscow State Univ	1			1		
Gurzhi, R. N.	Physics Inst imeni P. N. Lebedev, AS, USSR					1	
Hing Hu	Joint Inst for Nuclear Research					1	
Heber, Va. G.	Joint Inst for Nuclear Research						1
Ingarden, R. S.	Physics Inst, Polish Acad of Sciences	2			1	1	
Ioffe, B. L.	Acad of Sciences, USSR	½:	2 1/3	1/3	1 1/3		
Ivanenko, D. D.	Moscow State Univ	2 4/2: 1/3 3/2	2/2 2/3	½	½	1/3	
Izmirilov, S. V.		1:				½	
Kalitsin, N. S.	State Univ of Bulgaria	2			1	1	
Karpman, V. I.	Minsk Pedagogical Inst imeni A. M. Gorkiy	1:1			1	1	
Kaschluhn, F.	Joint Inst for Nuclear Research						2

~~FOR OFFICIAL USE ONLY~~

		1953	1954	1955	1956	1957	1958
Kerimov, B. K.	Moscow State Univ			½	2/2	2/2	
Khalatnikov, I. M.	Inst of Physical Problems imeni S. I. Vavilov, AS, USSR		4/3 ½	1 3/2 1/3	1½ 2/3	1	
Khalfin, L. A.	All-Union Inst of Prospecting Physics				1		
Khlebnikov, A. K.	Acad of Sciences, USSR				1/3		
Khokhlov, Yu, K.	Physics Inst imeni P. N. Lebedev, AS, USSR		1				
Khristov, Kh. Ya.	Moscow State Univ				1		
Kirzhnits, D. A.	Physics Inst imeni P. N. Lebedev, AS, USSR		1		2	1	
Klepikov, N. P.	Lab of Nuclear Problems, Joint Inst for Nuclear Research	1/3		1	1	2	
Klimontovich, Yu.L.	Moscow State Univ	1½:	1		1	1	
Kobozev, N. I.	Moscow State Univ			1			
Kolesnikov, N. N.	Moscow Power Engineering Inst imeni G. M. Krzhizhanovskiy	½:				1	
Kompaneyets, A. S.	Inst of Chem Physics, AS, USSR		1				
Korst, N.	Moscow State Univ			1/3			
Krokhin, O. N.	Acad of Sciences, USSR				1/3		

~~FOR OFFICIAL USE ONLY~~

		1953	1954	1955	1956	1957
Krolikowski, W.	Inst of Physics, Polish Acad of Sciences				½	
Kudryavtsev, V. S.						
Kuni, F. M.	Leningrad State Univ imeni A. A. Zhdanov				1 1	
Kunin, P. Ye.	Latvian State Univ	½				
Kurdgelaidze, D. F.	Moscow State Univ	1/3	1½			½
Kurtenkov, L. A.						1
Landau, L. D.	Inst of Physical Problems, imeni S. I. Vavilov, AS, USSR	1	4/3	1 2/2	1 2/3	1
Lapidus, L. I.	Lab of Nuclear Problems, Joint Inst for Nuclear Research			½	3	
Lebedev, V. I.	Moscow State Univ	½				
Lipmanov, E. M.	Novozybkov Pedagogical and Teachers Inst	2:2		2		
Livshits, M. S.	Inst of Physical Problems imeni S. I. Vavilov, AS, USSR			3	1	
Logunov, A. A.	Moscow State Univ		1	3½	1½ 1/3	1/3
Lomsadze, Yu. M.	Science Res Inst of Physics, Moscow State Univ			3	1	

~~FOR OFFICIAL USE ONLY~~

		1953	1954	1955	1956	1957	1958
Maksimenko, V. M.	Physics Inst imeni P. N. Lebedev, AS, USSR					1	
Markov, M.	Physics Inst imeni P. N. Lebedev, AS, USSR	1		1	2		
Matveyev, A. N.	Moscow State Univ	1		1 1/3	1		
Mayer, M. E.	Joint Inst for Nuclear Research						½
Medvedev, B. V.	Math. Inst imeni V. A. Steklov, AS, USSR	3/2⁝ ½		2	1	2	½ ¼
Mickevic, N. V. (Miskevich)	Moscow State Univ			1			
Migdal, A. B.	Acad of Sciences, USSR			½		1	
Mikhaylov, V.	Physics Inst imeni P. N. Lebedev, AS, USSR	½					
Minlos, R. A.			½				
Mirianashvili, M. M.	Moscow State Univ	1⁝			½		
Natanzon, M. S.		1					
Neganov, B. S.	Joint Inst for Nuclear Research					2	
Nelipa, N. F.	Physics Inst imeni P. N. Lebedev, AS, USSR	1⁝	1				
Novozhilov, Yu. V.	Leningrad State Univ imeni A. A. Zhdanov	2⁝1	2	1	1	3	

		1953	1954	1955	1956	1957	195
Ogiyevetskiy, V. I.	Electro Physical Lab. - Now part of Joint Inst for Nuclear Research				2		
Okun, L. B.	Joint Inst for Nuclear Research					½	
Ovsyannikov, L. V.					1		
Parasyuk, O. S.	Inst Mathematics, AS, Ukrainian SSR			2	½		
Pekar, S. I.	Inst of Physics, AS, Ukrainian SSR	½	3	1	2½		
Peterson, V. R.		1					
Petras, M.				1			
Podgoretskiy (M. I.)	Physics Inst emini P. N. Lebedev, AS USSR					1	
Pokrovskiy, V. L.	Yeniseysk Teachers Inst					1 2/2	
Poliyevktov-Nikoladze, N. M.		1		2½			
Polivanov, M. K.	Moscow State Univ			1			5/4/1/3
Polovin, R. V.		1			1		
Pomeranchuk, I. Ya.	Leningrad Physico-Technical Inst, AS, USSR		1/3	4½ 1/3	2 1/3		
Pontecorvo, B. (M.)	Joint Inst for Nuclear Research (Formerly an Italian citizen; now a Soviet)					½	
Popovici, A.						1	

~~FOR OFFICIAL USE ONLY~~

1958

2/2

5/4/1/3

½

1

		1953	1954	1955	1956	1957	1958
Pugachev, Ya. I.		½					
Rayski, G.	Inst of Theor Phys (Poland) Copernicus Univ				1	1	
Ryazanov, M. I.	Moscow Engineering-Phys Inst					1	
Ritus, V. I.	Physics Inst imeni P. N. Lebedev, AS USSR				1	2	
Rosental, I. L.	Physics Inst imeni P. N. Lebedev, AS, USSR		½	1			
Rudik, A. (P.)	Inst Physical Problems imeni S. I. Vavilov, AS, USSR	½:			1/3		
Rumer, Yu. B.	Yeniseysk Teachers Inst	3:2				½	
Ruusik, I. Kn.	Inst of Physics and Astronomy, Acad of Sciences, Estonian SSR		1				
Ryazanov, G. V.	Moscow State Univ					1	
Ryndin, R. (M.)	Lab of Nuclear Problems, Joint Inst for Nuclear Research			½			
Rzewuski, J.	Polish physicist	2			½		
Sannikov, D. G.					½		
Shirkov, D. V.	Moscow State Univ		½	½			
Seldowitsch, J. B. (See Zel'dovich, Ya. B.)					1		

~~FOR OFFICIAL USE ONLY~~

~~FOR OFFICIAL USE ONLY~~

		1953	1954	1955	1956	1957	1958
Shapiro, I. S.	Moscow State Univ	2:	2		1		
Shirkov, D. K.				5/2	4/2	2/2	2/2
Shirokov, M. F.	Moscow Aviation Inst imeni S. Ordzhonikidze		½				½
Shirokov, Yu. M.	Moscow State Univ	2:3½	2	1	1½	3½	
Silin, V. D.	Physics Inst imeni P. N. Lebedev, AS, USSR	1	1	1½1/3			
Sirkov, D. V.				1			
Skobelkin, V. I.	Moscow State Univ		1				
Smorodinskiy, Ya. A.	Lab of Nuclear Problems, Joint Inst for Nuclear Research			½			
Sokolik, G. A.	Moscow State Univ		½	1	1	½	
Sokolov, A. A.	Moscow State Univ	2:3/2 1/3		1½ 1/3	2 3/2	1 2/2	1 1/3
Sokolov, S. N.	Joint Inst for Nuclear Research					1	
Sokolov, L. D.	Lab of Nuclear Problems, Joint Inst for Nuclear Research				1	1	
Solovyev, L. D.					1	1	
Solovyev, V. G.	Lab of Nuclear Problems Joint Inst for Nuclear Research				2	2	1
Solovyev, A. N.	Moscow State Univ					1/3	
Stepanov, B. M.	Moscow State Univ			1	1½		

~~FOR OFFICIAL USE ONLY~~

1958

2/2 ¼

½

/2 1 1/3

1

/3

		1953	1954	1955	1956	1957	1958
Stratonvich, R. L.	L'vov State Univ imeni I. Franko				1		
Sudakov, V. V.	Leningrad Physico-Technical Inst				3 2/2 1/3	1/3	
Suffezynski, M.	Polish physicist		1				
Svidzinskiy, A. V.	Moscow State Univ				1		
Taksar, I. M.	Latvian State Univ	1	½			½	
Tal'yanskiy, I. I.	Livov State Univ imeni I. Frando		1				
Tamm, I. Ye.	Physics Inst imeni P. N. Lebedev, AS, USSR	½: 1/3		1/3		1	
Tarasov, Yu. A.	Moscow State Univ				1		
Temko, S. V.					1		
Tavkelidze, A. N.	Joint Inst Nuclear Research, Moscow State Univ					½ 1/3	
Terletskiy, Ya. P.	Science Research Inst of Physics, Moscow State Univ	1:	1		2	1	
Ter-Martirosyan, K. A.	Physico-Technical Leningrad Inst, AS, USSR				1 3/2 1/3		
Ternov, I. M.	Moscow State Univ	½ 1/3		1/3			
Tevikyan, R. V.	Yerevan State Univ imeni V. M. Molotov				1	1	
Tsytovich, V.N.	Moscow State Univ				½		
Tulub, A. V.	Leningrad State Univ imeni A. A. Zhdanov				½		

		1953	1954	1955	1956	1957	1958
Tumanov, K. A.	Moscow State Univ	1½	1		½		
Tyablikov, S. V.	Math. Inst imeni V. A. Steklov, AS, USSR	3:2					
Ulegla, I.	Joint Inst for Nuclear Research					1	
Verle, I. I.		1					
Volkov, D.				1/3			
Votruba, V.	Joint Inst for Nuclear Research (Polish physicist)						½
Vyalov, G. N.	Physics Inst imeni P. N. Lebedev, AS, USSR				1		
Yaglom, A. M.	Inst Geophysics, AS, USSR				½		
Yaichnitsyn, V. G.	Dnepropetrovsk State Univ imeni 300th Anniv of the Union of Russia and the Ukraine				1		
Yappa, Yu. A.	Leningrad State Univ imeni A. A. Zhdanov	1:		1			
Yeleonskiy, V. M.	Ural Polytech Inst imeni S. M. Kirov					1	
Zaytsev, G. A.	Ivanovo Chemico-Technology Inst	3		5		1	
Zartavenko, L. G.	Joint Inst for Nuclear Research					¼	
Zel'dovich, Ya. B. (Same as Seldowitsch, J. B.)	Inst of Chemical Physics, AS, USSR	1:			1		

FOR ~~OFFICIAL USE~~ ONLY

		1953	1954	1955	1956	1957	1958
Zharkov, G. F.	Physics Inst imeni P. N. Lebedev, AS, USSR	1			1		
Zyryanov, P. S.	Ural Polytechnical Inst imeni S. M. Kirov					1	

FOR ~~OFFICIAL USE~~ ONLY

APPENDIX E

BIBLIOGRAPHY

This bibliography is a complete listing of all the articles of interest in this study. It was compiled by canvassing all the appropriate available journals* on quantum field theory. Where an article has been abstracted or reviewed, those references are also shown.

About 25 of the articles listed in the bibliography are preprints from the Joint Institute for Nuclear Research in Moscow. These articles are designated by the word "Preprint" in parentheses at the end of the citation.

Abrikosov, A.A.

"On the Compton Effect and Mutual Scattering of Particles at High Energy in Quantum Electrodynamics and Pseudoscalar Theory," DAN 102, 1097** NSA 6551 (1955)

"On the Infrared Catastrophe in Quantum Electrodynamics," ZhETF 30, 96 (1956). MR 18, 174 (1957) Phys Abs 4811 (1956)

"Scattering of High Energy Electrons by Electrons and Positrons," ZhETF 30, (1956). Phys Abs 6704 (1956)

-----and Khalatnikov, I.M.

"Asymptotic Expression for Green's Function of Electrons in Quantum Electrodynamics," DAN 95, 773 (1954). NSA 4469 (1954)

"The Use of Two Limiting Momenta in Field Theories," DAN 103, 993 (1955) MR 17, 565 (1956)

-----and Galanin, A.D. and Khalatnikov, I.M.

"Green's Functions in the Theory of Mesons with a Weak Pseudoscalar Coupling," DAN 97, 793 (1954). MR 16, 317 (1955)
NSA 7145 (1954)
Phys Abs 7970 (1956)

-----and Galanin, A.D.; Joffe, B.L.; and Pomeranchuk, I.Ya.

"Green's Functions in Meson Theories," Nuovo Cim VIII, 782 (1958)

---

*Abbreviations for the journals are found at the end of the bibliography.

**In these citations, the underlined number appearing after the name of the journal indicates the volume, and the second number indicates the page. For example, DAN 102, 1097 shows that the article appeared in DAN, volume 102, page 1097. The number in parentheses is the year of publication. The numbers following the citations for Physical Abstracts indicate the abstract number. In cases where an article, or an abstract of it has appeared in other sources, they have also been listed.

Abrikosov, see Landau, L.D.

Adirovich, E.I. and Podgoreckii, M.I.
"On the Interaction of Microsystems with Zero-point Fluctuations of an Electromagnetic Field," ZhETF 26, 150 (1954).
MR 16, 101 (1955) Phys Abs 9914 (1954)

Afrikyan, L.M.
"Multiple Pair Production in Quantum Electrodynamics," ZhETF 33, 531 (1957) JETP 6, 414 (1958)

"On the Theory of Creation and Annihilation of Anti-protons," ZhETF 30, 734 (1956) A: 1, 443 (1957)

"Theory of the Production of Electron Positron Pairs in Collisions of Slow - Mesons with Nuclei," ZhETF 33, 280 (1957)
JETP 6, (1958)

Akhiyezer, A.I. (also Akhiezer)
"Diffracted Radiation of Photons by Particles with Spin 1/2," DAN 94, 651 (1956). MR 16, 548 (1955)
Phys Abs 1892 (1957)

-----and Polovin, R.
"Radiative Corrections to the Scattering of Electrons by Electrons," DAN 90, 55 (1953). Phys Abs 8223 (1953)

"Removal of Divergencies in Quantum Electrodynamics," UFN 51, 3 (1953). MR 16, 317 (1955) NSA 1264 (1954)

-----and Aleksin, V., and Volkov, D.
"On Some Effects Resulting from the Interaction of an Electromagnetic Field with a Vacuum of Scalar Charged Particles," DAN 104, 830 (1955). MR 17, 1034 (1956)

Alekseyev, A.I.
"Covariant Equation for Two Annihilating Particles," JETP 5, 696 (1957) NSA 12, 8 (1958)

Aleksin, see Akiezer

Aleksin, V.F., and Volkov, D.V.
"Radiation Corrections to Particle Scattering in External Field and to Compton Effect in Scalar Quantum Electrodynamics," ZhETF 33, 1044 (1957) JETP 6, 803 (1958)

"Interaction of the Electromagnetic Field with the Vacuum of Nuclear Charge of Particles," DAN 104, 830 (1955). NSA 1964 (1956)

Arzhanykh, I.S.
"Coupled Systems of the Meson Field," DAN 110, 351 (1956).
Phys Abs 1903 (1957) A: 1631
MR 19, 365 (1958)

"Representation of the Meson Field by Retarded Potentials," DAN 110
953 (1956). Phys Abs 3960 (1957) A: 1792
NSA 3624 (1957)
MR 19, 2 (1958)

Askar'yan, G.A.
On the Effect of the Oscillation of the Meson Shell of Nucleons
on the Probability of Particle Interactions," ZhETF 26,
751 (1954) NSA 458 (1955)

Asanov, A.R.
"Note on a Variant of Non-Local Field Equations," ZhETF 30, 619
(1956). Phys Abs 98 (1957)

Averbakh, B.L. (also Auerbach)
-----and Fradkin, E.S.
"Renormalizability of Pseudoscalar Meson Theory with Pseudovector
Coupling," ZhETF 30, 756 (1956); sup to 30, no 4,7.
JETP 3, 862 (1957)
MR 18, 176 (1957)
NSA 4206 (1957)
Phys Abs 7129 (1956)

Baldin, A.
"On a Rule for the Interaction of the Electromagnetic Field with
Nucleon and Mesonic Field," Nuovo Cim III, series X,
no 1 (1956).

"Isotopic Invariance of π-Meson Field" DAN 96, 949 (1954)
NSA 6002 (1954)

-----and Mikhailov, V.
"On the Two Types of Charge Invariance," DAN 91, 479 (1953).
NSF, tr, 101 Phys Abs 3101 (1954)

Barashenkov, V.S.
"Compton Effects in the Extended Electron," ZhETF 71, 694 (1956)
JETP 4, 559 (1957)

"The Construction of a Phenomenological Scattering Matrix with Non-local Interaction," ZhETF 32, 368 (1957) JETP, 5, 313 (1957)
Phys Abst 7613 (1957)

"Contribution to the Theory of Non-local Interactions," ZhETF 31,
837 (1956). Phys Abs 2975 (1957)
JETP 4, 5 (1957)
NSA 12, 4, (1958)
A: 1773

"Some Observations on Possible Formulations of the Theory of
Extended Particles," ZhETF 28, 579 (1955).
JETP 1, 467 (1955)
MR 17, 221 (1956)
NSA 6041 (1956)
Phys Abs 7694 (1955)

"On the Renormalizability of the Hamiltonian Formulation of Theory
with the Form-Factor," Nuovo Cim V, 1469 (1957)

"Concerning Some Possibilities of Formulation of a Relativistically
Invariant Theory of Extended Particles," ZhETF 32, 566 (1957)
JETP 5, 470 (1957)
NSA 12, 6 (1957)

-----and Barbasev, B.M.
"Statistical Weight of a System of Particles with Arbitrary Spins,"
Joint Institute for Nuclear Research, Laboratory of Theoretical
Physics - Nuovo Cim, sup VII, series X, no 1 (1958)

"Statistical Theory of Particle Multiple Production in High Energy
Nucleon Collisions." Joint Institute for Nuclear Research,
Laboratory of Theoretical Physics, Nuovo Cim, sup VII,
series IV, no 1 (1958)

"Electrical Polarizability of the Meson Cloud in a Nucleon," Joint
Institute for Nuclear Research - Laboratory of Theoretical
Physics. A: P-169 (1958) (Preprint)

Barbasev, B.M. see Barasenkov, V.S.

Baiyer, V.N.
-----and Pekar, S.I.
"Strong Coupling Nucleomesodynamics. II. The Ground and Isobar
States, Nucleon Charge and Spin," ZhETF 30, 317 (1956);
sup to 30, no 2,6.
JETP 3, 340-350 (1956).
MR 18, 174 (1957)
NSA 2206 (1957)
Phys Abs 4836 (1956)
A: B-6

Bazarov, I.P.
"Equations with Variational Derivatives and Distribution Functions for Systems with Complex Interaction," DAN 110, 38 (1956). Soviet Physics Doklady 1, 520 (1956)

Belen'kiy, S.Z.
"Connection Between Scattering and Multiple Production of Particles," (1956). Nuclear Physics 2, 259 (1957)

"Theory of Multiple Production of Particles at High Energy," ZhETF 28, 111 (1955). NSA 4025 (1955)

-----Landau, L.D.
"Hydrodynamische Theorie der Mehrfacherzeugung von Teilchen," UFN 56, 309 (1955) Fort der Phys 3, 536 (1955)

Belyayev, S.T.
-----and Budker, G.I.
"The Relativistic Kinetic Equation," Proceedings of the Academy of Sciences, USSR, 107, 6 (1956) Soviet Physics Doklady 1, 2 (1956)

Berestetskiy, V.B., (also Beresteckii, V.B.)
"Asymptotic Behavior of Electromagnetic Polarization of the Vacuum in the Presence of Meson Interactions," ZhETF 29, 585 (1955).
JETP 2, 540 (1956)
MR 17, 922 (1956)
Phys Abs 2638 (1956)

-----and Byokkov, Yu. A.
"K-Meson Scattering with Change of Intrinsic Parity," Nuclear Physics 3, 153-156 (1957)

-----and Kroklin, O.N. and Khlebnikov, A.K.
"Radiative Correction to the Magnetic Moment of the u-meson," ZhETF 30, (1956). Phys Abs 7127 (1956)

Bilenkiy, S.M., see Bogolyubov, N.N.

Blank, V.Z.
"Behavior of the Green's Function of the Electron for Small Momenta," DAN 104, 706 (1955). MR 17, 1032 (1956)

"Behavior of the Vertex Part at High Energies," DAN 107, 389 (1956). Phys Abs 4810 (1956)

"Application of a Renormalized Group to Different Scattering Problems in Quantum Electrodynamics," ZhETF 32, 932 (1957) JETP 5, 759 (1957)
NSA 12 no. 8 (1958)
Phys Abst 8378 (1957)

-----and Shirkov, D.V. (also Sirkov, D.V.)
"Asymptotic Investigation of Vertex Part in Quantum Electrodynamics," DAN 111, 1201 (1956). Phys Abs 5040 (1957)

"Inverse Dispersions Relations," ZhETF 33, 1251 (1957)
JETP 6, 962 (1958) (Preprint)

"Improvement of Quantum Electrodynamics Perturbation Theory with Help of Renormalization Group." Nuclear Physics 2, 356 (1956)
Phys Abs 5829 (1957)

-----and Bonch-Bruevich, V.L., and Shirkov, D.V.
"Remarks on the Multiplication Renormalization Group in Quantum Theory of Fields," ZhETF 33, 265 (1957)
JETP 6, 204 (1958)
Phys Abs 61, 724
NSA 8894 (1958)

Blokhintsev, D.I.
"A Non-Hamiltonian Method in the Theory of Elementary Particles," ZhETF 17, 266 (1947)

"Non-Linear Field Theory and the Theory of Relativity," Nuovo Cim, III, sup 629 (1955)

"Non-Local and Non-Linear Field Theories," UFN 61 (1957)
NSA 7381 (1957)
Phys Abs 5840 (1957)

"Theory of Nucleons" ZhETF 29, 33 (1955).
JETP 2, 23 (1956)
Phys Abs 8496 (1955)

"When Does a Weak Interaction Become Strong?" Joint Institute of Nuclear Research (1957) NSA 12, no 2 (1958)

"On a Possible Limit of the Applicability of Quantum Electrodynamics," Joint Institute for Nuclear Research (Preprint)
A: P-148 (1958)

Bogolyubov, N.N.
"Casual Operators in Quantum Field Theory," DAN 99, (1954)

"Condition of Casuality in the Quantum Theory of Fields," IAN 19, 237 (1955). NSA 7595 (1955)

"Equations with Variational Derivatives in Problems of Statistical Physics and Quantum Field Theory," Moscow State University 10, no 4-5, 115-124 (1955). Phys Abs 5817 (1957)

"Foundation of Relativistic Quantum Field Theory," DAN 81, 757 (1951) Abhandlungen aus der Sowjetischen Physik, Folge IV, p 7-10 Verlag Kultur and Fortschritt, Berlin, 1954 MR 13, 71 (1954) MR 17, 112 (1956) (German tr)

"On Representation of Green-Schwinger Functions by Means of Functional Integrals," DAN 99 225 (1954).
MR 16, 778 (1955)
Phys Abs 7954 (1956)

"On a New Form of Adiabatic Perturbation Theory in the Problem of Particle Interaction with a Quantum Field," Ukran Mat Zh, 2.
MR 19, no 3 (1958)

"On a Variational Principle in the Many-body Problem," DAN, SSSR 119, 244 (1958), Phys Abs 3719 (1958)

-----and Parasyuk, O.S.
"On the Analytic Continuation of Generalized Functions," DAN 109, 717 (1956) (Preprint)
MR 18, 404 (1957)

"On the Theory of Multiplication of Causal Singular Functions," DAN 100, 25 (1955).
MR 17, 112 (1956)
Phys Abs 7955 (1956)

"On the Subtractive Formalism in Multiplication of Causal Singular Functions," DAN 100, 429 (1955)
MR 17, 112 (1956)
Phys Abs 7956 (1956)

-----and Shirkov, D.V. (also Sirkov, D.V.)
"Application of the Renormalization Group to Improvement of Formulas in Perturbation Theory," DAN 103, 391 (1955).
MR 17, 441 (1956)
NSA 802 (1957)
Phys Abs 82 (1957)

"Charge Renormalization Group in Quantum Field Theory," Nuovo Cim (10) 3, 845 (1956)
MR 17, 1260 (1956)
Phys Abs 4805 (1956)

"A Model of Lee Type in Quantum Electrodynamics," DAN 105, 685 (1955). MR 17, 1033 (1956)

"Multiplicative Renormalization Group in Quantum Field Theory," ZhETF 30, 77 (1956). MR 17, 1260 Phys Abs 4806 (1956)

"The Multiplicative Renormalization Group in the Quantum Theory of Fields," JETP 3, 57 (1956) MR 18, 1106 (1957)

"Problems in the Quamtum Theory of the Field," UFN 57, 3 (1955). Phys Abs 4182 (1956)

"Problems in Quantum Field Theory," UFN 55, 149 (1955). NSA 4907 (1955) Phys Abs 902 (1956)

"On the Renormalization Group in Quantum Electrodynamics," DAN 103, 203 (1955). MR 17, 441 (1956) NSA 720 (1955) Phys Abs 81 (1957)

-----and Shirkov, D.V.

"Problem der Quantem feld Theorie," UFN 52, 189 (1954) Fort d Phys 4, 438 (1956)

"Problems der quantem theorie der Felder," UFN 55, 149 (1955) Fort d Phys 3, 439-495 (1955)

-----and Zubarev, D.N.

"Wave Functions of Lower States of Interacting Bose Particles Systems," ZhETF 28, 129 (1955)

-----and V.S. Vladimirov

"On the Analytic Continuation of Generalized Functions," (1957) (In Russian) A: Joint Institute of Nuclear Research (Preprint)

-----and Bilenky, S.M. and Logunov, A.A.

"Dispersion Relations for Weak Interactions," Nuclear Physics 5, no 2 383-389 (1958)

"Dispersion Relations in the Case of Weak Interactions," DAN 115, 891 (1957) Phys Abs 2789 (1958) (Preprint)

-----and Medvedev, B.M. and Polivanov, M.K.

"On the Indefinite Metric in Quantum Field Theory," Dubna, 1958. Joint Institute for Nuclear Research. A: P-176 (Preprint)

-----and Medvedev, B.V. and Polavamov, M.K. and Shirkov, D.V.
"Problems of the Theory of Dispersion Interrelationships," Joint Institute of Nuclear Research, Laboratory of Theoretical Physics (1957) NSA 12, no 2 (1958) (Preprint)

Bonch-Bruyevich, V.L. (also Bonc-Bruevic, V.L.)
"Adiabatic Approximation in the Theory of the Green's Function," DAN 105, 689 (1955). MR 17, 1032 (1956)

"Spectral Representation of the Green's Function in the Non-relativistic Many-body Problem," ZhETF 31, 522 (1956). JETP 4, 456 (1957) Phys Abs 1885 (1957) A: 1664

-----and Medvedev, B.V.
"The Bringing of the Product of Operators to Canonical Form in the Theory of Second Quantization," ZhETF 25, 410 (1953). Phys Abs 39 (1955)

"On the Invariant Construction of a Quantum Theory of Fields. II." ZhETF 22, 425 (1952) MR 14, 227 (1953) NSA 1307 (1953)

Bonch-Bruevich, V.L. see Blank, V.Z.

Bonch-Bruevich, V.L. see Medvedev, B.V.

Borgardt, A.A.
"On the Theory of Meson Fields. I. Vector Field of General Type in the Vacuum," ZhETF 24, 24 (1953). NSA 7190 (1954) Phys Abs 9918 (1954)

"On the Theory of Meson Fields. II. Field with Sources," ZhETF 24, 284 (1953). NSA 7191 (1954) Phys Abs 9919 (1954)

"On the Theory of Meson Fields. III. Conservation of Physical Quantities," ZhETF 30, 330 (1956); Supplement to 30, no 2,6. MR 18, 96 (1957) NSA 2207 (1957) Phys Abs 4837 (1956)

"The Gravitational Self Energy of Particles in the Classical Field Theories," ZhETF 28, 377 (1955) JETP 1, 380 (1955) NSA 2958) (1955)

"Matrix Aspects of the Theory of Bosons." ZhETF 30, 334 (1956); sup to 30, no 2,6. MR 18, 96 (1957) NSA 809 (1957) Phys Abs 4851 (1956)

"Non-linear Meson Field of a Nucleon at Rest," DAN 109, 1107 (1956).
Phys Abs 1901 (1957)
A: 1600
MR 19, no 3 (1958)

"Non-linear Meson Field Equations," ZhETF 33, 60 (1957).
JETP 6, 43 (1958)
NPA 8889 (1958)
Phys Abs 2800 (1958)

"Pseudoscalar Interaction in Non-linear Mesodynamics," DAN 110, 42 (1956) Soviet Physics Doklady 1, 624 (1956)
Phys Abs 1902 (1957)
A: 1475
NSA 7614 (1958)

Borovikov, V.A.

"One Topological Problem Connected with Problems in Quantum Electrodynamics," Uspekhi Matem. nauk. 11, no 3, 113-118 (1956).
A: B-5

Brodskiy, A.M.

"General Theory of Meson Scattering," DAN 111, 787 (1956).
Phys Abs 3963 (1957)
MR 18, 10 (1957)

"On the Derivation of the Low Equation in the Theory of Meson Scattering," ZhETF 32, 616 (1957)
JETP 5, 509 (1957)
Phys Abs 61, 721 (1958)

"Problem of Renormalization in Mesodynamics," DAN 105, 939 (1956).
MR 17, 1034 (1955)
Phys Abs 1062 (1957)

-----and Ivanenko, D. and Korst, N.

"Difference of Masses of Elementary Particles," DAN 105, 1192 (1955).
MR 18, 97 (1957)

Brodskiy, A.M. see Ivanenko, D.

Budker, G.I. see Beliaev, S.T.

Buymistrov, V.M. and Pekar, S.I.

"Quantum States of Particles Coupled to a Harmonically Oscillating Continuum with Arbitrary Strong Interaction, I"
"Case of Absence of Translational Symmetry," ZhETF 32, 1193 (1957).
JETP 5, 970 (1957)

Byckkov, Yu. A. see Beretelsky, V.B.

Chang Lee
"Stationary States of Electron-Positros Systems and Annihilation Transitions," ZhETF 33, 365 (1957)
JETP 6, 281 (1958)

Chavchanidze, V.V.
"On the Equations of Quantum Electrodynamics," Soobac. Akademii Nauk Gruzin SSSR 17, 15 (1956)
MR 18, 174 (1957)

"On the Interaction of Boson-Fermion Fields," DAN 104, 205 (1955).
MR 17, 811 (1956)
NSA 1160 (1956)

Chernanskiy, D.S. see Feinberg, E.L.

Chou Kuang Chao and M.I. Shirokov
"Relativistic Theory of Reactions Involving Polarized Particles," (1958) (In English)
A: P-122 Joint Institute for Nuclear Research (Preprint)

Companeets, A.S. (also Kompaneets, A.S.)
"Equation of Self Consistent Fields for Nuclei by Calculation of Electrostatic Force," ZhETF 26, 153 (1954).
NPA 456 (1955)

"On the New Formulation of Electrodynamics by Dirac," DAN 82, 873 (1952).
Phys Abs 5450 (1953)

Cytovic, V. see Ivanenko, D.

Demkov, Yu. N., (also Denkov)
"Principle of Detailed Equilibrium in Quantum Mechanics and Certain Homologies for Scattering Amplitudes in the Theory of Collisions," DAN 97, 1003 (1954)

Dolginov, A.Z.
"Relativistic Spherical Functions," ZhETF 30, 746 (1956).
A: B-6

Duan-I-Shi
"Generalized Regular Solutions for a Point Charge in General-relativistic Scalar Meson-field Theory," ZhETF 31, 1089 (1956).
Phys Abs 5071 (1957)

"General Covariant Formulation of the Field Theory and General Laws of Conservation," Joint Institute of Nuclear Research, Laboratory of Theoretical Research. 11p. (1957)
NSA 12, no 2 (1958)

Dyatlov, I.T. and Ter-Martirosyan, K.A.
"Asymptotic Theory of the Scattering of Mesons by Mesons," ZhETF 30, 416 (1956).
Phys Abs 5702 (1956)
A: B-6

-----Sudakov, V.V. and Ter-Martirosyan, K.A.
"Asymptotic Meson-Meson Scattering Theory," ZhETF 32, 767 (1957)
JETP 5, 631 (1957)

Dykman, I.M. and Pekar, S.I.
"Strong Coupling Nucleomesodynamics, III. Translational Motion, Meson-field Mass and Nuclear Magnetic Moment," ZhETF 30, 1125 (1956).
JETP 3, 882 (1957)
NSA 4207 (1957)
Phys Abs 8593 (1956)

Eleonskii, V.M. and Zyrianov, P.S.
"Contribution to the Theory of Collective Motion of Particles in Quantum Mechanical Systems," JETP 5, 432 (1957)
NSA 12, no 6 (1958)

"Application of the Hartree-Fock equations to a system of Quasi Particles," ZhETF 33, no 1, 289-91 (1957)
Phys Abs 724 (1958)

Faddeyev, L.D.
"Uniqueness of Solution of the Inverse Scattering Problem," Vestnik Leningrad University 11, no 7, 126-130 (1956)
MR 18, 259 (1957)

Faynberg, V. Ya. (also Faynberg)
"Non-linear Equations in Quantum Field Theory," ZhETF 30, 608 (1956).
MR 18, 176 (1957)
NSA 2216 (1957)
Phys Abs 7965 (1956)

"On the Theory of Excited States of Nucleons I., II," ZhETF 25, 636, 644 (1954).
Phys Abs 2408, 2409 (1955)

-----and Fradkin, E.
"Dispersion Relations for Fermi Particles," DAN 109, 507 (1956).
Soviet Physics Doklady 1, 455 (1956)
NSA 1706 (1957)
Phys Abs 1055 (1957)
A: 1431

Fainberg, V. Ya. see Silin, V.P.

Fedjanin, V.K. and Tavillielidze, A.N.
"Approximate Equations for Proton Scattering Amplitude on Nucleons,"
Joint Institute for Nuclear Research (1958)
A: P-125 (Preprint)

Fedorov, F.I.
"Reduction of Wave Equations for Spin 0 or 1 to the Hamiltonian Form," ZhETF 31, 140 (1956)
Phys Abs 1078 (1957)
JETP 4, 139 (1957)

Feynberg, E.L. and Chernavskiy, D.S.
"Higher Approximations in the Self-Consistent Field Method of Meson Theory," DAN 108, 619 (1956)
Soviet Physics Doklady 1, 354 (1956)

"Deuteron Stability in Meson Theory," DAN 103, 589 (1955).
NSA 1137 (1956)

Filimonov, G.F. and Shirokov, Yu. M. (also Sirkov, Yu. M. and Shirkov, Yu.M.)
"Plural Interaction Hamiltonian in Quantum Electrodynamics,"
ZhETF 32, 99 (1957)
JETP 5, 84-88 (1957)
Phys Abs 5041 (1957)

Fischer, J.
"Equations for the Green Functions in Quantum Electrodynamics," (1957) (In English) Joint Institute of Nuclear Research (Preprint)

Fradkin, E.E.
"Particle with Spin 3/2 in an Electromagnetic Field," ZhETF 32, 363 (1957)
JETP 5, 298 (1957)
Phys Abs 7599 (1957)

"On the Rarita-Schwinger Method in the Theory of Particles of Half-integral Spin," (1957).
JETP 5,1203 (1957)
Phys Abs 2148 (1958)
ZhETF 32, 1479

-----and Izmirilov, S.V.
"On the Permissible Transformations of Equations for Particles with Higher Spins," DAN 114, 277 (1957).
Phys Abs 9003 (1957)

Fradkin, E.S.
"Concerning Some General Relations of Quantum Electrodynamics,"
ZhETF 29, 258 (1955)
JETP 2, (1956)

"On the Asymptotics of Green's Functions in Quantum Electrodynamics,"
ZhETF 28, 750 (1955).
MR 17, 333 (1956)
Phys Abs 1049 (1957)

"Dispersion Relation for Arbitrary Scattering," ZhETF, 31, 515 (1956).
JETP 4, 450 (1957)
Phys Abs 3974 (1957)
A: 1655

"Green's Functions for the Interaction of Nucleons with Mesons,"
DAN 98, 47 (1954).
MR 16, 317 (1955)
Phys Abs 7987 (1956)

"On the Problem of Asymptotic Green's Function in Meson Theory with Weak Pseudoscalar Coupling," ZhETF 29, 377 (1955).
JETP 2, 340 (1956)
NSA 9718 (1956)
Phys Abs 915 (1956)

"On the Problem of Interaction of Two Quantum Fields," DAN 100, 897 (1955).
MR 17, 219 (1956)
NSA 4030 (1955)
Phys Abs 7991, (1956)

"On Quantum Field Theory. I," ZhETF 29, 121 (1955).
MR 17, 219 (1956)
NSA 7598 (1955)
Phys Abs 8485 (1955)

"On Renormalization in Quantum Electrodynamics," ZhETF 26, 751 (1954).
MR 16, 317 (1955)
Phys Abs 44 (1955)

"On Some General Relations in Quantum Electrodynamics," ZhETF 29, no 2 (8), 258-261 (1955)
Phys Abs 59 (1956)

Fradkin, E.S. see Avrorin, and Fainberg, V.

Frenkel', Ya. I. (now deceased)
"Remarks on Quantum Field Theory of Matter," UFN 42, 69-75 (1950)

Galanin, A.D.
"On the Expansion Parameter in the Pseudoscalar Meson Theory with Pseudoscalar Coupling," ZhETF 26, 417 (1954).
MR 16, 549 (1955)
Phys Abs 53 (1955)
NSA 2089 (1955)

"On the Possibility of Formulating a Meson Theory with Several Fields," ZhETF 5, 460 (1957)
NSA 12, no 6 (1958)
ZhETF 32, 552-558 (1957)

"Convergence of the Perturbation Theory Series for a Non-relativistic Nucleon," ZhETF 33, 285 (1957)
JETP 6, 221 (1958)

"Radiative Corrections in Quantum Electrodynamics. I, II," ZhETF 22, 448, 462 (1952).
MR 14, 436 (1953)
NSA 1300 (1953)

"Relativistic Equations of Interacting Particles," ZhETF 22, 448 (1952).
NSA 763 (1954)

"A Relativistic Equation of Interacting Particles," ZhETF 23, 488 (1952).
MR 14, 707 (1953)
Phys Abs 5298 (1953)

"Some Remarks on Divergences in the Theory of a Pseudoscalar Meson with Pseudovector Coupling," ZhETF 26, 423 (1954).
MR 16, 888 (1955)
NSA 2090 (1955)
Phys Abs 54 (1955)

-----and Lapidus, L.I.
"Observations on Mixed Meson Theories," ZhETF 31, 359 (1956).
Phys Abs 3973 (1957)
A: 1449

-----and Ioffe, B.L. and Pomeranchuk, I. Ya.

"On the Asymptotics of Green's Functions of a Nucleon and Meson in the Pseudoscalar Theory with Weak Coupling," ZhETF 29, 51 (1955).
MR 17, 440 (1956)
NSA 7597 (1955)
Phys Abs 1070 (1957)

"Renormalization of Mass and Charge in the Covariant Equations of Quantum Field Theory," DAN 98, 361 (1954).
MR 16, 547 (1955)
NSA 2042 (1955)

Galanin, A.D. see Abrikosov

Geylikman, B.T.

"On Polarization of the Vacuum in the Theory of Strong Scattering," DAN 91, 225 (1953).
MR 15, 918 (1954)
Phys Abs 6287 (1954)

"On the Quantum Theory of Wave Fields," DAN 90, 359 (1953).
MR 15, 379 (1954)
NSA 5452 (1953); NSA 464 (1954)
Phys Abs 8233 (1953)

"On the Theory of Strong Coupling for Meson Fields," DAN 90, 991 (1953).
MR 15, 918 (1954)
NSA 1457 (1954); 5661 (1953)
Phys Abs 3100 (1954)

On the Theory of Strong Coupling," DAN 91, 390 (1953).
MR 15, 918 (1954)
Phys Abs 6286 (1954)

"On the Theory of Strong Coupling for Meson Fields I, II," ZhETF 29, 417, 438 (1955).
JETP 2, 601 (1956); 509 (1956)
MR 17, 1162 (1956)
Phys Abs 916, 917 (1956)

"On the Theory of Strong Coupling for Meson Fields. III," ZhETF 29, 572 (1955).
JETP 2, 451 (1956)
MR 17, 1163 (1956)
Phys Abs 918 (1956)

"Quantum Theory of Distributed Fields," DAN 90, 359 (1953).
NSA 5452 (1953)

Geizenberg, V. (Heisenberg, Werner)
"The Contemporary Interpretation of the Element Particle Theory,"
IAN 60, 413 (1956)
NSA 3629, (1957)

Gel'fand, I.M. and Minlos, R.A.
"Solution of the Quantum Field Equations," DAN 97, 213 (1954).
Translated MR 16, 315 (1955)

-----and Yaglom, A.M.
"Integration in Function Spaces and Its Application to Quantum Physics," Usephi Mat. Nauk 11, 77-114 (1956).
MR 17, 1261 (1956)

Ginzburg, I.F.
"On Emergence from the Region of Weak Coupling in the Two-charge Meson Theory," DAN 110, 535 (1956).
Soviet Physics Doklady 1, 560 (1956)
Phys Abs 1904 (1957)
A: 1644
NSA 7615 (1958)
Phys Abs 1904 (1957)

-----and Shirkov, D.V.
"Asymptotic Behavior of Higher Green's Functions," Joint Institute for Nuclear Research, March 1958. (Preprint)

Ginsburg, V.L. and Tamm, I.E.
"On the Theory of Spin," Translated by G. Belkov. National Research Council of Canada, Ottawa. Tech. translation TT-305, 23 pp. (1952). ZhETF 17, 227 (1947); MR 14, 839 (1953)

Gol'fand, Yu. A.
"Construction of Propagation Functions by the Method of Quasi-fields,"
ZhETF 28, 140 (1955).
MR 17, 221 (1956)
Phys Abs 5214 (1955)

"Fermi Fields and Spinors of Infinite Span," DAN 13, 68 (1957).
NSA 8238 (1957)

"Transformation Properties of the Electron-positron Field Amplitudes,"
ZhETF 31, 535 (1956).
JETP 4, 461 (1957)
Phys Abs 1917 (1957)

"Generalized Phase-shift Analysis as a Consequence of the Unitary of the Smatrix," ZhETF 31, 224 (1956).
Phys Abs 1916 (1957)

Golubenkov, V.N. and Smorodinskiy, Ia. A.
"The Lagrangian Function for a System of Identically Charged Particles," ZhETF 31, 330 (1956).
JETP 4, 442 (1957)

Gor'kov, L.P.
"On the Asymptotic Form of the Green's Function of an Electron," DAN 105, 656 (1955).
MR 17, 1033 (1956)

"Green's Function of Charged Particles in the Region of the Infra-red Catastrophe." ZhETF 30, 790 (1956).
Phys Abs 7132 (1956)

"Two Limiting Momenta in Scalar Electrodynamics," ZhETF 32, 359 (1957).
JETP 5, 167 (1957)
Phys Abs 5830 (1957)

"Determination of the Phase Shifts of the Matrix Elements of the S-Matrix," ZhETF 33, 1431 (1957).
NSA 12, no 9 (1958)

-----and Khalatnikov, I.M.
"Asymptotic Behaviour of Green's Functions in the Electrodynamics of Particles with Spin Zero," DAN 104, 197 (1955).
MR 17, 566 (1956)

"Electrodynamics of Charged Scalar Particles," ZhETF 31, 1062 (1956).
JETP 4, 777 (1957)
Phys Abs 2969 (1957)
A: 1885

"Perturbation Theory and Asymptotic Behavior of Green's Functions in the Electrodynamics of Particles with Spin Zero," DAN 103, 799 (1955).
MR 17, 566 (1956)
NSA 1139 (1956)

Grigoryev, V. I.
"Generalized Method of Calculation of Damping in the Quantum Theory of Fields," ZhETF 25, 40 (1953).
Phys Abs 42 (1955)

"Generalized Method of Calculation of Damping in Relativistic Quantum Field Theory," ZhETF 30, 873 (1956).
Phys Abs 8003 (1956)
JETP 3, 691 (1956)
MR 19, no 2 (1958)

"Quantum Field Theoretical Solutions Without Perturbation Theory,"
ZhETF 72, 146 (1957)
JETP 5, 109 (1958)

"On the Question of Role of Damping in the Theory of Bound Particles,"
ZhETF 25, 51 (1953),
Phys Abs 43 (1955)

"Solutions in Quantum Theory of Fields without Recourse to Perturbation Methods," ZhETF 32, 146 (1957).
Phys Abs 5874 (1957)

Grigoryev, V.I. see Ivanenko, D.

Gurevich, A.V.
"Quantization of Fields Obeying Equations with Higher Derivatives I,"
ZhETF 24, 149 (1953).
Phys Abs 9920 (1954)
NSA 7193 (1954)

Gurzhi, R.N.
"On the Scattering of Photons by Nucleons,"
JETP 3, 941 (1957)

Halatnikov, I.M. (see other spelling: Khalatnikov)

Halfin, L.A. (see also Khalfin, L. A.)
"Physical Invariance of Quantization," Vestnik Leningrad University 11, no 22, 12 (1956)
MR 19, 362 (1958)

Heber, Von G.
"Messprozess und Algebraische Eigenschaften der Feldgrossen in einer Einfachen Model-Feld Theorie," Vereingtes Insitut fur Kernforschung Laboratorium fur Meoretische Physik
A: P-150 (1958) (Preprint)

Ninghu (Ning Hu)
"The Proper Meson Field of a Physical Nucleon," Joint Institute for Nuclear Research
A: P-87 (1957)

Ingarden, R.S.
"On a New Type of Relativistically Invariant Linear Local Field Equations," DAN 108, 56 (1956).
Soviet Physics Doklady 1, 256 (1956)
MR 18, 542 (1957)
Phys Abs 7137 (1956)

"Equations of Motion and Field Equation in the Five Dimensional Unitary Theory of Relativity," DAN 88, 773 (1953)
NSA 5220 (1953)

Ioffe, B.L.
"Dispersion Relations for Scattering and Photon Production," ZhETF 21, 538 (1956).
JETP 4, 534 (1957)
Phys Abs 3721 (1957)
A: 1888

"On the Divergence of a Perturbation-Theory Series in Quantum Electrodynamics," DAN 94, 437 (1954).
MR 15, 917 (1954)
Phys Abs 2989 (1957)

"Systems of Covariant Equations in Quantum Field Theory," DAN 95, 761 (1954).
MR 16, 100 (1955)
NSA 4468 (1954)
Phys Abs 5034 (1957)

-----and Rudik, A.
"On the Decay of the Pi-Meson," DAN 82, no 3, 359 (1952).
Phys Abs 5099 (1953)

-----and Pomeranchuk, I.Ya. and Rudik, A.P.
"Dispersion Relations for Scattering of Pi-Mesons by Deuterons," ZhETF 31, 712 (1956).
JETP 4, 588 (1957)
Phys Abs 3002 (1957)
A: 1895

Ioffe, B.L. see Galanin, A.D.

Ivanenko, D.D.
"Introduction to the Theory of Elementary Particles, Part II," UFN 32, 261 (1947)

-----and Brodskiy, A.M.
"Divisible Processes and Non-linearity in the Theory of Elementary Particles," DAN 84, 683 (1952).
Phys Abs 5300 (1953)

"Interaction of Gravity with Vacuum Particles," DAN 92, 731 (1953)
MR 16, 547 (1955)
NSA 1767 (1954)
Phys Abs 7128 (1954)

"On a Non-linear Quantum Theory of the Electron," ZhETF 24, 383 (1953).
Phys Abs 48 (1955)

-----and Cytovic, V.
"The Relativistic Equation of Three Coupled Bodies," DAN 99, 373 (1954).
MR 16, 982 (1955)
Phys Abs 8581 (1956)

-----and Grigoryev, V.I.
"On the Interpretation of Regularization Procedures in Quantum Electrodynamics," ZhETF 21, 563 (1951)

-----and Kolesnikov, N.
"The Electrino Hypothesis," DAN 87, 923 (1952).
MR 14, 828 (1953)
Phys Abs 3083 (1954)
NSA 3650 (1953)

Ivanenko, D.D. and Kurdgelaidze, D.F.
"The Basic Equations of Mesodynamics," DAN 96, 39 (1954).
MR 16, 887 (1955)
NSA 5460 (1954)
Phys Abs 7988 (1956)

-----and Lebebev, V.
"Multiple Processes in Interactions," ZhETF 22, 638 (1952).
Phys Abs 618 (1953)

-----and Mirianasvili, M.
"Non-linear Generalization of the Dirac Spin or Equation," DAN 106,
413 (1956).
Soviet Physics Doklady 1, 67 (1956)
MR 18, 95 (1957)
Phys Abs 6350 (1956)
A: B-6

-----and Sokolik, G.
"The Theory of Particles of Arbitrary Isotopic Spin and the Method of Fusion," DAN 97, 635 (1954).
MR 16, 888 (1955)
Phys Abs 7979 (1956)

"Unified Description of Ordinary and Isotopic Spare,"
Nuovo Cim 6, 226 (1957)

-----and Kurdgelaidze, D.F. and Larin, S.
"Remarks on Non-linear Mesodynamics," DAN 88, 245 (1953).
MR 14, 827 (1953)
NSA 4996 (1953)
Phys Abs 6471 (1953)

Ivanenko, D. see Brodskii, A., Sokolov, A.A.

Izmirilov, S.V.
"On the Relativistic Quantum Theory of Particles with Internal Rotational Degrees of Freedom," ZhETF 17, 629 (1947).
NSA 4292 (1953)

Izmirilov, S.V. see Fradkin, E.E.

Kalitsin, N.S.
"On Certain New Methods of Eliminating Divergencies in Quantum Electrodynamics," Ref. Zhur - Fizika, no 2 (1957)
no 2949 A: B-5

"On the Five-dimensional Theory of Nuclear Interaction and a New Solution of the Dipole Difficulty," C.R. Acad. Bulg. Sci 7, no 3, 1-5 (1956).
Phys Abs 74 (1956)

"On the Interaction of an Electron with the Fluctuations of the Electro-Magnetic Field in a Vacuum," ZhETF 25, 407 (1953).
Phys Abs 2406 (1955)

"A New Variant of Equations of the Meson Vector Theory." ZhETF 24, 293 (1953).
Phys Abs 8044 (1954)

Karpman, V.I.
"On a Connection Between the Method of Regularization and Theories of Particles with Arbitrary Spin," DAN 89, 257 (1953).
MR 15, 379 (1954)
NSA 3974 (1953) and 5450 (1953)
Phys Abs 7444 (1953)

"Quantization of Wave Fields with Finite Number of Components," ZhETF 21, 1337 (1951)

"On the S-matrix for Particles with Arbitrary Spin," ZhETF 30, 1104 (1956).
JETP 3, 934 (1957)
NSA 4209 (1957)
Phys Abs 8602 (1956)
A: 1410

Kaschluhn, F.
"Impulse Approximation and Dispersion Relations for Pion-Deuteron Scattering," Joint Institute for Nuclear Research
A: P-198 (1958) (Preprint)

"Dispersion Relations for Pion-Deuteron Scattering II," Joint Institute for Nuclear Research.
A: P-183 (1958) (Preprint)

Kerimov, B.K. see Sokolov, A.A.

Khalatnikov, I.M. (Also Halatnikov)
"Concerning the Elastic Scattering of High Energy Particles," Institute for Physical Problems, Academy of Sciences, USSR, (1957)
Nuclear Physics 3, 433 (1957)

"Representation of Green's Function in Quantum Electrodynamics in the Form of Continuous Integrals." ZhETF 28, 633 (1955).
JETP 1, 568 (1955)
MR 17, 332 (1956)
NSA 6092 (1956)
Phys Abs 7690 (1955)

Khalatnikov, I.M. see Abrikosov; Gor'kov, L.P.; and Landau, L.D.

Khalfin, L.A.

"Causality Conditions and Physical Realizability Criterion in Quantum Field Theory," DAN 111, 345 (1956).
Phys Abs 3948 (1957)

Khlebnikov, A.K. see Berestetskiy

Khokhlov, Yu. K.

"Description of the Interaction of a System of Particles with the Electromagnetic Field," ZhETF 26, 576 (1954).
MR 16, 547 (1955)
NSA 6809 (1955)
Phys Abs 55 (1955)

Khristov, Kh. Ya.

"Approximate Expression for Green Function in the Neutron Kinetic Equation," DAN 111, 1197 (1956).
Phys Abs 5056 (1957)

Kirzhnits, D.A.

"Contribution to Field Theory Involving a Cut-off Factor," ZhETF 23, 534 (1957)
JETP 5, no 3 445 (1957)
NSA 12, no 6 (1958)

"The Mass of Photon in Quantum Electrodynamics," ZhETF 30, 796 (1956).
Phys Abs 7125 (1956)
JETP 3, no 5 (1956)

"Mass Renormalization in the Tamm-Dancoff Method," ZhETF 30, 971 (1956).
Phys Abs 7977 (1956)
JETP 3, no 5 (1956)
A: B-6; no 1, 204 (1957)

"On the Question of Meson-Nucleon Interactions," ZhETF 27, 6 (1954).
MR 17, 1166 (1956)
Phys Abs 57 (1955)

Klepikov, N.P.

"Application of the Theory of Singular Integral Equations to Problems of Scattering of Particles in an External Field," ZhETF 30, 701 (1956), sup to 30, no 4,5.
MR 18, 259 (1957)
Phys Abs 8002 (1956)

"Radiation of Photons and Electron-positron Pairs in a Magnetic Field," ZhETF 26, 19 (1956).
Phys Abs 10479 (1956)

"Solution of the System of Equations for a Vacuum Functional," DAN 100, 1057 (1955).
MR 17, no 2, 221 (1956)
Phys Abs 8489 (1955)

"On the Theory of the Vacuum Functional," DAN 98, 937 (1954).
MR 16, 887 (1955)
Phys Abs 7990 (1956)

Klepikov, N.P. see Sokolov, A.A.

Klimontovich, Yu. L. (also Klimontovich, Yu. L.)
"Determination of Characteristic Values of Physical Quantities by Means of Quantum Distribution Function," DAN 108, 1033 (1956)
MR 18, 360 (1957)
A: 1425

"Relativistic Equation for the Quantum Distribution Function," DAN 87, 927 (1952).
MR 14, 826 (1953)
NSA 3970 (1953)
Phys Abs 3135 (1954)

"Second Quantization in Phase Space," DAN 96, 43 (1954).
MR 16, 888 (1955)
Phys Abs 8571 (1956)

"On the Method of "Secondary Quantization" in Phase Space," ZhETF 33, 982 (1957)
NSA 12, no 4 (1958)

-----and Silin, V.P.
"Spectrum of System of Interaction Particles," ZhETF 23, 151 (1952)
NSA 3291 (1953)

Kobozev, N.I.
"On Physical Interpretation of the Broglie Equations," ZhETF 29, 2007 (1955)
NSA 2759 (1956)

Kolesnikov, N.N.
"On Green's Function in Radiation Diffusion Relation," ZhETF 33 817 (1957).
NSA 12, no 4, (1958)

Kolesnikov, N.N. see Ivanenko, D.

Kompaneyets, A. (See other spelling: Companeets, A.S.)

Korst, N. see Brodskii, A.

Krokhin, O.N. see Berestetskiy, V.B.

Krolikowski, W. and Rzewski, J.
"On Potentials in the Theory of Quantized Fields," Nuovo Cim III, 260 (1956)
MR 19, no 2 (1958)

Kudryavtsev, V.S.
"On Quasi-classical Quantization," ZhETF 31, 688 (1956)
JETP 4, 527 (1957)
Phys Abs 2967 (1957)
A: 1735

Kuni, F.M.
"Dispersion Relations for Nucleon-nucleon Scattering," DAN 111, 571 (1956).
Phys Abs 5063 (1957)

Kunin, P. Ye.
-----and Taksar, I.M.
"On Relativistic Effects in the Interaction of Nucleons," Latv PSR Zinat Akad Vestis no 8, 137 (1952).
Phys Abs 9952 (1954)

"Some Relativistic Properties of the Behavior of Spin 1/2 Particles,"
ZhETF 32, 506 (1957)
JETP 5, 426 (1957)

Kurdgelaidze, D.F.
"Non-linear Scattering in Electrodynamics and Mesodynamics," Vestnik Moscow University 9, no 8, 81 (1954).
MR 17, no 1, 113 (1956)

"On the Non-linear Generalization of the Meson and Spinor Field Equations," ZhETF 32, 1156 (1957)
JETP 5, 856 (1957)
Phys Abs 2149 (1958)

Kurdgelaidze, D.F. see Ivanenko, D.

Kurtenkov, L.A.
"Statistical Treatment of Elementary Particles Structure," ZhETF 33
554 (1957)
JETP 6, 433 (1958)
Phys Abs 3712 (1958)

Landau, L.D.
"On the Quantum Theory of Fields," Niels Bohr and the Development of
Physics, p 52-69
MR 17, 692 (1956)

"Gradiant Transformations of the Green's Functions of Charged Particles,
ZhETF 29, 89 (1955).
JETP 2, 60 (1956)
Phys Abs 8482 (1955)

"On the Multiple Production of Particles during Collision of Fast
Particles," IAN 17, 51 (1953)
NSA 5195 (1955)

-----and Pomerancuk, I.
"On Point Interaction in Quantum Electrodynamics," DAN 102, 489 (1955).
MR 17, 440 (1956)
NSA 5830 (1956)

-----and Abrikosov, A. and Khalatnikov, L.
"An Asymptotic Expression for the Green Function of a Photon in Quantum
Electrodynamics," DAN 95, 1177 (1954).
MR 16, 316 (1955)
NSA 4808 (1954)
Phys Abs 7968 (1956)

"An Asymptotic Expression for the Green Function of an Electron in
Quantum Electrodynamics," DAN 95, 733 (1954).
MR 16, 316 (1955)
Phys Abs 7967 (1956) and 1049 (1957)

"The Mass of Electron in Quantum Electrodynamics," DAN 96, 261
(1954).
MR 16, 316 (1955)
Phys Abs 7969 (1956)

"On the Quantum Theory of Fields," Nuovo Cim III, sup 80 (1956)
MR 18, 97 (1957)

"On the Removal of Infinities in Quantum Electrodynamics," DAN 95,
497 (1954).
MR 16, 315 (1955)
NSA 4466 (1954)
Phys Abs 7966 (1956)

Landau, L.D. see Belenki, S.S.

Lapidus, L.I.
"Isotopic Invariance and Creation of Particles," JETP 4, 740 (1957)
NSA 12, no 4 (1958)

"Application of Dispersion Relations to π-N Scattering at Low Energies,"
Joint Institute for Nuclear Research (Preprint)
A: P-113 (1958)

Lapidus, L.I. see Galinin, A.D.

Larin, S. see Ivanenko, D.

Lebebev, V.I. see Ivanenko, D.

Lipmanov, E.M.
"On Invariant Commutation Relations and the Exclusion of Supplementary Conditions in Quantum Theory of the Meson Field," DAN 67, 627 (1949).

"Radiative Corrections in the Decay of μ-Mesons," DAN 90, 999 (1953).
NSF-tr-139 (English translation)
Phys Abs 3081 (1954)

"Regularized Theory of Systems of Fields," ZhETF 30, 214 (1956).
Phys Abs 5679 (1956)

"A Relativistically Invariant Form of Electrodynamics without Longitudinal and Scalar Fields," ZhETF 27, 135 (1954).
MR 16, 318 (1955)
Phys Abs 721 (1955)

"Relativistically Invariant Formulation of Electrodynamics without Longitudinal and Scalar Fields," ZhETF 30, 538 (1956).
MR 18, 174 (1957)
Phys Abs 6343 (1956)

"Quantum Theory of Meson Field," DAN 67, 627 (1949)

Liubimov, A.L. see Zartavenko, L.G.

Livshits, M.S.
"The Application of Non Self-Adjoint Operators to Scattering Theory,"
JETP 3, 91 (1957)

"On the Compound State Formed in the Scattering of Elementary Particles," DAN 3, 799 (1956).
Phys Abs 5849 (1957)

"Concerning the Application of Non Self-adjoint Operators in Scattering Theory," ZhETF 31, 121 (1956).
Phys Abs 1071 (1957)

"The Scattering Matrix of the Compound System," DAN 3, 67 (1956)
Phys Abs 3961 (1957)

Logunov, A.A.

"Concerning a Certain Generalization of the Renormalization Group," ZhETF 30, 793 (1956).
Phys Abs 83 (1957)
JETP 766 (1956)

"Dispersion Relations for Virtual Processes," DAN 117, 792 (1957)
Phys Abs 724 (1958)

"Green's Function in Scalar Electrodynamics in the Region of Small Momenta," ZhETF 29, 871 (1955).
Phys Abs 2643 (1956)
JETP 2, no 2 (1956)

"Spectral Representation and the Renormalization Group," DAN 109, 740 (1956).
Soviet Physics Doklady 1, 478 (1956)
NSA 2203 (1957)
Phys Abs 1051 (1957)
MR 19, no 1 (1958)
A: 1436

"Vertex Part in Scalar Electrodynamics in the Region of Large Momenta," DAN 106, 223 (1956).
Soviet Physics Doklady 1, 420 (1956)
MR 17, 1033 (1956)
Phys Abs 7124 (1956)

-----and Stepanov, B.M.

"Dispersion Relations for the Photoproduction of Pions," DAN 110, 368 (1956)
Soviet Physics Doklady 1, 552 (1956)

-----and Tavkelioze, A.N.

"Dispersion Relations for Photoproduction of Pions of Nucleons," ZhETF 32, 1393 (1957)
JETP 5, no 6 (1957)

-----and Tavkelioze, A.N. and Solovyov
"Photoproduction Processes and Dispersion Relations," Joint Institute of Nuclear Research, Laboratory of Theoretical Physics, Dubna, USSR Moscow State University, USSR (1957)
Nuclear Physics 4, 427 (1957)

Logunov, A.A.; Solovev, L.D.; Kukin, V.; Frenkin, A.R.
"Dispersion Relations for Virtual Photoproduction," Joint Institute for Nuclear Research
A: P-161 (1958) (Preprint)

Logunov, A.A. see Bogolyubov, N.N.

Lokhov, Iu. N. see Galanin, A.G.

Lomsadze, Yu.M.
"A Possibility in the Quantum Theory of Fields," ZhETF 31, 887 (1956).
Phys Abs 3958 (1957)
A: 1787

"Concerning a Certain Possibility in Quantum Field Theory," JETP 4, 754 (1957)
NSA 12, no 4 (1958)

"On the Potential in the Pair Theory of Nuclear Forces." DAN 110, 545 (1956).
Phys Abs 1905 (1957)
A: 1646
MR 19, no 1 (1958)
Soviet Physics Doklady 1, 571 (1956)

"On the Singularity of the Electromagnetic Potential in the Higher Approximations of Perturbation Theory," ZhETF 30, 707 (1956).
Ref. Zhur - Fizika, no 2 (1957), no 2946
A: B-5

Maksimenko, V.M.
"On Annihilation of Nucleons." ZhETF 33, 232 (1957)
JETP 6, 189 (1958)

Markov, M.
"On Dynamically Deformable Form Factors in the Theory of Elementary Particles,"
Nuovo Cim v III, sup 760 (1956)

"On Dynamically Deformable Form Factors in the Theory of Elementary Particles."
Supplemental Nuovo Cim, v IV, no 2 (1956)

"A Dynamically Deformable Form Factor of Elementary Particles," ZhETF 25, 527 (1953).
Phys Abs 733 (1955)

"On the Theory of the Dynamically Deformable Form Factor," DAN 101, 51 (1955).
MR 17, no 1, 113 (1956)
Phys Abs 7992 (1956)

Matveyev, A.N. (also Matveyev)
"Operational Method in Quantum Field Theory," Vestnik Moscow University, no 8 (10), 99-104 (1953)

"The Role of Spin in the Radiation from a Radiating Electron," ZhETF 31, 479 (1956).
JETP 4, 409 (1957)

"The Role of Spin in the Study of the Radiating Electron," ZhETF 29, 700 (1955)
JETP 2, 356 (1956)

Matveyev, A.N. see Sokolov, A.A.

Mayer, M.E. and Shirkov, D.V.
"On Thirring's Two-dimensional Model," Joint Institute for Nuclear Research, Laboratory of Theoretical Physics
A: P-187 (1958) (Preprint)

Medvedev, B.V.
"On Construction of the Scattering Matrix I. Integral Causality Condition in Bogolyubov's Method," ZhETF 31, 791 (1956).
Phys Abs 3006 (1957)
JETP 4, 671 (1957)
NSA 12, no 4 (1958)

"On Construction of the Scattering Matrix II. Non-local Interaction Theory," ZhETF 32, 97 (1957)
JETP 6, 343 (1958)
Phys Abs 5072 (1957)

"On the Construction of the Scattering Matrix in Quantum Field Theory with non-local Interaction," DAN 103, 37 (1955).
MR 17, 443 (1956)
NSA 6813 (1955)

"On the Unitarity of the S-matrix in the Quantum Theory of a Field in the Non-local Interaction," DAN 100, 433 (1955).
MR 17, 565 (1956)
Phys Abs 6755 (1955)
NSA 2995 (1955)

-----and Bonch-Bruyevich, V.L.
"Invariant Construction of Quantum Field Theory," ZhETF 22, 425 (1952).

-----and Polivanov, M.K.
"On a Classical Model of Indefinite Metric," Joint Institute for Nuclear Research
A: P-180 (1958) (Preprint)

Medvedev, B.V. see Averbakh; Bonch-Bruyevich, V.L.; Bogolyubov, N.N.

Mickevic, N.V.
"The Scalar Field of a Stationary Nucleon in a Non-linear Theory,"
ZhETF 29, 354 (1955)
MR 17, 1031 (1956)
JETP 2, 197 (1956)

Migdal, A.B. ([illegible])
"The Momentum Distribution of Interacting Fermi Particles,"
ZhETF 32, 399 (1957).
JETP 5, 333 (1957)

-----and Polievktov-Nikoladze, N.M.
"Quantum Kinetic Equation for Double Collisions." DAN 103, 233 (1955).
MR 18, 98 (1957)

Mikhaylov, V. see Baldin, A.

Minlos, R.A. see Gel'fand, I.M.

Mirianashvili, M.M.
"On the Relativistic Magnetic Moment of Charged Particles," Soobsceniya Akad Nauk Gruzin. SSR. 8, 613 (1947).
MR 14, 339 (1953)

Mirianashvili, M.M. see Ivanenko, D.

Natanzon, M.S.
"Self Acceleration of a Charge Under the Action of its Own Field,"
ZhETF 25, 448 (1953).
NSA 1620 (1956)

in

Neganov, B.S.

"The Problem of Nuclear Structure," ZhETF 33, 260 (1957)
JETP 6, 200 (1958)

"The Structure of Nucleons," Joint Institute of Nuclear Research, Laboratory of Nuclear Problems (1957) 23 pp
NSA 12, no 2 (1958)

Nelipa, N.F.

"The Quantum Theory of a "Radiating" Electron," DAN 85, 1259 (1952).
MR 14, 437 (1953)

"Quantum Theory of a Radiating Electron. II." ZhETF 27, 421 (1954).
MR 16, 982 (1955)
NSA 1422 (1955)
Phys Abs 1909 (1955); Phys Abs 5521 (1953)

Novozhilov, Yu. V. (Leningrad State University)

"Application of Fok's Method of Functionals to the Problem of Self-Energy." ZhETF 22, 264 (1952).
MR 14, 228 (1953)
NSA 1240 (1953)

"Causal Operator in Quantum Field Theory." DAN 99, 533 (1954).
MR 16, 546 (1955)
NSA 2093 (1955)

"On the Choice of the 'Unperturbed' Energy Operator in the Theory of the Interaction of a Nucleon with the Pseudoscalar Meson Field." DAN 92, 931 (1953). English Translation: NSF-tr-217
Phys Abs 8045 (1954)

"On Eigen-energy of the Electron and Radiative Corrections."
DAN 83, 201 (1952).
Phys Abs 5294 (1953)

"Quantum Field Theory with Causal Operators." ZhETF 31, 493
JETP 4, 553 (1957)
Phys Abs 1888 (1957)
A: 1620

nlya

"On the Quantum Theory of a Field with Causal Operators," DAN 99, 723 (1954).
MR 16, 778 (1955)
NSA 2045 (1955)
Phys Abs 8572 (1956)

"Quantum Theory of a Field with Causal Operators and the Schwinger Functional," DAN 104, 47 (1955).
MR 17, 922 (1956)

"Scale Transformation and Virial Theorem in Quantum Field Theory," ZhETF 31, 171 (1957).
JETP 5, 138 (1957)
Phys Abs 5890 (1957)

"Methods of Functionals in Quantum Field Theory," UFN 61, 53 (1957).
Phys Abs 6916 (1957)

"The Variational Principle and the Virial Theorem for the Continuous Dirac Spectrum," ZhETF 31, 1084 (1956).
JETP 4, 928 (1957)

Ogiyevetskiy, V.I. (Electrophysical Laboratory Akademii Nauk USSR)
"On Possible Interpretation of Perturbation Series in the Quantum Theory of Fields," DAN 108, 919 (1956).
NSA 2202 (1957)

"A Possible Interpretation of the Perturbation Theory Series in the Quantum Theory of Fields," DAN 109, 919 (1956).
Phys Abs 1048 (1957) MR 18, 541 (1957)

Okun, L.B. and Pontecorvo, B.
"Some Remarks on Slow Processes of Transformation of Elementary Particles," ZhETF 32, 1587 (1957)
JETP 5, no 6 (1957)

Ovsyannikov, L.V.
"General Solution of the Equations of the Renormalization Group," DAN 109, 1112 (1956).
Phys Abs 1893 (1957)
A: 1627
MR 19, 120 (1958)

Parasyuk, O.S.
"On the Theory of Causal Singular Functions," DAN 100, 643 (1955).
MR 17, 112 (1956)
Phys Abs 7957 (1956)

"Multiplication of Causal Functions for Non-coincident Arguments," IAN 20, 843 (1956).
MR 19, 250 (1958)

Parasyuk, O.S. see Bogolyubov, N.N.

Pekar, S.I. (Physics Institute of Ukranian Academy of Science)

"Criteria of Applicability of the Theory of Strong Coupling of Particles with a Meson Field," ZhETF 27, 579 (1954). MR 16, 1186 (1955) NSA 1691 (1955) Phys Abs 1525 (1955)

"On the Existence of Stationary Quantum States of Point Nucleon Interacting with a Meson Field," ZhETF 29, 599 (1955). JETP 2, 462 (1956) MR 18, 444 (1957) Phys Abs 1855 (1956)

"The Freely Moving Nucleon." ZhETF 27, 411 (1956).
MR 16, 1186 (1955)
NSA 2091 (1955)
Phys Abs 1524 (1955)

"Non-existence of Discrete Energy Levels and the Corresponding States for a Particle with Spin 1/2 in a Given Pseudoscalar Potential Field," DAN 97, 1011 (1954). MR 16, 983 (1955)

"Strong Coupling Nucleomesodynamics I. Approximate Method Spin-Charge Motion," ZhETF 30, 304 (1956); sup to 30, no 2,6 (1956) MR 18, 174 (1957) Phys Abs 4835 (1956) A: B-6

"Theory of Strong Coupling of a Particle (Nucleon) with a Meson Field," ZhETF 27, 398 (1954).
MR 16, 1186 (1955)
NSA 1421 (1955)
Phys Abs 1523 (1955)

Pekar, S.I. see Beyyer, V.N.; Buimistrov, V.M.; and Dykman, I.M.

Peterson, V.R.

"Problem of the Transverse Energy of the Electron in a Linear Generalization of Electrodynamics," ZhETF 24, 56 (1953).
Phys Abs 9937 (1954)

Petras, M.

"A Note to Bhabha's Equation for a Particle with Mass Spin 3/2," Czech J Phys, 5, 418 (1955).
Phys Abs 1849 (1956)

Podgoretskiy, M.I.

"On Superpositions According to the Internal Structure of Elementary Particles," ZhETF 33, 790 (1957).
NSA 12, no 4 (1958)

Pokrovskiy, V.L.
"Generalization of Gauge Invariance and Combined Inversion," ZhETF 33, 269 (1957). Phys Abs 724 (1958)
JETP 6, 208 (1958) NSA 8895 (1958)

-----and Rumer, Iu. B.
"Note on the Theorem of Pauli on the Relation of Spin and Statistics."
JETP 3, 264 (1957)

"Conservation of Parity in the Theory of Elementary Particles," ZhETF 33, 277 (1957) JETP 6, 208 (1958) Phys Abs 726 (1958)

Poliyevktov-Nikoladze, N.M.
"On the Derivation of the Relativistic Equations for Free Particles with Spin 1/2," Soobsceniya Akad. Nauk Gruzin. SSR 9, 11 (1948). MR 14, 340 (1953)

"On the Green's Function for a Photon," DAN 105, 703 (1955).
MR 17, 1260 (1956)

"Renormalization of Charge without Perturbation Theory," DAN 105, 458 (1955). MR 17, 1260 (1956)

Poliyevktov-Nikoladze, N.M. See Migdal, A.B.

Polivanov, M.K.
"On a New Derivation of the Equations for Green's Functions in Quantum Electrodynamics," DAN 100, 1061 (1955).
MR 17, no 1, 113 (1956)
Phys Abs 8490 (1955)

Polovin, R.V.
"Radiative Corrections to the Scattering of Electrons by Electrons and Positrons," ZhETF 31, 449 (1956)
JETP 4, 385 (1957)

Polovin, R.V. See Akhiezer

Pomerancuk, I. Ya. (Pomeranchuk, I. Ya.)
"Equality of the Renormalized Charge in Quantum Electrodynamics,"
DAN 103, 1005 (1956).
MR 17, 565 (1956)
NSA 2949 (1956)

"A Generalization of Vord's (Ward's) Theorem to the Case of Light of Finite Wave Length for Particles with Spin Zero," ZhETF 100, 41 (1955).
Phys Abs 9412 (1955)

"Solution of the Equations of Pseudoscalar Meson Theory with Pseudoscalar Coupling," ZhETF 29, 869 (1955).
Phys Abs 1061 (1957)

"Vanishing of Renormalized Charge in Electrodynamics and in Meson Theory." Nuovo Cim III, 1186 (1956)
MR 18, 540 (1957)
Phys Abs 6385 (1956)

"On Renormalization of Meson Charge in Pseudoscalar Theory with Pseudoscalar Coupling," DAN 104, 51 (1955).
MR 17, 1033 (1956)
NSA 1962 (1956)
Phys Abs 1059 (1957)

"On the Vanishing of the Renormalized Meson Charge in Pseudoscalar Theory with Pseudoscalar Coupling," DAN 105, 461 (1955).
MR 17, 1034 (1956)
NSA 2960 (1956)
Phys Abs 1060 (1957)

-----and Sudakov, V.V. and Ter-Martirosyan, K.A.
"Vanishing of Renormalized Charges in Field Theories with Point Interaction." Phys Rev 103, 784 (1956)
Phys Abs 7126 (1956)
MR 18, no 6 (1957)

Pomeranсuk, I. see Galanin and Landau

Pontecorvo, B. (M.) see Okun', L.

Popovici, A.
"Non-linearity of the Field in Conformal Reciprocity Theory."
JETP 5, 642 (1957)
NSA 12, no 8

Pugachev, Ya. I. and Shirokov, M.F.
"Part Played by the Gravitational Field in the Formation of the Mass of an Electron." ZhETF 24, 375 (1953).
Phys Abs 9938 (1954)

Rayski, G. (Institute of Theoretical Physics, Copernicus University, Toran, Poland)
"Bi-local Field Theories and their Experimental Tests II," Nuovo Cim 5, 872 (1957)
MR 14, no 2 (1958)

"Remarks on Bi-local Field Theory," ZhETF 31, 705 (1956)
JETP 4, 577 (1957)
NSA 12, no 3 (1958)

Ryazonov, M.I. (Moscow Engineering - Physics Institute)
"Phenomenological Study of the Effect of Non-conducting Medium in Quantum Electrodynamics," ZhETF 32, 1244 (1957)
JETP 5, 786 (1957)
Phys Abs 67 (1958)

Ritus, V.I. (P.N. Lebedev Physical Institute, Academy of Sciences, USSR)
"Renormalization of the Equations of the New Tamm-Dancoff Method," ZhETF 30, 965 (1956)
Phys Abs 7976 (1956)
A: B-6
JETP 5, 820 (1956)

"Invariant Representations of the Scattering Matrix," ZhETF 33, 1264 (1957).
JETP 6, 972 (1958)

"The Scattering of Photons by Nucleons and Nuclear Isobars," JETP 3, 926 (1957)

Rosental, I.L. (Lebedev Physics Institute)
"The Fermi Theory of Multiples Production of Particles in Nucleon Collision," ZhETF 28, 118 (1955).
NSA 4027 (1955)

-----and Tschernauski, D.S.
"Theoretische und Experimentelle Daten Uber die Erzeugung von Teilchen bei Hohen Energien," UFN 52, 185 (1954)
Fort der Phys 4, 560 (1956)

Rudik, A. see Ioffe, B.L.

Rumer, Yu. B. (Yenisei Teachers' Institute)
"Action as a Coordinate of Space. IV," ZhETF 21, 454 (1951)

"Action as a Space Coordinate," ZhETF 22, 742 (1952).
MR 14, 606 (1953)
Phys Abs 1362 (1953)

"Action as a Space Coordinate VII," ZhETF 23, 35 (1952).
MR 14, 706 (1953)
Phys Abs 2925 (1953)

"Action as Coordinate of Space VIII, IX," ZhETF 24, 303 (1953)
Phys Abs 33, 34 (1955)

Rumer, Yu. B. see Pokrovskii, V.L.

Ruusik, I.Kn. (Institute of Physics and Astronomy, Academy of Sciences)
"Notes on Electrodynamics with Higher Derivatives," ZhETF 27, 260 (1954).
Phys Abs 722 (1955)

Ryazanov, G.V.
"The Sum Over Trajectorics for Dirac Equation," ZhETF 33, 1437 (1957).
NSA 12, no 9 (1958)

Ryndin, R.(M.) and Smorordinskiy, Ya.A.
"Invariant Transformation Cross-section of Non-polarized Particles,"
DAN 103, 169 (1955).
NSA 7205 (1956)

Rzewuski, J.
"Conservation Laws in Non-local Field Theories," Acta Phys Pol 12, 14 (1953)
MR 16, 980 (1955)

"Quantization of a Certain Class of Non-local Field Theories," Acta. Phys. Polon. 12, 100 (1953)
MR 16, 981 (1955)

"On Inversions of Space and Time." Acta Phys Pol 15, 435 (1957)

Rzewuski, J. see Krolikowski, W.

Sannikov, D.G. see Shirokov, Yu.M.

Seldowitsch, J.B. (see also Zel'dovich, J. B.)
"Über die Theorie der Antiteidchen, die Lachungen der Elementarteilchen und die Eigenchaltzen Schwerer Neutrales Mesonen," UFN 59, 377 (1956)
Fort der Phys 5, 570 (1957)

Shapiro, I.S. (also Sapiro)

"Expansion of Wave Functions in Irreducible Representations of the Lorentz Group," DAN 106, 647 (1956).
Soviet Physics Doklady 1, 91 (1956)
NSA 8068 (1956)
Phys Abs 5698 (1956)

"Symmetry Properties in the Theory of Elementary Particles and Nuclear Processes," UFN 53, 7 (1954).
MR 16, 321 (1955)

"On Transformation Laws for the Spinors Appearing as Solution of the Dirac Equation," ZhETF 22, 524 (1952).
MR 14, 339 (1953)
NSA 1291 (1953)

"On Transformation Properties of Wave Functions of Particles with Spin 1/2," ZhETF 23, 412 (1952).
MR 14, 1047 (1953)
NSA 4181 (1954)

"Decay in Particle with Zero Rest Mass," ZhETF 27, 393 (1954).
NSA 1420 (1955)

Shirkov, D.K. see Blank, B.Z.; Bogolyubov, N.N.; and Filimonov, G.F.

Shirokov, M.F. see Chou Kuang Chao and Pugachev, Ya. I.

Shirokov, Yu.M. (also Iu. Shirkov)

"On the Conditions of the Relativistic Invariance of the Quantum Theory." DAN 111, 1223 (1956).
NSA 6170 (1957)
Phys Abs 5878 (1957)

"On the Interaction of Particles of a New Type of Spin 1/2 with an External Field." DAN 99, 737 (1954).
MR 16, 982 (1955)
Phys Abs 7980 (1956)

"On a New Class of Relativistic Equations for Elementary Particles."
DAN 94, 857 (1954).
MR 15, 916 (1955)
NSA 4178 (1954)
Phys Abs 1923 (1957)

"Quantum Electrodynamics in Configuration Representation I."
ZhETF 24 14 (1953).
Phys Abs 9925 (1954)

"Quantum Electrodynamics in Configuration Space III. Interaction of Electrons and Positrons with the Electromagnetic Field." ZhETF 24, 135 (1953).
NSA 7192 (1954)
Phys Abs 9927 (1954)

"Quantum Electrodynamics in Configuration Representation." ZhETF 24, 129 (1953).
Phys Abs 9926 (1954)

"A Relativistic Theory of Free Particles with Three Dimensional Extension." ZhETF 22, 539 (1952).
MR 14, 437 (1953)
NSA 6601 (1954)

"On the Spin of Particles with Zero Rest Mass." ZhETF 23, 78 (1952).
MR 14, 437 (1953)
NSA 2433 (1953)

"On a Theory of Interaction of a Three-dimensional Extended Particle with an External Field." ZhETF 24, 47 (1953).
Phys Abs 9931 (1954)

"A Group-Theoretical Consideration of the Basis of Relativistic Quantum Mechanics. I - The General Properties of the Inhomogeneous Lorentz Group." ZhETF 33, 861 (1957).
JETP 6, 664 (1958)
NSA 12, no 4 (1958)

"A Group-Theoretical Consideration of the Basis of Relativistic Quantum Mechanics. II. Classification of the Irreducible Representations of the Inhomogeneous Lorentz Group."
ZhETF 33, 1196 (1957).
JETP 6, 919 (1958)

"A Group-Theoretical Consideration of the Basis of Relativistic Quantum Mechanics III. Irreducible Representation of the Classes P_0 and O_0 and the Non-completely-reducible Representations of the Inhomogeneous Lorentz Group." ZhETF 33, 1208 (1957).
JETP 6, 929 (1958)

-----and Sannikov, P.G.
"On the Problem of Unquantized Relativistically Invariant Renormalized Equations for a Three-Dimensional Extended Particle."
ZhETF 31, 113 (1956).
JETP 3, 13 (1957)
NSA 4760 (1957)
Phys Abs 94 (1957)
A: 1457
MR 19, no 1 (1958)

Shirokov, Yu.M. see Filimonov, G.F. and Tumanov, K.A.

Silin, V.D. (P.N. Lebedev Institute of Physics)
"On the Article 'On the Spectrum of Excited Systems of Many Particles'."
ZhETF 28, 749 (1955)
Phys Abs 8519 (1955)

"On a Modified Tamm Method." ZhETF 27, 754 (1954).
MR 16, 778 (1955)
Phys Abs 6750 (1955)

"On a Theory of Interaction of Nucleons and Mesons." ZhETF 24, 389 (1953).
NSA 208 (1955)
Phys Abs 49 (1955)

-----and Fainberg, V. Ya.
"The Tamm-Dancoff Method." UFN 56, 569 (1955).
Phys Abs 2657 (1956)

-----and Tamm, I.E. and Fainberg, V.Ya.
"Method of Truncated Field Equations and its Application to the Scattering of Mesons by Nucleons." ZhETF 29, 6 (1955).
JETP 2, 3 (1956)
Phys Abs 8502 (1955)

Sirkov, D.V.
"The Two-charge Renormalization Group in Pseudoscalar Meson Theory."
DAN 105, 972 (1955).
MR 17, 1033 (1956)
Phys Abs 1065 (1957)

Skobelkin, V.I.
"On Double Ray-refraction in Non-linear Electrodynamics." ZhETF 27, 677 (1954)
MR 16, 547 (1955)

Smoorodinskiy, Ya. A.
"The Non-analyticity of the Non-relativistic Scattering Amplitude and the Potential." Joint Institute of Nuclear Research P-135 (1958) (Preprint)

Smosordinskiy, Ya.A. see Ryndin, R.

Sokolik, G.A.
"Classification of Non-linear Equations and Relativistically Invariant Interactions by Representations of the Lorentz Group, and the Fusion Theory." DAN 106, 429 (1956).
Soviet Physics Doklady 1, 57 (1956)
MR 17, 1031 (1956)
NSA 8067 (1956)
Phys Abs 7116 (1956)

"On the Theory of Non-linear Relativistically Invariant Equations."
DAN 101, 817 (1955).
MR 17, 331 (1956)
Phys Abs 7115 (1956)

Sokolik, G.A. see Ivanenko, D.

Sokolov, A.A.
"The Classical Theory of Elementary Particles (the Point Electron)."
Vestnik Moscow University, issue 2, 16 (1947)

"On Relativistic Motion of Electrons in Magnetic Fields when Quantum Effects are Taken into Account." Moscow State University,
Nuovo Cim. III, Sup 743 (1956)

"Remarks on the Quantum Theory of a Gravitational Field." Vestnik Moscow University Ser. Fiz. Mat. Estest. Nauk 1952, no 9, 9 (1952).
MR 15, 82 (1954)

"Further Discussion on the Quantum Theory of the Radiating Electron."
Ref Zhur - Fizika, no 2 1957, no 2943
A: B-5

-----and Ivanenko, D.
"Quantum Field Theory." DAN 91, 47 (1953)

-----and Kerimov, B.K.
"On the Damping Theory of Particle Scattering by a Fixed Center."
ZhETF 31, 1080 (1956)
JETP 4, 921 (1957)

"Scattering of Zero Spin Particles Including Damping." DAN 108,
611 (1956).
MR 18, 443 (1957)
Phys Abs 8583 (1956)

"On the Scattering of Particles by a Form Center According to the
Radiation Damping Theory." Nuovo Cimento V, 783 (1957)

"On the Theory of Scattering of Dirac Particles, Taking Damping into
Account." DAN 105, 961 (1955).
MR 18, 98 (1957)
Phys Abs 1064 (1957)

"Effect of Damping on Polarization of Dirac Particles." ZhETF 33,
827 (1957).
JETP 6, 639 (1958)

-----and Ternov, I.M.
"Motion of Fast Electrons in a Magnetic Field." DAN 92, 537 (1953).
English translation, U.S. National Science Foundation
NSF-tr-137
Phys Abs 6272 (1954)

-----and Tystovich, V.N.
"Theory of Electron Field Mass in the Presence of a Medium." ZhETF
30, 136 (1956).
Phys Abs 4820 (1956)
JETP 3, 94 (1956)
MR 19, 362 (1958)

-----and Tumanov, V.S.
"Uncertainty Relation and Fluctuation Theory." ZhETF 30, 802
(1956).
Phys Abs 7123 (1956)

-----and Ivanenko, D.D.; and Ternov, I.M.
"Excitation of Microscopic Oscillations by Quantum Fluctuations."
DAN 111, 334 (1956).
Phys Abs 3980 (1957)
MR 19, 362 (1958)

-----and Kerimov, B.K. and Guseinov, I.I.
"Damping Theory Study of Elastic Scattering of Dirac Particles with
Account of Polarization Effects," Nuclear Physics 5, 390 (1958)

-----and Klepikov, N.P. and Ternov, I.M.
"On the Question of Radiation by Fast Electrons in a Magnetic Field."
DAN 89, 665 (1953).
Phys Abs 9224 (1953)

-----and Matveev, A.N. and Ternov, I.M.
"On Polarization and Spin Effects in the Theory of Radiating Electron."
DAN 102, 65 (1955).
NSA 5543 (1955)

Sokolov, S.N.
"Green's Function for a Photon Accurate to e^4." ZhETF 32, 1261 (1957).
Phys Abs 722 (1958)

Solovyev, A.N. see Logunov

Solovyev, L.D. (Institute of Nuclear Problems)
"The Asymptotic Electron Green's Function in the Infrared Region to an Accuracy of e^4." DAN 110, 203 (1956).
Phys Abs 1895 (1957)
A: 1546

"Dispersion Relations for S and P Waves for Meson Photoproduction in First Order of 1/M." ZhETF 33, 801 (1957).
JETP 6, 617 (1958)

Solovyev, V.G. (Institute of Nuclear Problems)
"Nuclear (Green) Propagation Function in Quadratic Approximation."
DAN 3, 578 (1956).
Phys Abs 3951 (1957)

"A Particular Model in Quantum Field Theory." DAN 108, 1041 (1956).
Soviet Physics Doklady 1, 392 (1956)
MR 18, 444 (1957)
NSA 805 (1957), 8888 (1958)
Phys Abs 100 (1957)

"Investigation of a Model in Quantum Field Theory." ZhETF 32, 1050 (1957)
JETP 5, 859 (1957)
Phys Abs 724 (1958)
NSA 6947 (1958)

"On the Conservation of Combined Parity." ZhETF 33, 537 (1957)
JETP 6, 419 (1958)
Phys Abs 2761 (1958)

"The Hypothesis of Conservation of Combined Parity Only in Strong Electromagnetic and Weak Interactions." Nuclear Physics 6, 618 (1958)
Phys Abs 2762 (1958)

"The Langrangian Interaction and Operators of Baryon and Meson Fields." Joint Institute for Nuclear Research, Laboratory of Theoretical Physics (1958) (Preprint)
A: P-133

Stepanov, B.M.

"On the Introduction of Dynamical Variables in Quantum Field Theory."
DAN 100, 889 (1955).
MR 17, 220 (1956)
NSA 4029 (1955)
Phys Abs 7958 (1956)

"Non Relativistic Regulation of the S-matrix." DAN 108, 1045 (1956).
Soviet Physics Doklady 1, 346 (1956)
MR 18, 443 (1957)
NSA 806 (1957)
Phys Abs 101, (1957)

Stepanov, R.L. see Logunov

Stratonvich, R.L. (L'vov State University)

"Gauge-Invariant Analogue of Wigner's Distribution." DAN 109, 72 (1956).
MR 18, 360 (1957)
Soviet Physics Doklady 1, 414 (1956)

"A Certain Method for Calculation of Quantum Function." Dokl. Akad. Nank. USSR 115, 1097 (1957)
Phys Abs 2814 (1958)

Sudakov, V.V. (Technical - Physical Institute Academy of Sciences)

"Consequences of the Renormalizability of Quantum Electrodynamics and Meson Theory." ZhETF 31, 729 (1956).
JETP 4, 616 (1957)
Phys Abs 3949 (1957)
NSA 12, no 3 (1958)
MR 19, no 2 (1958)

"Scattering of Mesons by Mesons in Quantum Meson Field Theory." DAN 3, 338 (1956).
Phys Abs 3962 (1957)
MR 19, no 1 (1958)

"Vertex Parts for Very High Energies in Quantum Electrodynamics."
ZhETF 30, 87 (1956).
MR 17, 1033 (1956)
Phys Abs 4809 (1956)

-----and Ter-Martirosyan, K.A.
"Consequences of Renormalizability of Pseudoscalar Meson Theory with
Two Interaction Constants." ZhETF 31, 899 (1956).
Phys Abs 3975 (1956)

"Consequences of Renormalizability of Pseudoscalar Meson Theory with
Two Interaction Constants." ZhETF 31, 902 (1956).
JETP 4, 763 (1957)
NSA 12, no 4 (1958)

Sudakov, V.V. see Pomeranchuk, I. Ya. (also Pomerancuk); and Dyatlov, I.T.

Suffezynski, M.
"Quantization of Non-linear Electrodynamics." Acta. Phys. Polon.
13, 291 (1954).
MR 16, 777 (1955)
Phys Abs 3427 (1955)

Svidzinskiy, A.V.
"Determination of the Green's Functions for the Block-Nordsieck
Model by a Functional Integration Method." ZhETF 31, 324
(1956).
JETP 4, 179 (1957)
Phys Abs 1890 (1957)
MR 19, no 2 (1958)
A: 1538

Taksar, I.M.
"Particle with Spin 3/2 in a Magnetic Field." Akad. Nauk, Latv.
SSR Trudy Institute Fiz 6, 114 (1953).
MR 16, 983 (1955)

Taksar, I.M. see Kunin, P.E.

Tal'yanskiy, I.I.
"On Positive Definiteness of the Energy in a Theory with Higher
Derivatives." DAN 97, 433 (1954).
MR 16, 319 (1955)
Phys Abs 7989 (1956)

Tamm, I. Ye. (P.N. Lebedev Physical Institute, Academy of Sciences, USSR)
"On the Structure of Nucleons." ZhETF 32, 178 (1957).
JETP 5, 154 (1957)
Phys Abs 6885 (1957)

-----and Silin, V.P. and Fainberg, V. Ya.
"On a Relativistic Theory of the Interaction of Nucleons." ZhETF
24, 3 (1953).
NSA 7189 (1954)
Phys Abs 9941 (1954)

Tamm, I. Ye. see Ginsburg, V.L. and Silin, V.P.

Tarasov, Yu.A. (Moscow State University)
"On the Interaction Between Nucleons and Antinucleons." ZhETF 30, 603 (1956)
A: no 1 (1957), no 444

Temko, S.V.
"On the Derivation of the Fokker-Plank Equation for Plasma."
ZhETF 31, 1021 (1956)
JETP 4, 898 (1957)

Tavkelidze, A.N. see Logunov, A.A.

Terletskiy, Ya. P.
"On Relativistic Repulsion Effects in Scalar Field and Attraction Effects in Vector Field." ZhETF 30, 419 (1956)
A: no 1 (1957)m no 216
A: B-6

"Rest Mass of EM Radiation." DAN 63, 519 (1948). (In Russian)

"The Structure of Elementary Particles." DAN 94, 209 (1954). (In Russian)
Phys Abs 2980 (1957)

"On a Rational System of Symbols for Fundamental Particles."
ZhETF 31, 703 (1957).
JETP 4, 574 (1957)

Ter-Martirosyan, K.A. (Leningrad Physics - Technical Institute)
"Charge Renormalization for Arbitrary Values of e_0 which are not Small." ZhETF 31, 157 (1956). (In Russian)
JETP 4, 442 (1957)
Phys Abs 1054 (1957)
A: 1462

Ter-Martirosyan, K.A. see Dyatlov, I.I.; Pomerancuk, I.Ya.; and Sudakov, V.V.

Ternov, I.M. see Sokolov, A.A.

Tevikyan, R.V. (Erevan State University)
"Solution of Schwinger's Equation for the Bloch-Nordsieck Model."
ZhETF 30, 949 (1956).
Phys Abs 7120 (1956)
A: B-5

"Two Electron Green's Function in the Block-Nordsieck Approximation."
ZhETF 32, 1573 (1957).
Phys Abs 61, no 724

Tschernauski, D.S. see Rosental, I.L.

Tsollner, V.; Khrustalev, O.; Serebryakov, V.; Lesnov, A.
"Dispersion Relations for the Process+ N '+"+N' in the Approximation of a Stationary Nucleon." Joint Institute of Nuclear Research (1958)
A: P-158 (Preprint)

Tsytovich, V.N. see Sokolov, A.A.

Tulub, A.V. see Novozhilov, Yu. V.

Tumanov, K.A.
"Correction to Tumanov's Article 'Quantum Electrodynamics in Configurational Representation, Part 5. Two Photon Annihilation of Positronium'." ZhETF 26, 512 (1954)

"Quantum Electrodynamics in a Configurational Representation. Part 5. Two-Photon Annihilation of Positronium."
ZhETF 25, 385 (1953)

-----and Shirokov, Yu. M.
"Quantum Electrodynamics in Configuration Representation IV. Relativistic Equation for the Electron-positron System."
ZhETF 24, 369 (1953).
Phys Abs 40 (1955)

Tumanov, V.S. see Sokolov, A.A.

Tyablikov, S.V. (Math. Institute, Academy of Sciences)
"Adiabatic Form of Perturbation Theory in the Problem of Particles Interacting with a Quantum Field." ZhETF 21, 377 (1951),
these Rev. 13, 412
MR 16, 315 (1955)
NSA 4906 (1955)

"Excited States of Particles in a Field." DAN 81, 31 (1951)

"Questions of Invariance Under Translation in the Theory of Adiabatic Approximation." Ukrain. Mat. Zurnal 5, 152 (1953).
MR 15, 489 (1954)

"On a Study of the Interaction of Electrons with a Photon Field
by the Method of Intermediate Coupling." ZhETF 25, 688 (1953).
Phys Abs 5084 (1955)

"On the Theory of Interaction of a Particle with a Quantized Field."
ZhETF 21, 16 (1951)

Ulegla, I. (Joint Institute of Nuclear Research)
"Anomolous Equations for Spin 1/2 Particles." ZhETF 38, 473 (1957)
NSA 12, no 4 (1958)
JETP 6, no 2 (1958)

Verle, I.I.
"New Approach to the Question of the Influence of Relativistic
Terms in the Meson Theory of Nuclear Forces." ZhETF 25,
19 (1953) (Preprint)
NSA 2085 (1955)
Phys Abs 51 (1955)

Vladimirov, V.S.
"On the Determination of the Regions of Analyticity." Joint Institute
of Nuclear Physics (1958) (Preprint)
A: P-146

Volkov, D. see Ahiezer

Votruba, V. and Lokajicek, M.
"An Algebraic System of Fundamental Particles." Joint Institute for
Nuclear Research (1958)
A: P-181 (Preprint)

Vyalov, G.N.
"The Anomalous Magnetic Moment of Nucleus." ZhETF 31, 620 (1956)
Phys Abs 3001 (1957)
JETP 4, 562 (1957)

Yaglom, A.M. see Gel'fand, I.M.

Yaichnitsyn, V.G.
"Static Solution of a Non-linear Meson Equation." ZhETF 31, 1082
(1956).
Phys Abs 3977 (1957)
JETP 4, 925 (1957)

Yappa, Yu.A. (Leningrad State University)
"In Connection with the Article of V.I. Karpman "On the Question of a Connection Between the Method of Regularization and Theories of Particles with Arbitrary Spin.'" ZhETF 28, 123 (1955).
Phys Abs 3436 (1955)

"On a Connection Between Theories of Regularization and Theories of Particles with Arbitrary Spin." DAN 86, 51 (1952).
MR 14, 608 (1953)
Phys Abs 3082 (1954)
NSA 3971 (1953)
NSA 4456 (1954)

Zaytsev, G.A.
"Concrete Representation of States of Particles with Spin 1/2 in Non-relativistic Quantum Mechanics." ZhETF 25, 653 (1953).
MR 17, no 3, 330 (1956)
Phys Abs 2410 (1955)

"Description of the Electromagnetic Field by Means of Matrices."
ZhETF 28, 524 (1955).
JETP 1, 4 (1955)
NSA 6090 (1956)

"On the Interpretation of Dirac's Equations for an Electron."
ZhETF 29, 176 (1955).
MR 17, no 3 (1956)
NSA 7599 (1955)
Phys Abs 68 (1956)

"Real Spinors in Curvilinear Coordinates and in Pseudoriemannian Space." ZhETF 29, 345 (1955).
JETP 2, (1956)
MR 17, 564 (1956); 18, 94 (1957)
Phys Abs 6357 (1956)

"Real Spinors in Four-dimensional Minkowski Space." ZhETF 25, 667 (1953)
MR 17, no 3, 330 (1956)
Phys Abs 2411 (1955)

"Relativistically Invariant Equations for an Electron which Replace Dirac's Systems of Equations." ZhETF 28, 530 (1955).
MR 17, no 3, 330 (1956)
Phys Abs 2411 (1955)

"Tensors which are Characterized by Two Real Spinors." ZhETF 29, 166 (1955) Reviewed in MR 17, 330
JETP 2, 240 (1956)
MR 18, 94 (1957)

"The Use of Real Spinors for the Description of the Electromagnetic Field." ZhETF 25, 675 (1953).
Phys Abs 4364 (1955)

"On the Fundamental Relativistically Invariant Equation for a Spin 1/2 Particle." DAN 113, 1248 (1957).
NSA 10373 (1957)
Soviet Physics Doklady 2, no 2 (1957)
Phys Abs 8389 (1957)

Zartavenko, L.G.; Liubimov, A.L.; Ogievitsky, V.I.; and Podgoretsky, M.I.
"On a Possibility of K-meson Investigation." Joint Institute of Nuclear Research, USSR (1957).
Nuclear Physics 3, 549 (1957)

Zel'dovich, Ia. B. (see also Seldowitsch)
"Perturbation Theory for the One-dimensional Quantum Mechanical Problem and the Lagrange Method." ZhETF 31, 1101 (1956)
JETP 4, 442 (1957)

"On the Theory of Elementary Particles." DAN 86, 505 (1952).
Phys Abs 3098 (1954)

Zharkov, G.F.
"Nucleon-nucleon Scattering According to the Theory of Damping."
JETP 2, 55 (1956)

"On the Magnetic Moment of the Neutrino." ZhETF 24, 529 (1953).
NSA 2089 (1955)

Zyryanov, P.S. see Eleonskiy, V.M.

The following abbreviations are used in the bibliography:

A	Abstracts from other sources*
Acta Phys Pol	Acta Physica Polonica
DAN	Doklady Akademii Nauk (Reports of the Academy of Sciences of the USSR)
Fort der Phys	Fortschritte der Physik
IAN	Izvestiya Akademii Nauk SSSR (News of the Academy of Sciences USSR)
JETP	American Translation of Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki (ZhETF)
NPA	Nuclear Physics Abstracts
NSA	Nuclear Science Abstracts
NSF	National Science Foundation
Nuovo Cim	Il Nuovo Cimento
MLRA	Monthly List of Russian Accessions (Library of Congress)
MR	Mathematical Reviews
Nuclear Physics	Nuclear Physics
Physica	Physica
Phys Abs	Physics Abstracts
Phys Rev	Physics Review
American Translation of DAN	Soviet Physics Doklady
UFN	Uspekhi Fizicheskikh Nauk (Progress of the Physical Sciences)
VAN	Vestnik Akademii Nauk, (Progress of the Academy of Sciences, USSR)

---

*English translations of Soviet physics abstract, Referativnyy Zhurnal-Fizika, and other sources were supplied mainly by the U.S. Joint Publications Research Service in New York City.

REFERENCES FOR APPENDICES B AND C

APPENDIX B

Part I

1. Kramers, H. A. "Rapports du 8^{e} Conseil Solvay 1948," p 241, R. Stoops, Brussels, 1950.
2. Dyson, F. J. Physical Review <u>75</u>, 486 1949
3. Schweber, S.S.; Bethe, H.A.; and de Hoffman, F. "Mesons and Fields, vol 1," Row Peterson, Evanston, Ill., 1955
4. Lee, T.D. Physical Review <u>95</u>, 1329, 1954
5. Kallen, G; and Pauli, W.K. Danskevidensk. Selskl, mat-fys. Medd., <u>30</u>, (7), 1955
6. Kallen, G. Danski vidensk. Selsk., mat-fys. Medd. <u>27</u> (12), 1953
7. Kallen, G. Helv. phys. Acta. <u>25</u>, 417, 1952
8. Lehmann, H. Nuov. Cim. <u>11</u>, 342, 1954
9. Gell-Mann, M and Low, F.E., Phys. Rev. <u>95</u>, 1300, 1954
10. Bogolyubov, N.N. and Shirkov, D.V. Nuov. Cim. <u>3</u> 845 (1956
11. Landau, L.D.; Abrikosov, A.; and Hatatnikov, L. Nuov. Cim. (Supp.) <u>3</u>, 80, 1956
12. Schwinger, J. Proc. N.A.S. of U.S. <u>37</u>, 452, 455, 1951
13. Fradkin, E.S., Soviet Physics JETP <u>2</u>, 148, 1956
14. Pomeranchuk, I.; Sudskov, V.V.; and Ter-Martirosyan, K.A.; Phys. Rev. <u>103</u>, 784, 1956
15. Abrikosov, A.A., et. al., Phys. Rev. <u>111</u>, 321, 1958
16. Dyson, F.J. unpublished lecture notes, Comumbia U., spring 1957
17. Kallen, G., CERN Symposium, 1956, CERN, Geneva, Switzerland, p 187, 1956

Part II

1. Pomeranchuk, I. Nuovo Cim v3, p 1186, 1956

2. Lehmann, H.; Symanzik, K.; and Zimmerman, W.Z.; Il Nuovo Cimento, v 2, p 425, 1955

APPENDIX C

Part I

1. Bogolyubov, N.N., Ukr. Mat. Zhurn. <u>2</u>, <u>3</u>, 1950

2. Bardeen, Cooper, and Schrieffer, Physical Review, <u>108</u>, 1175, 1957

3. Bogolyubov, N.N., Il Nuovo Cimento 7, 794, 1958

4. University of Maryland, Physics Department, Technical Report 115

Part II

1. Physical Review, 104, 1760, 1956

2. -----, 95, 1612, 1954