Symmetries of equations of quantum mechanics

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Abstract

This book is devoted to the analysis of old (classical) and new (non-Lie) symmetries of the fundamental equations of quantum mechanics and classical field theory, and to the classification and algebraic-theoretical deduction of equations of motion of arbitrary spin particles in both Poincaré invariant approach. The authors present detailed information about the representations of the Galilei and Poincaré groups and their possible generalizations, and expound a new approach for investigating symmetries of partial differential equations; this leads to finding previously unknown algebras and groups of invariance of the Dirac, Maxwell and other equations.

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Preface to the English Edition

"In the beginning was the symmetry"
W. Heisenberg

"Hidden harmony is stronger then the explicit one"
Heraclitus

The English version of our book is published on the initiative of Dr. Edward M. Michael, Vice-President of the Allerton Press Incorporated. It is with great pleasure that we thank him for his interest in our work.

The present edition of this book is an improved version of the Russian edition, and is greatly extended in some aspects. The main additions occur in Chapter 4, where the new results concerning complete sets of symmetry operators of arbitrary order for motion equations, symmetries in elasticity, super- and parasupersymmetry are presented. Moreover, Appendix II includes the explicit description of generalized Killing tensors of arbitrary rank and order: these play an important role in the study of higher order symmetries.

The main object of this book is symmetry. In contrast to Ovsiannikov's term "group analysis" (of differential equations) [355] we use the term "symmetry analysis" [123] in order to emphasize the fact that it is not, in general, possible to formulate arbitrary symmetry in the group theoretical language. We also use the term "non-Lie symmetry" when speaking about such symmetries which can not be found using the classical Lie algorithm.

In order to deduce equations of motion we use the "non-Lagrangian" approach based on representations of the Poincaré and Galilei algebras. That is, we use for this purpose the principles of Galilei and Poincaré-Einstein relativity formulated in algebraic terms. Sometimes we use the usual term "relativistic equations" when speaking about Poincaré-invariant equations in spite of the fact that Galilei-invariant subjects are "relativistic" also in the sense that they satisfy Galilei relativity principle.

Our book continues the series of monographs [[127], [157], [171], [10*], [11*] devoted to symmetries in mathematical physics. Moreover, we will edit "Journal of Nonlinear Mathematical Physics" which also will related to these problems.

We hope that our book will be useful for mathematicians and physicists in the English-speaking world, and that it will stimulate the development of new symmetry approaches in mathematical and theoretical physics.

Only finishing the contemplated work one
understands how it was necessary to begin it
B. Pascal

Preface

Over a period of more than a hundred years, starting from Fedorov's works on symmetry of crystals, there has been a continuous and accelerating growth in the number of researchers using methods of discrete and continuous groups, algebras and superalgebras in different branches of modern natural sciences. These methods have a universal nature and can serve as a basis for a deep understanding of the relativity principles of Galilei and Poincaré-Einstein, of Mendeleev's periodic law, of principles of classification of elementary particles and biological structures, of conservation laws in classical and quantum mechanics etc.

The foundations of the theory of continuous groups were laid a century ago by Sofus Lie, who proposed effective algorithms to calculate symmetry groups for linear and nonlinear partial differential equations. Today the classical Lie methods (completed by theory of representations of Lie groups and algebras) are widely used in theoretical and mathematical physics.

Our book is devoted to the analysis of old (classical) and new (non-Lie) symmetries of the basic equations of quantum mechanics and classical field theory, classification and algebraic theoretical deduction of equations of motion of arbitrary spin particles in both Poincaré and Galilei-invariant approaches. We present detailed information about representations of the Galilei and Poincaré groups and their possible generalizations, and expound a new approach to investigation of symmetries of partial differential equations, which enables to find unknown before algebras and groups of invariance of the Dirac, Maxwell and other equations. We give solutions of a number of problems of motion of arbitrary spin particles in an external electromagnetic field. Most of the results are published for the first time in a monographic literature.

The book is based mainly on the author's original works. The list of references does not have any pretensions to completeness and contains as a rule the papers immediately used by us.

We take this opportunity to express our deep gratitude to academicians N.N. Bogoliubov, Yu.A. Mitropolskii, our teacher O.S. Parasiuk, correspondent member of Russian Academy of Sciences V.G. Kadyshevskii, professors A.A. Borgardt and M.K. Polivanov for essential and constant support of our researches in developing the algebraic-theoretical methods in theoretical and mathematical physics. We are indebted to doctors L.F. Barannik, I.A. Egorchenko, N.I. Serov, Z.I. Simenoh, V.V. Tretynyk, R.Z. Zhdanov and A.S. Zhukovski for their help in the preparation of the manuscript.

Introduction

The symmetry principle plays an increasingly important role in modern researches in mathematical and theoretical physics. This is connected with the fact that the basis physical laws, mathematical models and equations of motion possess explicit or unexplicit, geometric or non-geometric, local or non-local symmetries. All the basic equations of mathematical physics, i.e. the equations of Newton, Laplace, d'Alembert, Euler-Lagrange, Lame, Hamilton-Jacobi, Maxwell, Schrodinger etc., have a very high symmetry. It is a high symmetry which is a property distinguishing these equations from other ones considered by mathematicians.

To construct a mathematical approach making it possible to distinguish various symmetries is one of the main problems of mathematical physics. There is a problem which is in some sense inverse to the one mentioned above but is no less important. We say about the problem of describing of mathematical models (equations) which have the given symmetry. Two such problems are discussed in detail in this book.

We believe that the symmetry principle has to play the role of a selection rule distinguishing such mathematical models which have certain invariance properties. This principle is used (in the explicit or implicit form) in a construction of modern physical theories, but unfortunately is not much used in applied mathematics.

The requirement of invariance of an equation under a group enables us in some cases to select this equation from a wide set of other admissible ones. Thus, for example, there is the only system of Poincaré-invariant partial differential equations of first order for two real vectors **E** and **H**, and this is the system which reduces to Maxwell's equations. It is possible to "deduce" the Dirac, Schrödinger and other equations in an analogous way.

The main subject of the present book is the symmetry analysis of the basic equations of quantum physics and deduction of equations for particles of arbitrary spin, admitting different symmetry groups. Moreover we consider two-particle equations for any spin particles and exactly solvable problems of such particles interaction with an external field.

The local invariance groups of the basic equations of quantum mechanics (equations of Schrodinger, of Dirac etc.) are well known, but the proofs that these groups are maximal (in the sense of Lie) are present only in specific journals due to their complexity. Our opinion is that these proofs have to be expounded in form easier to understand for a wide circle of readers. These results are undoubtedly useful for a deeper understanding of mathematical nature of the symmetry of the equations mentioned. We consider local symmetries mainly in Chapter 1.

It is well known that the classical Lie symmetries do not exhaust the invariance properties of an equation, so we find it is necessary to expound the main results obtained in recent years in the study of non-Lie symmetries, super- and parasupersymmetries. Moreover we present new constants of motion of the basic equations of quantum physics, obtained by non-Lie methods. Of course it is interesting to demonstrate various applications of symmetry methods to solving concrete physical problems, so we present here a collection of examples of exactly solvable equations describing interacting particles of arbitrary spins.

The existence of the corresponding exact solutions is caused by the high symmetry of the models considered.

In accordance with the above, the main aims of the present book are:

1. To give a good description of symmetry properties of the basic equations of quantum mechanics. This description includes the classical Lie symmetry (we give simple proofs that the known invariance groups of the equations considered are maximally extensive) as well as the additional (non-Lie) symmetry.

2. To describe wide classes of equations having the same symmetry as the basic equations of quantum mechanics. In this way we find

the Poincaré-invariant equations which do not lead to known contradictions with causality violation by describing of higher spin particles in an external field, and the Galilei-invariant wave equations for particles of any spin which give a correct description of these particle interactions with the electromagnetic field. The last equations describe the spin-orbit coupling which is usually interpreted as a purely relativistic effect.

3. To represent hidden (non-Lie) symmetries (including super- and parasupersymmetries) of the main equations of quantum and classical physics and to demonstrate existence of new constants of motion which can not be found using the classical Lie method.

4. To demonstrate the effectiveness of the symmetry methods in solving the problems of interaction of arbitrary spin particles with an external field and in solving of nonlinear equations.

Besides that we expound in details the theory of irreducible representations of the Lie algebras of the main groups of motion of four-dimensional space-time (i.e. groups of Poincaré and Galilei) and of generalized Poincaré groups *P(1,n)* . We find different realizations of these representations in the basises available to physical applications. We consider representations of the discrete symmetry operators *P* , *C* and *T* , and find nonequivalent realizations of them in the spaces of representations of the Poincaré group.

The detailed list of contents gives a rather complete information about subject of the book so we restrict ourselves by the preliminary notes given above.

The main part of the book is based on the original papers of the authors. Moreover we elucidate (as much as we are able) contributions of other investigators in the branch considered.

We hope our book can serve as a kind of group-theoretical introduction to quantum mechanics and will be interesting for mathematicians and physicists which use the group-theoretical approach and other symmetry methods in analysis and solution of partial differential equations.

List of references

1. A. Adamczyk and R. Raczka, New Relativistic Wave Equations Associated with Indecomposable Representations of the Poincaré Group, Preprint/ Int. Center of Theor. Phys. IC/78/100, Trieste, 1978.
2. K.J. Akdeniz, "On classical solutions of Gürsey's conformal-invariant spinor model", Lettere al Nuovo Cimento, vol. 33, no. 2, pp. 40-44, 1982.
3. A.I. Akhiezer and V.B. Berestetskii, Quantum Electrodynamics [in Russian], Nauka, Moscow, 1981.
4. P.A. Amundsen, "Position operators and transformation properties of a relativistic Hamiltonian theory for any spin", Physica Norvegica, vol. 8, no. 2, pp. 107-112, 1975.
5. N. Anderson and A.M. Arthurs, "An extension of a conservation laws for the electromagnetic field", International Journal of Electronics, vol. 57, no. 4, pp. 477-478, 1984.
6. R.L. Anderson and N.H. Ibragimov, Lie-Bäcklund Transformations in Applications, SIAM, Philadelphia, 1979.
7. R.L. Anderson, S. Kumei, and C. Wulfman, "Invariants of the equations of wave mechanics, I, II", Rev. Mexicana Fis., vol. 21, pp. 1-33, 35-37, 1972.
8. E. Angelopolous, M. Flato, C. Fronsdal, and D. Sternheimer, "Massless particles, conformal group and de Sitter universe", The Physical Review, D, vol. 23, no. 6, pp. 1278-1289, 1981.
9. V.G. Bagrov and D.M. Gitman, Exact Solutions of Relativistic Wave Equations, Kluwer Academic Publ., Dordrecht, 1990.
10. B. Bakamjian and L.H. Thomas, "Relativistic particle dynamics. II", The Physical Review, vol. 92, no. 5, pp. 1300-1309, 1953.
11. M.M. Bakri, "De-Sitter symmetry field theory. I. One-particle theory", Journal of Mathematical Physics, vol. 10, no. 2, pp. 298-320, 1969.
12. L.F. Barannik, "Projective unitary-antiunitary representations of finite Abel groups", Group-Theoretical Studies of Equations of Mathematical Physics [in Russian], pp. 47-52, Inst. of Matem. Acad. Sci. of Ukraine, Kiev, 1985.
13. L.F. Barannik and W.I. Fushchich, "On subalgebras of the Lie algebra of the extended Poincaré group P(1,n)", Journal of Mathematical Physics, vol. 28, no. 7, pp. 1445-1448, 1987.
14. L.F. Barannik and W.I. Fushchich, "On continuous subgroups of the generalized Schrödinger groups", Journal of Mathematical Physics, vol. 30, no. 2, pp. 280-290, 1989.
15. V. Bargman, "Irreducible unitary representations of the Lorentz group", Annals of Mathematics, vol. 48, no. 3, pp. 568-640, 1947.
16. V. Bargman, "On unitary ray representations of continuous groups", Annals of Mathematics, vol. 59, no. 1, pp. 1-46, 1954.
17. V. Bargman and E.P. Wigner, "Group theoretical discussion of relativistic wave equations", Proceedings of National Academy of Sciences of U.S., vol. 34, pp. 221-223, 1948.
18. W.A. Barker and F.N. Glover, "Reduction of relativistic two-particle equations to approximate form. III", The Physical Review, vol. 99, no. 1, pp. 317-324, 1955.
19. A.O. Barut and S. Komy, "Derivation of nonperturbative relativistic two-body equations from the action principle in quantum electrodynamics", Fortschrite der Physik, vol. 33, no. 6, pp. 309- 318, 1985.
20. A.O. Barut and R. Raczka, Theory of Group Representations and Applications, PWN, Warsaw, 1977.
21. A.O. Barut and Xu Bo-Wei, "Meron-like solutions of conformally covariant coupled nonlinear field equations", Physica, D, vol. 6, no. 1, pp. 137-139, 1982.
22. H. Bateman, "On the conformal transformations of a space of four dimensional and their applications to geometric optics", Proceedings of London Mathematical Society, ser. 7, pp. 70-92, 1909.
23. H. Bateman, "The transformation of Electrodynamical equations", Proceedings of London Mathematical Society, ser. 8, pp. 223-

264, 1909.
24. F. Bayen and M. Flato, "Remarks on conformal space", Journal of Mathematical Physics, vol. 17, no.7, pp. 1112-1114, 1976.
25. J. Beckers, "Sur le tenseur de moment angulaire intrinsique et le groupe de Poincaré", Bullletin de la Société Royale des Sciences de Liège, vol. 36, no. 11-12, pp. 643-653, 1967.
26. J. Beckers and N. Debergh, "On parasupersymmetry and remarkable Lie structures", Journal of Physics A: Mathematical and General, vol. 23, no. 14, pp. 751S-L755S, 1990.
27. J. Beckers and N. Debergh "On the symmetries of relativistic spin-1/2 particle equations", Journal of Physics A: Mathematical and General, vol. 24, no. 12, pp. 2889-2901, 1991.
28. J. Beckers, N. Debergh, and A.G. Nikitin, "More on symmetries of the Schrödinger equation", Journal of Physics A: Mathematical and General, vol. 24, no. 21, pp. L1269-L1275, 1992.
29. J. Beckers and M. Jaspers, "On timelike, lightlike and spacelike realizations of Poincaré generators", Annals of Physics (N.Y), vol. 113, no. 2, pp. 237-256, 1978.
30. F.J. Belifante, "Magnetic moment of neutron and proton", The Physical Review, vol. 92, no. 4, pp. 994-997, 1953.
31. V.B. Berestetskii, E.M. Livshits, and L.P. Pitaevskii, Relativistic Quantum Theory [in Russian], Nauka, Moscow, 1990.
32. E. Bessel-Hagen, "Uber die Erhaltungratze der Electrodynamik", Math. Ann., vol. 84, no. 2, pp. 258-263, 1921.
33. H.A. Bethe and E.E. Salpeter, Quantum Mechanics of Atoms with One and Two Electrons, Springer-Verlag, Berlin, 1957.
34. S.J. Betti, "Exotic atoms", Soviet journal Fizika Elementarnykh Chastits i Atomnogo Yadra vol. 13, no. 1, pp. 164-232, 1982.
35. H.J. Bhabha, "Relativistic wave equations for elementary particles", Review of Modern Physics, vol. 17, no. 2-3, pp. 200-215, 1945.
36. L.C. Biedenharn and M.Y. Han, "A two -component spherical factorization of the Klein-Gordon and Kramers equations", Physics Letters, B, vol. 36, pp. 475-476, 1971.
37. J.D. Bjorken and S.D. Drell, Relativistic Quantum Mechanics, McGraw-Hill Book Company, 1964.
38. S.A. Bludman, "Some theoretical consequences of a particle having mass zero", The Physical Review, vol. 107, no. 4, pp. 1163-1168, 1957.
39. G. Blumen and S. Kumei, Symmetries and Differential Equations, Springer, New York, 1989.
40. N.N. Bogolyubov, Lectures on the Theory of Symmetry of Elementary Particles [in Russian], Izd. Mosk. Univ., Moscow, 1966.
41. N.N. Bogolyubov, A.A. Logunov, A.I. Oksak, and T.T. Todorov, General Principles of Quantum Field Theory [in Russian], Nauka, Moscow, 1987.
42. N.N. Bogolyubov and D.V. Shirkov, Introduction to the Theory of Quantized Fields [in Russian], Nauka, Moscow, 1973.
43. A.A. Bogush and L.G. Moroz, Introduction to a Theory of Classical Fields [in Russian], Nauka i Tekhnika, Minsk, 1968.
44. A.A. Borgardt, "Anticommutative matrices in meson theory", Doklady Akademii Nauk SSSR (N.S.), vol. 78, no. 6, pp. 1113-1115, 1951.
45. A.A. Borgardt, "Photon wave equations", Eksperimental'naya i Teoreticheskaya Fizika (JETP), vol. 34, no. 5, pp. 1323-1325, 1958.
46. A.A. Borgardt and D.Ya. Karpenko, "Boson in the field of plane electromagnetic wave", Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki (JETP), vol. 50, no. 4, pp. 1167-1170, 1966.
47. A.A. Borgardt and D.Ya. Karpenko, "Kepler Problem for Charged Vector Boson [in Russian], Preprint/Inst. Theor. Phys. Acad. Sci. Ukraine, ITF-71-105R, Kiev, 1971.
48. M. Born and L. Infeld, "Foundations of the new field theory", Proceedings of the Royal Society A, vol. 144, no. 2, pp. 425-451, 1934.
49. V.A. Borodovitsin and I.M. Ternov, "Invariant definition of relativistic spin states in quantum theory", Teoreticheskaya i Matematicheskaya Fizika, vol. 59, no. 2, pp. 20-223, 1984.
50. S.K. Bose and R. Parker, "Zero-mass representation of Poincaré group and conformal invariance", Journal of Mathematical Physics, vol. 10, no. 5, pp. 812-813, 1969.
51. C. Boyer, "The maximal kinematical invariance group for an arbitrary potential", Helvetica Physica Acta, vol. 47, no. 4, pp. 589-605, 1974.
52. A.J. Bracken, "A comment on the conformal invariance of zero-mass Klein-Gordon equation", Lettere al Nuovo Cimento, vol. 2, no. 11, pp. 574-578, 1971.
53. A.J. Bracken and B. Jessup, "Local conformal invariance of the wave equation for finite-component fields. I. The condition for invariance and fully-reducible fields", Journal of Mathematical Physics, vol. 23, no. 10, pp. 1925-1946, 1982.
54. G. Breit, "The effect of retardation on the interaction of two electrons", The Physical Review, vol. 34, no. 4, pp. 553-573, 1929.
55. R.H. Brennich, "The irreducible ray representations of the full inhomogeneous Galilei group", Annals de Institute de Henri Poincaré, vol. 13, no. 2, pp. 137-161, 1970.
56. P. Budini, "On conformally covariant spinor field equations", Czechoslovac Journal of Physics, B, vol. 29, no. 2, pp. 6-21, 1979.
57. A.A. Bykov, I.M. Dremin and A.V. Leonidov, "Potential models of quarkonium", Uspekhi Fizicheskich Nauk, vol. 143, no. 1, pp. 3-32, 1984.
58. A.Z. Capri, "First-order wave equations for half-odd-integral spins", The Physical Review, vol. 178, no. 5, pp. 2427-2433, 1969.
59. J.F. Carinena, "Semiunitary projective representations of the complete Galilei group", Journal of Mathematical Physics, vol. 22, no. 8, pp. 1548-1558, 1981.
60. J.F. Carinena and M. Satander, "Galilean relativistic wave equations", Journal of Physics A: Mathematical and General, vol. 15, no. 2, pp. 343-353, 1982.
61. L. Castell, "The relativistic position operator at subatomic level", Il Nuovo Cimento, vol. 49, no. 10, pp. 285-290, 1967.
62. Th. Cazenave, "An introduction to nonlinear Schrödinger equations", Textos de Metodos Matematicos de Universidade Federal do Rio de Janeiro, vol. 22, pp. 235-281, 1990.
63. R. Chatterjee, and J.M. Dixon, "On source of spin-orbit coupling in the Schrödinger representation", Canadian Journal of Physics, vol. 57, no. 2, pp. 2072-2077, 1979.
64. R. Chatterjee and T. Lulek, "Origin of the spin-orbit interaction", Acta Physica Polonica A, vol. 56, no. 22, pp. 2902- 2915, 1979.

65. R.W. Childers, R.W., "Two-body Dirac equation for semirelativistic quarks", The Physical Review D, vol. 26, no. 10, pp. 2902-2915, 1982.
66. Yu.A. Chirkunov, "Group properties of the Lame equation [in Russian], Dinamika Sploshnoi Sredy 14, pp. 128-130, Institute of Hydrodinamics, Novosibirsk, 1973.
67. Z.V. Chraplyvy, "Reduction of relativistic two-particle equation to approximate form. II", The Physical Review, vol. 92, no. 5, pp. 1310-1322, 1953.
68. P.A. Clarkson and M.D. Kruskal, "New similarity reductions of the Boussinesq equation", Journal of Mathematical Physics, vol. 30, no. 10, pp. 2201-2213, 1989.
69. F. Coester, "Relativistic quantum mechanics of particles with direct interaction", The Physical Review, D, vol. 26, no. 6, pp. 1348-1367, 1982.
70. E. Cuningham, "The principle of relativity in electrodynamics and an extension thereof", Proceedings of London Mathematical Society, vol. 8, pp. 77-98, 1909.
71. Yu.A. Danilov, Group Properties of the Maxwell and Navier-Stokes Equations [in Russian], Preprint/Khurchatov Inst. Nucl. Energy, IAE-1452, Moscow, 1967.
72. Yu.A. Danilov, Group Properties of the Dirac Equation [in Russian], Preprint/Khurchatov Inst. Nucl. Energy, IAE-1736, Moscow, 1968.
73. C.G. Darwin, "The wave equation of the electron", Proceedings of the Royal Society London, A, vol. 118, no. 780, pp. 654-680, 1928.
74. A. Da Silveira, "Invariance algebras of the Dirac and Maxwell equations", Il Nuovo Cimento, A, vol. 56, no. 4, pp. 385-395, 1980.
75. A.S. Davidov, "Wave equations of a particle having spin 3/2 in absence of field", Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki (JETP), vol. 13, no. 9-10, pp. 313-319, 1943.
76. M.G. De Amaral and N. Zagury, "Quark model with one-gluon corrections. Ground states", The Physical Review, D, vol. 26, no. 11, pp. 3119-3122, 1982.
77. P.A.M. Dirac, "The quantum theory of the electron. I., II", Proceedings of the Royal Society London, A, vol. 117, no. 778, pp. 616-624, 1928; vol. 118, no. 779, pp. 351-361, 1928.
78. P.A.M. Dirac, "Relativistic wave equations", Proc. Roy. Soc. London, A, vol. 155, pp. 447-459, 1936.
79. P.A.M. Dirac, "Wave equations in conformal space", Annals of Mathematics, vol. 37, no. 2, pp. 429-442, 1936.
80. P.A.M. Dirac, "Forms of relativistic dynamics", Reviews of Modern Physics, vol. 21, no. 3, pp. 392-399, 1949.
81. P.A.M. Dirac, The Principles of Quantum Mechanics, Clarendon Press, Oxford, 1958.
82. P.A.M. Dirac, "A positive-energy relativistic wave equation", Proceedings of the Royal Society London, A, vol. 22, pp. 435-445, 1972.
83. V.K. Dobrev, G. Mack, V.P. Petkova, S.G. Petrova, and T.T. Todorov, Harmonic Analysis on the n-Dimensional Lorentz Group and Its Application to Conformal Quantum Field Theory, Lect. Notes in Phys., 63, Springer-Verlag, 1977.
84. A.D. Donkov, V.G. Kadyshevskii, and M.D. Mateev, "Non-euclidean momentum space and two-body problem", Teoreticheskaya i Matematicheskaya Fizika, vol. 50, no. 3, pp. 366-369, 1982.
85. V.A. Dorodnitsyn, I.V. Kniazeva, and S.R. Svirishtevskii, "Group properties of the heat equation with source in two-dimension and three-dimension cases", Differential'nye Uravnenya, vol. 19, no. 7, pp. 1215-1224, 1983.
86. I.S. Dowker, "A wave equations for massive particles of arbitrary spin", Proceedings of the Royal Society London, A, vol. 293, no. 1450, pp. 35-42, 1967.
87. R.J. Duffin, "On the characteristic matrices of covariant systems", The Physical Review, vol. 54, p. 1114, 1938.
88. S. Durand, J.M. Lina, and L. Vinet, "Symmetries of massless Dirac equation in Minkowski space", The Physical Review, D, vol. 38, no. 12, pp. 3837-3839, 1988.
89. S. Durand and L. Vinet, "Dynamical parasuperalgebras of parasupersymmetric harmonic oscillator, cyclotron motion and Morse Hamiltonians", Journal of Physics A: Mathematical and General, vol. 23, no. 16, pp. 3661-3672, 1990.
90. A. Einstein, "Zur Electrodynamics bewegter Korper", Ann. L. Phys., vol. 17, p. 891, 1905.
91. A.R. Edmonds, Angular Momentum in Quantum Mechanics,. Princeton University Press, Princeton, 1960.
92. V.M. Fedorchuck, "Splitting subalgebras of the Lie algebra of the generalized Poincaré group P(1,4)", Ukrainskii Matematicheskii Zhurnal, vol. 31, no. 6, pp. 717-722, 1979.
93. V.M. Fedorchuck, "Nonsplitting subalgebras of the Lie algebra of the generalized Poincaré group P(1,4)", Ukrainskii Matematicheskii Zhurnal, vol. 33, no. 5, pp. 696-700, 1981.
94. V.M. Fedorchuck, "On reduction and some exact solutions of nonlinear wave equation", Symmetry and Solutions of Nonlinear Equations of Mathematical Physics [in Russian], pp. 73-76, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1987, 73-76.
95. F.I. Fedorov, "Generalized relativistic wave equations", Doklady Akademii Nauk SSSR (N.S.), vol. 82, no. 1, pp. 37-40, 1952.
96. F.I. Fedorov and A.F. Radyuk, "Meson in the field of plane electromagnetic wave", Yadernaya Fizika, vol. 20, no. 3, pp. 503-513, 1974.
97. F.I. Fedorov, Lorentz Group [in Russian], Nauka, Moscow, 1979.
98. R.P. Feynman and M. Gell-Mann, "Description of the Fermi interaction", The Physical Review, vol. 109, no. 1, pp. 193-197, 1958.
99. M. Fels and N. Kamran, "Non-factorizable separable systems and higher-order symmetries of the Dirac operator", Proceedings of the Royal Society London, A, vol. 428, pp. 229-249, 1990.
100. M. Fierz and W. Pauli, "On relativistic wave equations for particles of arbitrary spin in an electromagnetic field", Proceedings of the Royal Society London, A, vol. 173, pp. 211-232, 1939.
101. M. Flato, J. Simon, and D. Sternheimer, "Conformal invariance of field equations", Annals of Physics (N.Y), vol. 61, no. 1, pp. 78-97, 1970.
102. V.A. Fock, "Zur Schrödingerschen Wellenmechanik", Zeitschrift für Physik, vol. 38, no. 3, pp. 242-250, 1926.
103. V.A. Fock, "Hydrogen atom and non-Euclidean geometry", Izvestiya Akademii Nauk SSSR, vol. 2, no. 2, pp. 169-179, 1935.
104. V.A. Fock, "Zur theorie des Wasserstoffatoms", Fortshritte der Physik, vol. 98, pp. 145-147, 1935.

105. V.A. Fock, Foundations of Quantum Mechanics [in Russian], Nauka, Moscow, 1976.
106. L.L. Foldy, "Syntesis of covariant particle equations", The Physical Review, vol. 102, no. 2, pp. 568-573, 1956.
107. L.L. Foldy, "Relativistic particle system with interaction", The Physical Review, vol. 122, no. 1, pp. 275-288, 1961.
108. L.L. Foldy and S.A. Wouthuysen "On the Dirac theory of spin 1/2 particles and its non-relativistic limit", The Physical Review, vol. 78, no. 1, pp. 29-37, 1950.
109. D.M. Fradkin, "Conserved quantities associated with symmetry transformations of relativistic free-particle equations of motion", Journal of Mathematical Physics, vol. 6, no. 6, pp. 879-890, 1965.
110. J. Fröhlich and H. Pilkuhn, "Relativistic two-particle effects in exotic atoms", Journal of Physics, B, vol. 17, no. 1, pp. 147- 162, 1984.
111. P. Furlan, "Internal symmetries from field theories in higher dimensions", Czechoslovac Journal of Physics, vol. 32, no. 6, pp. 634-644, 1982.
112. P. Furlan and R. Raczka, R., A New Approach to Unified Field Theories, 1980, Preprint/Int. Center for Theor. Phys, IC/80/181, Miramare-Trieste, 1980.
113. W.I. Fushchich, On Additional Invariance of Relativistic Equations of Motion[in Russian], Preprint/Inst. for Theoretical and Phys., ITP-70-32E, Kiev, 1970.
114. W.I. Fushchich, "On the P- and T-noninvariant two-component equations for the neutrino", Nuclear Physics, B, vol. 21, no. 2, pp. 321-330, 1970.
115. W.I. Fushchich, "Representations of complete inhomogeneous de Sitter group and equations in five-dimensional approach", Teoreticheskaya i Matematicheskaya Fizika, vol. 4, no. 3, pp. 360-382, 1970.
116. W.I. Fushchich, "On additional invariance of relativistic equation of motion", Teoreticheskaya i Matematicheskaya Fizika, vol. 7, no. 1, pp. 3-12, 1971.
117. W.I. Fushchich, "On three types of relativistic equations for a particle with nonzero mass", Lettere al Nuovo Cimento, vol. 4, no. 9, pp. 344-346, 1972.
118. W.I. Fushchich, "P, C, T- properties of the Poincaré invariant equations for massive particles", Lettere al Nuovo Cimento, vol. 6, no. 4, pp. 133-137, 1973.
119. W.I. Fushchich, "On a motion equation for two particles in relativistic quantum mechanics", Lettere al Nuovo Cimento, vol. 10, no. 4, pp. 163-167, 1974.
120. W.I. Fushchich, "On additional invariance of the Dirac and Maxwell equations", Lettere al Nuovo Cimento, vol. 11, no. 10, pp. 508-512, 1974.
121. W.I. Fushchich, "On additional invariance of the Klein-Gordon-Fock equation", Doklady Akademii Nauk SSSR (N.S.), vol. 230, no. 3, 570-573, 1976.
122. W.I. Fushchich, "On new method of investigation of group properties of systems of partial differential equations", Group-Theoretical Methods in Mathematical Physics [in Russian], pp.5-44, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1978.
123. W.I. Fushchich, "On new method of investigation of group properties of equations of mathematical physics", Doklady Akademii Nauk SSSR (N.S), vol. 246, no. 4, pp. 846-850, 1979.
124. W.I. Fushchich, "Symmetry in problems of mathematical physics", Algebraic-Theoretical Studies in Mathematical Physics [in Russian], pp. 6-18, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1981, 6-28.
125. W.I. Fushchich, "On symmetry and exact solutions of some multidimensional equations of mathematical physics", Algebraic-Theoretical Methods in Problems of Mathematical Physics [in Russian], pp. 4-23, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1983.
126. W.I. Fushchich, "On symmetry and exact solutions of nonlinear wave equations", Ukrainskii Matematicheskii Zhurnal, vol. 39, no. 1, pp. 116-123, 1987.
127. W.I. Fushchich, L.F. Barannik, and A.F. Barannik, "Subgroup analysis of the Galilei and Poincaré groups and reduction of nonlinear equations [in Russian], Naukova Dumka, Kiev, 1991.
128. W.I. Fushchich and R.M. Cherniha, "The Galilean relativistic principle and nonlinear partial differential equations", Journal of Physics A: Mathematical and General, vol. 18, no. 10, pp. 3491-3503, 1985.
129. W.I. Fushchich and R.M. Cherniha, On Exact Solutions of Two Dimensional Nonlinear Equations of Schrödinger Type[in Russian], Preprint/Inst. of Math. Acad. Sci. of Ukraine, 86.85, Kiev, 1986.
130. W.I. Fushchich, V.I. Chopyk, and P.J. Myronyuk, "Conditional invariance and exact solutions of three-dimensional equations of acoustics", Doklady Akademii Nauk Ukrainy, vol. 9, no. 9, pp. 25-28, 1990.
131. W.I. Fushchich and I.A. Egorchenko, "On symmetry properties of complex-valued nonlinear wave equations", Doklady Akademii Nauk SSSR, vol. 298, no. 7, pp. 347-351, 1988.
132. W.I. Fushchich and A.L. Grishchenko, "On the CP-noninvariant equations for the particles with zero mass and spin s = 1/2", Lettere al Nuovo Cimento, vol. 4, no. 20, pp. 927-928, 1970.
133. W.I. Fushchich, A.L. Grishchenko, and A.G. Nikitin, "On the relativistic equations of motion without superfluous components", Teoreticheskaya i Matematicheskaya Fizika, vol. 8, no. 2, pp. 192-205; Theoretical and Mathematical Physics, vol. 8, no. 2, pp. 766-779, 1971.
134. W.I. Fushchich and V.V. Kornyak, "Computer algebra application for determining Lie and Lie-Bäcklund symmetries of differential equations", Journal of Symbolic Computations, vol.7, no. 8, pp. 611-619, 1989.
135. W.I. Fushchich and I.Yu. Krivski, On Wave Equations in 5-Space of Minkowski, Preprint/ Inst. for Theor. Phys., ITP-68-72, Kiev, 1968.
136. W.I. Fushchich and I.Yu. Krivski, "On representations of the inhomogeneous de Sitter group and equations in five-dimensional Minkowski space", Nuclear Physics, B, vol. 14, no. 2, pp. 321-330, 1969.
137. W.I. Fushchich, I.Yu. Krivski, and V.M. Simulik, On Vector Lagrangians of Electromagnetic and Spinor Fields[in Russian], Preprint/ Inst. of Math. Acad. Sci. of Ukraine, 87.54, 1987.
138. W.I. Fushchich and V.V. Nakonechny, "Algebraic-theoretical analysis of the Lame equation", Ukrainskii Matematicheskii Zhurnal, vol. 32, no. 2, pp. 267-273, 1980.

139. W.I. Fushchich and A.G. Nikitin, "On the possible types of equations for zero-mass particles", Lettere al Nuovo Cimento, vol. 7, no. 11, pp. 439-442, 1973.
140. W.I. Fushchich and A.G. Nikitin, "On the Poincaré-invariant equations for particles with variable spin and mass", Reports on Mathematical Physics, vol. 8, no. 1, pp. 33-48, 1975.
141. W.I. Fushchich and A.G. Nikitin, "On the Galilei-invariant equations for particles with arbitrary spin", Lettere al Nuovo Cimento, vol. 16, no. 3, pp. 81-85, 1976.
142. W.I. Fushchich and A.G. Nikitin, "On the new invariance groups of the Dirac and Kemmer-Duffin-Petiau equations", Lettere al Nuovo Cimento, vol. 19, no. 9, pp. 347-352, 1977.
143. W.I. Fushchich and A.G. Nikitin, "Conformal invariance of relativistic equations for arbitrary spin particles", Letters in Mathematical Physics, vol. 2, no. 2, pp. 471-475, 1978.
144. W.I. Fushchich and A.G. Nikitin, "Group properties of Maxwell's equations", group-Theoretical Methods in Mathematical Physics [in Russian], pp. 45-80, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1978.
145. W.I. Fushchich and A.G. Nikitin, "On the invariance groups of a quasirelativistic equation of motion", Doklady Akademii Nauk SSSR, vol. 238, no. 1, pp. 46-49. 1978.
146. W.I. Fushchich and A.G. Nikitin, "On the invariance groups of relativistic equations for spinning particles interacting with external fields", Lettere al Nuovo Cimento, vol. 21, no. 16, pp. 541-546, 1978.
147. W.I. Fushchich and A.G. Nikitin, "Poincaré-invariant equations of motion for particles of arbitrary spin", Fizika Elementarnych Chastits i Atomnogo Yadra, vol. 9, no. 3, pp. 501-553, 1978.
148. W.I. Fushchich and A.G. Nikitin, "On the new invariance algebras of relativistic equations for massless particles", Journal of Physics A: Mathematical and General, vol. 12, no. 6, pp. 747-757, 1979.
149. W.I. Fushchich and A.G. Nikitin, "On the new invariance group of Maxwell's equations", Lettere al Nuovo Cimento, vol. 24, no. 2, pp. 220-224, 1979.
150. W.I. Fushchich and A.G. Nikitin, "Reduction of the representations of the generalized Poincaré algebra by the Galilei algebra", Journal of Physics A: Mathematical and General, vol. 13, no. 7, pp. 2319-2330, 1980.
151. W.I. Fushchich and A.G. Nikitin, "Nonrelativistic equations of motion for particles with arbitrary spin", Fizika Elementarnych Chastits i Atomnogo Yadra, vol. 12, no. 5, pp. 1157-1219, 1981.
152. W.I. Fushchich and A.G. Nikitin, "New symmetries of Maxwell equations", Czechoslovak Journal of Physics, B, vol. 32, no. 4, pp. 437- 480, 1982.
153. W.I. Fushchich and A.G. Nikitin, "On new and old symmetries of the Maxwell and Dirac equations", Fizika Elementarnych Chastits i Atomnogo Yadra, vol. 14, no. 1, pp. 5-57, 1983.
154. W.I. Fushchich and A.G. Nikitin, Symmetries of Maxwell's equations [in Russian], Naukova Dumka, Kiev, 1983.
155. W.I. Fushchich and A.G. Nikitin, "On one- and two-particle Galilei-invariant wave equations for any spin", Il Nuovo Cimento, A, vol. 81, no. 3, pp. 664-660, 1984.
156. W.I. Fushchich and A.G. Nikitin, "On the new invariance algebras and superalgebras of relativistic wave equations", Journal of Physics A: Mathematical and General, vol. 20, no. 3, pp. 537-549, 1987.
157. W.I. Fushchich and A.G. Nikitin, Symmetries of Maxwell's equations, D. Reidel, Dordrecht, 1987.
158. W.I. Fushchich and A.G. Nikitin, "On new symmetries and conservation laws for equations for elastic waves", Doklady Akademii Nauk SSSR, vol. 304, no. 2, pp. 333-335, 1989.
159. W.I. Fushchich and A.G. Nikitin, Symmetries of equations of quantum mechanics [in Russian], Nauka, Moscow, 1990.
160. W.I. Fushchich and A.G. Nikitin, "On superalgebras of symmetry operators of relativistic wave equations", Selected Topics in QFT and Mathematical Physics, Proceedings of the 5th International conference, Liblice, Czechoslovakia, June 25-30, 1989, pp. 385-391, World Scientific, 1990.
161. W.I. Fushchich and A.G. Nikitin, "On the new constants of motion for two- and three-particle equations", Journal of Physics A: Mathematical and General, vol. 23, no. 11, pp. L533-L535, 1990.
162. W.I. Fushchich, A.G. Nikitin, and V.A. Salogub, "On the equations of motion for particles with arbitrary spin in non-relativistic mechanics", Lettere al Nuovo Cimento, vol. 14, no. 13, pp. 483-488, 1975.
163. W.I. Fushchich, A.G. Nikitin and V.A. Salogub, "On the non-relativistic motion equations in the Hamiltonian form for arbitrary spin particles", Reports on Mathematical Physics, vol. 13, no. 2, pp. 175-185, 1978.
164. W.I. Fushchich, A.G. Nikitin and V.M. Susloparow, "Relativistic particle of arbitrary spin in the Coulomb and magnetic monopole field", Il Nuovo Cimento, A, vol. 87, no. 4, pp. 415-424, 1985.
165. W.I. Fushchich and Yu.N. Segeda, "On a new invariance algebra of the free Schrödinger equation", Doklady Akademii Nauk SSSR, vol. 232, no. 4, pp. 800-801, 1977.
166. W.I. Fushchich and V.M. Shtelen, "Conformal symmetry and new exact solutions of SU(2) Yang-Mills theory", Lettere al Nuovo Cimento, vol. 38, no. 2, pp. 37-40, 1983.
167. W.I. Fushchich and V.M. Shtelen, "On the invariant solutions of the nonlinear Dirac equation", Doklady Akademii Nauk SSSR, vol. 269, no. 1, pp. 88-92, 1983.
168. W.I. Fushchich and V.M. Shtelen, "On some exact solutions of the nonlinear Dirac equation", Journal of Physics A: Mathematical and General, vol. 16, no. 2, pp. 271-277, 1983.
169. W.I. Fushchich and V.M. Shtelen, "On approximate symmetry and approximate solutions of the non-linear wave equations with a small parameter", Journal of Physics A: Mathematical and General, vol. 22, no. 18, pp. L887-L890, 1989.
170. W.I. Fushchich and V.M. Shtelen, "Are Maxwell's equations invariant under the Galilei transformations?", Doklady Akademii Nauk Ukrainy, A, no. 3, pp. 22-26, 1991.
171. W.I. Fushchich V.M. Shtelen, and Serov, N.I., Symmetry analysis and exact solutions of nonlinear equations of mathematical physics [in Russian], Naukova Dumka, Kiev, 1989.
172. W.I. Fushchich, V.M. Shtelen, and R.Z. Zhdanov, "On the new conformally invariant equations for spinor fields and their exact solutions", Physics Letters, B, vol. 159, no. 2-3, pp. 189-191, 1985.

173. W.I. Fushchich and N.I. Serov, "On exact solutions of the Born-Infeld equation", Doklady Akademii Nauk SSSR, vol. 263, no. 3, pp. 582-586, 1981.
174. W.I. Fushchich and N.I. Serov, "Symmetry and exact solutions of the multidimensional Monge-Ampere equation", Doklady Akademii Nauk SSSR, vol. 273, no. 3, pp. 543-546, 1983.
175. W.I. Fushchich and N.I. Serov, "The symmetry and some exact solutions of the nonlinear many-dimensional Liouville, d'Alembert and eikonal equations", Journal of Physics A: Mathematical and General, vol. 16, no. 5, pp. 3645-3656, 1983.
176. W.I. Fushchich and N.I. Serov, "On some exact solutions of the three-dimensional non-linear Schrödinger equation", Journal of Physics A: Mathematical and General, vol. 20, no. 16, pp. L929-L933, 1987.
177. W.I. Fushchich and N.I. Serov, "Conditional invariance and exact solutions of the Boussinesq equation", Symmetry and Solutions of Nonlinear Equations of Mathematical Physics [in Russian], pp. 96-103, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1989.
178. W.I. Fushchich and N.I. Serov, "Conditional invariance and reduction of the nonlinear heat equation", Doklady Akademii Nauk Ukrainy, no. 7, pp. 23-27, 1990.
179. W.I. Fushchich, N.I. Serov and T.K. Amerov, "Conditional invariance of the nonlinear heat equation", Doklady Akademii Nauk Ukrainy, no. 11, pp. 16-21, 1990.
180. W.I. Fushchich, N.I. Serov and V.I. Chopyk, "Conditional invariance and nonlinear heat equation", Doklady Akademii Nauk Ukrainy, no. 9, pp. 17-19, 1988.
181. W.I. Fushchich and L.P. Sokur, Bargman-Wigner Equations on the Inhomogeneous de Sitter Group [in Russian], Preprint/Inst. for Theoretical Physics, ITF-69-33, Kiev, 1969.
182. W.I. Fushchich and I.M. Tsifra, "On symmetry of nonlinear equations of electrodynamics", Teoreticheskaya i Matematicheskaya Fizika, vol. 64, no. 1, pp. 41-50, 1985.
183. W.I. Fushchich and I.M. Tsifra, "On a reduction and solutions of nonlinear wave equations with broken symmetry", Journal of Physics A: Mathematical and General, vol. 20, no. 2, pp. L45-L48, 1987.
184. W.I. Fushchich and V.A. Tychinin, On Linearization of Some Nonlinear Equations by Nonlocal Transformations [in Russian], Preprint/ Inst. of Math. Acad. Sci. of Ukraine, IM 82-33, 1982.
185. W.I. Fushchich and V.A. Vladimirov, "On additional invariance of equations for vector fields", Doklady Akademii Nauk SSSR, vol. 257, no. 5, pp. 1105-1108, 1981.
186. W.I. Fushchich and R.Z. Zhdanov, "On some exact solutions of a system of nonlinear differential equations for spinor and vector fields", Journal of Physics A: Mathematical and General, vol. 20, no. 12, pp. 4183-4190, 1987.
187. W.I. Fushchich and R.Z. Zhdanov, "Symmetry and exact solutions of nonlinear Dirac equation", Fizika Elementarnykh Chastits i Atomnogo Yadra, vol. 19, no. 1, pp. 1154-1196, 1988.
188. W.I. Fushchich and R.Z. Zhdanov, "Non-local anzätze for the Dirac equation", Journal of Physics A: Mathematical and General, vol. 21, no. 1, pp. L1117-L1121, 1988.
189. W.I. Fushchich and R.Z. Zhdanov, "On the reduction and some exact solutions of the nonlinear Dirac and Dirac-Klein-Gordon equations", Journal of Physics A: Mathematical and General, vol. 21, no. 23, pp. L5-L9, 1988.
190. W.I. Fushchich and R.Z. Zhdanov, On Some Exact Solutions of Nonlinear D'Alembert and Hamilton Equations, Preprint/ Inst.for Mathematics and Applications, University of Minnesota, Minneapolis, 1988.
191. W.I. Fushchich and R.Z. Zhdanov, "On some new exact solutions of the nonlinear d'Alembert-Hamilton systems", Physics Letters, A, vol. 141, no. 3- 4, pp. 113-115, 1989.
192. W.I. Fushchich and R.Z. Zhdanov, "Symmetry and exact solutions of nonlinear spinor equations", Physics Reports, vol. 172, no. 4, pp. 123-174, 1989.
193. R.P. Gajda, "Quasirelativistic systems of interacting particles", Fizika Elementarnykh Chastits i Atomnogo Yadra, vol. 13, no. 2, pp. 427-493, 1982.
194. L. Garding, "Mathematics of invariant wave equations", Lecture Notes in Physics, vol. 73, pp. 102-164, Springer, Berlin, 1978.
195. J.P. Gazeau, "L'equation de Dirac avec masse et spin arbitraires: une construction simple et naturelle", Journal of Physics G: Nuclear Physics, vol. 6, no. 12, pp. 102-164, 1980.
196. J.P. Gazeau, "Simple construction of a relativistic wave equation with arbitrary mass and spin and Belifante's 1/s conjecture", Group Theoretical Methods in Physics: Proceedings of 9 Int. Colloq., Cocoyoc., 1980, Lecture Notes in Physics 135, pp. 230-233, Springer, Berlin, 1980.
197. I.M. Gelfand, R.A. Minlos, and Z.Ya. Shapiro, Representations of the Rotations and Lorentz Groups [in Russian], Fizmatgiz, Moscow, 1958.
198. I.M. Gelfand and V.A. Ponomarev, "Indecomposable representations of the Lorentz group", Uspekhi Matematicheskikh Nauk, vol. 23, no. 2, pp. 3-60, 1968.
199. I.M. Gelfand and V.A. Ponomarev, "Notes on classification of pair of commuting transformations in finite dimensional space", Functional'nii Analiz i Ego Prilozheniya, vol. 3, no. 4, pp. 81-82, 1969.
200. I.M. Gelfand and A.M. Yaglom, "General relativistic invariant equations and infinite-dimensional representations of the Lorentz group", Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki (JETP), vol. 18, no. 8, pp. 703-733, 1948.
201. A. Gersten, Conserved Currents of the Maxwell Equations with Electric and Magnetic Sources, Preprint/ CERN, TH 4688/87, Geneva, 1987.
202. V.L. Ginzburg, "On theory of spin of elementary particles", Doklady Akademii Nauk SSSR, vol. 31, no. 4, pp. 319-323, 1941.
203. V.L. Ginzburg and I.E. Tamm, "On Theory of spin", Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki (JETP), vol. 17, no. 3, pp. 25-237, 1947.
204. R.H. Good, "Particle aspects of the electromagnetic field equations", The Physical Review, vol. 105, no. 6, pp. 1914-1919, 1957.
205. T.J. Gordon, "Equivalent conserved currents and generalized Noether's theorem", Annals of Physics (N.Y), vol. 155, no. 1, pp. 85-107, 1984.
206. W. Gordon, "Die Energieniveans des Wasserstoffatoms nach der Diracschen Quantentheorie des Electrons", Zeitschrift für Physik, vol. 48, no. 1-2, pp. 11-14, 1928.

207. A.M. Grundland, J. Harnad, and P. Winternitz, "Symmetry reduction for nonlinear relativistically invariant equations", Journal of Mathematical Physics, vol. 25, no. 4, pp. 791-806, 1984.
208. R.F. Guertin, "Relativistic Hamiltonian equations for any spin", Annals of Physics (N.Y), vol. 88, no. 2, pp. 504-533, 1974.
209. R.F. Guertin, "Foldy-Wouthuysen transformation for any spin", Annals of Physics (N.Y), vol. 91, no. 2, pp. 386-412, 1975.
210. R.F. Guertin, Spin-1/2 Equation with Indefinite Metric, Preprint/ Rice University, RU/10, Houston, 1975.
211. R.F. Guertin and T.L. Wilson, "Noncausal effects in relativistic wave equations", Lettere al Nuovo Cimento, vol. 18, no. 16, pp. 521-524, 1977.
212. F. Gürsey, "On a conform-invariant spinor wave equation", Il Nuovo Cimento, vol. 3, no. 10, pp. 988-1006, 1956.
213. F. Gürsey, "Connection of charge independence and baryon number conservation with the Pauli transformation", Il Nuovo Cimento, vol. 7, no. 2, pp. 411-415, 1958.
214. C.R. Hagen, "Scale and conformal transformations in Galilean-covariant field theory", The Physical Review, D, vol. 5, no. 2, pp. 377-388, 1972.
215. C.R. Hagen and W.J. Hurley, "Magnetic moment of a particle with arbitrary spin", The Physical Review Letters, vol. 26, no. 24, pp. 1381-1384, 1970.
216. Harich-Chandra, "On relativistic wave equations", The Physical Review, vol. 71, no. 11, pp. 793-805, 1947.
217. Harich-Chandra, "Motion of electron in the field of a magnetic pole", The Physical Review, vol. 74, no. 8, pp. 883-887, 1948.
218. P. Havas, "Conservation laws for fields of zero rest mass II", The Physical Review, vol. 87, no. 5, pp. 898-899, 1952.
219. O. Heaviside, "On the forces, stresses and fluxes of energy in the electromagnetic field", Phil. Trans. Roy. Soc., A, vol. 183, pp. 423-480, 1893.
220. A.A. Helashwili, "Radial quasipotential equation for fermion and antifermion and infinitely increasing central potentials", Theoretical and Mathematical Physics, vol. 51, no. 2, pp. 201-210, 1982.
221. L. Hlavaty and J. Niederle, "Field equations invariant under indecomposable representations of the Lorentz group", Journal of Mathematical Physics, vol. 22, no. 8, pp. 1775-1780, 1981.
222. M. Humi, "Representations and invariant equations of E(3)", Journal of Mathematical Physics, vol. 28, no. 12, pp. 2807-2811, 1987.
223. W.J. Hurley, "Nonrelativistic quantum mechanics for particles with arbitrary spin", The Physical Review, D, vol. 3, no. 10, pp. 2339-2347, 1971.
224. W.J. Hurley, "Relativistic wave equations for particles with arbitrary spin", The Physical Review, D, vol. 4, no. 12, pp. 3605-3615, 1971.
225. W.J. Hurley, "Invariant bilinear forms and discrete symmetries for relativistic arbitrary spin fields", The Physical Review, D, vol. 10, no. 6, pp. 1185-1200, 1974.
226. N.H. Ibragimov "Group properties of wave equations for particles with zero mass", Doklady Akademii Nauk SSSR, vol. 178, no. 3, pp. 556-568, 1968.
227. N.H. Ibragimov "On invariance of the Dirac equation", Doklady Akademii Nauk SSSR, vol. 185, no.6, pp. 1226-1228, 1969.
228. N.H. Ibragimov Group of Transformations in Mathematical Physics [in Russian], Nauka, Moscow, 1983.
229. E. Inönü and E.P. Wigner, "Representations of the Galilei group", Il Nuovo Cimento, vol. 9, no. 8, pp. 705-718, 1952.
230. R. Jackiw, "Introduction to scale symmetry", Physics Today, vol. 25, no. 1, pp. 23-32, 1972.
231. K.R. James, "Electromagnetic moments for arbitrary spin", Proceedings of Physical Society London, vol. 1, no. 3, pp. 334-342, 1968.
232. L. Jansen, "B_2 diagrams and Bhabha equations with mass matrix", Z. Naturforsh., A, vol. 36, no. 4, pp. 301-310, 1981.
233. J. Jayaraman, "On the additional invariance of arbitrary spin relativistic wave equations", Journal of Physics A: Mathematical and General, vol. 9, no. 7, pp. 1181-1185, 1976.
234. J. Jayaraman, "A new linear Dirac-like spin-3/2 wave equation using Clifford algebra", Journal of Physics A: Mathematical and General, vol. 9, no. 10, pp. L131-L136, 1976.
235. K. Jonson and E.C.G. Sudarshan, "The impossibility of a consistent theory of a charged higher spin Fermi fields", Annals of Physics, vol. 13, no. 1, pp. 126-145, 1961.
236. M.H. Johnson and B.A. Lippman, "Relativistic motion in a magnetic field", The Physical Review, vol. 77, no. 5, pp. 702-707, 1950.
237. M.H. Johnson and B.A. Lippman, "Relativistic Kepler problem", The Physical Review, vol. 78, no. 3, p. 329, 1950.
238. V.G. Kadyshevski, "Quasipotential type equation for the relativistic scattering amplitude", Nuclear Physics, B, vol. 6, no. 2, pp. 125-148, 1968.
239. V.G. Kadyshevski, "Fundamental length hypothesis and new concept of gauge vector field", Nuclear Physics, B, vol. 2, no. 2, pp. 447-496, 1978.
240. V.G. Kadyshevski, "Fundamental length hypothesis in a gauge theory context", Group Theoretical Methods in Physics, Lecture Notes in Physics, vol. 94, pp.114-123, Springer, Berlin, 1979.
241. V.G. Kadyshevski, "New approach to theory of electromagnetic interaction", Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 11, no. 1, pp. 5-39, 1982.
242. E.G. Kalnins, Separation of Variables for Riemannian Spaces of Constant Curvature, Pitman Monographs, London, 1986.
243. E.G. Kalnins, W. Miller, jr., and G.C. Williams, "Matrix operator symmetries of the Dirac equation and separation of variables", Journal of Mathematical Physics, vol. 27, no. 7, pp. 1893-1990, 1986.
244. N.Kamran and R.G. McLenaghan, "Separation of variables and quantum numbers for Weyl neutrino field on curvied space-time", Letters in Mathematical Physics, vol. 7, no. 5, pp. 381-386, 1983.
245. N. Kamran, R.G. McLenaghan, and P. Winternitz, "The classification of complete sets of operators commuting with the Dirac operators in Minkowski space-time", Journal of Mathematical Physics, vol. 29, no. 2, pp. 403-411, 1988.
246. H.A. Kastrup, "Zur physicalischen Deuting und darstellungstheoretischen Analyse der konformen Transformation von Raum und Zeit", Annalen der Physik, vol. 9, pp. 388-428, 1962.
247. G.N. Katrin and T. Levin, "Quadratic first integrals of the geodesics in the spaces of constant curvature", Tensor, vol. 16, no. 1, pp.

97-103, 1965.
248. T.W.B. Kibble, "Conservation laws for free fields", Journal of Mathematical Physics, vol. 6, no. 7, pp. 1022-1025, 1965.
249. W. Killing, "Uber die Grundlagen der Geometrie", J. fur den Reine und Angew. Mathematical, vol.109, pp. 121-186, 1892.
250. Y.S. Kim and M.E. Noz, Theory and Applications of the Poincaré Group, Reidel, Dordrecht, 1986.
251. A.A. Kirillov, Elements of Representation Theory, Nauka, Moscow, 1972.
252. V.G. Kirillov-Ugryumov, Yu.P. Nikitin, and F.M. Sergeev, Atoms and Mesons, Atomizdat, Moscow, 1980.
253. O. Klein, "Quantentheorie und Fundimensionale Relativitats-Theorie", Zeitschrift für Physik, vol. 37, no. 12, pp. 895-906, 1926.
254. A.U. Klimyk, Matrix elements and Clebch-Gordon coefficients for group representations [in Russian], Naukova Dumka, Kiev, 1979.
255. M. Kolsrud, "Dirac-like generators of the inhomogeneous Lorentz group", Physica Norvegica, vol. 5, no. 3-4, pp. 169-176, 1971.
256. B.G. Konopelchenko, "Nonlinear integrable equations", Lecture Notes in Physics, vol. 270, pp. 371-384, Springer-Verlag, 1987.
257. G.A. Kotel'nikov, "On the symmetry of equations of the free electromagnetic field", Il Nuovo Cimento, B, vol. 72, no. 1, pp. 68-78, 1982.
258. R. Kotecky and J. Niederle, "Conformally covariant field equations. I. First-order equations with non-vanishing mass", Czech. J. Phys, B, vol. 25, no. 2, pp. 123-149, 1975; "II. First-order massless equations", Reports on Mathematical Physics, vol. 12, no. 2, pp. 237-249, 1976.
259. J. Kosmann-Schwarzbach, "Lie algebras of symmetries of partial differential equations", in: Differential Geometric Methods in Mathematical Physics, D. Reidel, Dordrecht, 1984.
260. R.A. Krajcik and L.L. Foldy, "Relativistic center-of- mass variables for composite systems with arbitrary internal interactions", The Physical Review, D, vol. 10, no. 6, pp. 1777-1795, 1974.
261. R.A. Krajcik and M.M. Nieto, "Bhabha first-order wave equations", The Physical Review, D, vol. 10, no. 12, pp. 4049-4060, 1974; vol. 11, no. 6, pp. 1442-1458, 1459-1468, 1975; vol. 14, no. 2, pp. 418-436, 1976.
262. K. Kraus, "Galilei covariance does not imply minimal electromagnetic coupling", Annals of Physics, vol. 37, no. 7, pp. 82-101, 1980.
263. J. Krause, "Galilean quantum kinematics", Journal of Mathematical Physics, vol. 29, no. 2, pp. 393-397, 1988.
264. I.Yu. Krivski and V.M. Simulik, "Noether's analysis of 'zilch'-conservation laws and their generalizations for the electromagnetic field. I. Using different formulations of minimal action principle", Teoreticheskaya i Matematicheskaya Fizika, vol. 80, no. 2, pp. 274-287, 1989.
265. I.Yu. Krivski, G.D. Romanenko and W.I. Fushchich, "Equations of Kemmer-Duffin type in five-dimensional Minkowski space", Teoreticheskaya i Matematicheskaya Fizika, vol. 1, no. 2, pp. 242-250, 1969.
266. W. Krolikowski, "Solving nonperturbatively the Breit equation for parapositronium", Acta Physica Polonica, B, vol. 12, no. 9, pp. 891-895, 1981.
267. W. Krolikowski, "Lagrangian triangle of Dirac particles (a model for the three-quark problem)", Acta Physica Polonica, B, vol. 15, no. 10, pp. 927-944, 1984.
268. W. Krolikowski and I. Rzewuski, "Relativistic radial equations for two spin-1/2 particles with a static interaction", Acta Physica Polonica, B, vol. 7, no. 7, pp. 487-496, 1976.
269. W. Krolikowski and A. Turski, "Relativistic two-body equation for one Dirac and one Duffin-Kemmer-Petiau particle, consistent with the hole theory", Acta Physica Polonica, B, vol. 17, no. 1, pp. 75-81, 1986.
270. B.V. Krylov and F.I. Fedorov, "Particle with spin 2 in the field of plane wave", Izvestiya Akademii Nauk Belorusskoii SSR, Ser. Fiz. Mat., 47-54, 1976.
271. L.D. Landau and E.M. Livshits, Field Theory [in Russian], Nauka, Moscow, 1964.
272. I. Larmor, Collected Papers, Claredon Press, London, 1928.
273. M. Le Bellac and J.-M. Levi-Leblond, "Galilean electromagnetism", Il Nuovo Cimento, B, vol. 14, no. 1, pp. 217-235, 1973.
274. A.A. Leonovich and A.B. Pestov, "Analog of Feynman-Gell-Mann equation for charged particle with spin 1", Yadernaya Fizika, vol. 35, no. 5, pp. 1353-1357, 1982.
275. H. Leutwyler and J. Stern, "Relativistic dynamics on a null plane", Annals of Physics, vol. 112, no. 1, pp. 94-164, 1978.
276. J.-M. Levi-Leblond, "Nonrelativistic particles and wave equations", Communications in Mathematical Physics, vol. 6, no. 4, pp. 286-311, 1967.
277. J.-M. Levi-Leblond, "Galilei group and Galilei invariance", Group theory and its applications, vol. 2, pp. 221-229, Acad. Press, New York, London, 1971.
278. D. Levi and P. Winternitz, "Non-classical symmetry reduction: example of the Boussinesq equation", Journal of Physics A: Mathematical and General, vol. 22, no. 15, pp. 2915-2924, 1989.
279. A.N. Leznov and M.V. Savel'ev, "Problems of theory of representations of semi-simple Lie groups", Fizika Elementarnykh Chastits i Atomnogo Yadra, vol. 7, no. 1, pp. 55-100, 1976.
280. S. Lie, Transformationgruppen, In 3 Bd., Leipzig, 1883.
281. S. Lie and F. Engel, Theorie der Transformationsgruppen, In 3 Bd., Leipzig, Teubner, 1988, 1890, 1893.
282. D.M. Lipkin, "Existence of a new conservation law in electromagnetic theory", Journal of Mathematical Physics, vol. 5, no. 5, pp. 696- 700, 1964.
283. A.A. Logunov and A.N. Tavkhelidze, "Quasi-optical approach in quantum field theory", Il Nuovo Cimento, vol. 29, no. 2, pp. 380-399, 1963.
284. I.S. Lomont, "Dirac-like wave equations for particles of zero rest mass and their quantization", The Physical Review, vol. 111, no. 6, pp. 1710-1716, 1958.
285. I.S. Lomont, "Conformal invariance of massless Dirac-like wave equations", Il Nuovo Cimento, vol. 22, no. 4, pp. 673-679, 1961.
286. I.S. Lomont and H.E. Moses, "Dirac-like wave equations for particles of nonzero rest mass and their quantization", The Physical Review, vol. 118, no. 1, pp. 337-344, 1960.
287. I.S. Lomont and H.E. Moses, "Simple realization of the infinitesimal generators of the proper orthochronous inhomogeneous Lorentz group for mass zero", Journal of Mathematical Physics, vol. 3, no. 3, pp. 405-408, 1962.

288. G.A. Lorentz, "Electromagnetic phenomena in a system moving with any velocity smaller that of light", Proceedings of Academy of Sciences, vol. 6, pp. 809-830, 1904.
289. G. Mack and A. Salam, "Finite-component field representation of conformal group", Annals of Physics, vol. 53, no. 1, pp. 174- 202, 1969.
290. A.L. Macfarlane, "Kinematics of the relativistic two- particle system", Journal of Mathematical Physics, vol. 4, no. 4, pp. 490-497, 1963.
291. E. Majorana, "Teoria relativistica di particelle con momento intrinseco arbitrario", Il Nuovo Cimento, vol. 9, no. 3, pp. 335-347, 1932.
292. E. Majorana, "Teoria simmetrica dell'electrone e del positrone", Il Nuovo Cimento, vol. 14, no.2, pp. 171-186, 1937.
293. A.A. Makarov, I.A. Smorodinsky, Kh. Valiev, and P. Winternitz, "A systematic search for nonrelativistic systems with dynamical symmetries", Il Nuovo Cimento, A, vol. 52, no. 4, pp. 1061-1084, 1967.
294. I.A. Malkin and V.I. Man'ko, Dynamical Symmetries and Coherent States of Quantum Systems [in Russian], Nauka, Moscow, 1979.
295. K. Mariwalla, "Dynamical symmetries in mechanics", Physics Letters, C, vol. 20, no. 5, pp. 289-362, 1975.
296. V.P. Maslov, V.G. Danilov, and K.A. Volosov, Mathematical Simulation of Processes of Heat and Mass Carry-Over [in Russian], Nauka, Moscow, 1987.
297. P.M. Mathews, "Relativistic Schrödinger equation for particles with arbitrary spin", The Physical Review, vol. 143, no. 5, pp. 978-986, 1966.
298. P.M. Mathews and S. Ramankrishnan, "General types of Hamiltonians for particles of any spin", Il Nuovo Cimento, vol. 50, no. 2, pp. 339-352, 1967.
299. J.C. Maxwell, Papers and Speeches [Russian translation], Nauka, Moscow, 1968.
300. D.H. Mayer, "Vector and tensor fields on conformal space", Journal of Mathematical Physics, vol. 16, no. 4, pp. 884-893, 1975.
301. A.M. Mikhailov, A.B. Shabat, and R.I. Yamilov, "Symmetry approach to classification of nonlinear equations. Complete list of integrable systems", Uspechi Matematicheskikh Nauk, vol. 42, no. 4, pp. 3-53, 1987.
302. J. Michelsson and J. Niederle, "On representation of the conformal group which when restricted to its Poincaré or Weyl subgroup remain irreducible", Journal of Mathematical Physics, vol. 13, no. 1, pp. 22-27, 1972.
303. J. Michelsson and J. Niederle, "Infinite set of conservation laws for linear and nonlinear field equations", Letters in Mathematical Physics, vol. 8, no. 8, pp. 195-205, 1984.
304. R. Mignani, E. Recami, and M. Badlo, "About a Dirac-like equation for the photon according to Ettore Majorana", Lettere al Nuovo Cimento, vol. 11, no. 12, pp. 568-572, 1974.
305. W. Miller, Symmetry and Separation of Variables, Addison-Wesley, Massachusetts, 1977.
306. H. Minkowski, "Space and time", The Principle of Relativity. A Collection of Works of Classics of Relativity, pp. 167-180, Atomizdat, Moscow, 1973.
307. Yu.A. Mitropolsky and A.K. Lopatin, Group- Theoretical Approach in Asymptotic Methods of Nonlinear Mechanics [in Russian], Naukova Dumka, Kiev, 1988.
308. P.A. Moldauer and K.M. Case, "Properties of half-integral spin Dirac-Fierz-Pauli particles", The Physical Review, vol. 102, no. 3, pp. 279-285, 1956.
309. H.E. Moses, "A spinor representation of Maxwell equations", Il Nuovo Cimento Suppl., vol. 7, no. 1, pp. 1-18, 1958.
310. J.E. Murphy, "Massless particles with infinite spin", The Physical Review, D, vol. 2, no. 6, pp. 1047-1055, 1970.
311. U. Niederer, "The maximal invariance group of the free Schrödinger equation", Helvetica Physica Acta, vol. 45, no. 5, pp. 802-810, 1972.
312. U. Niederer, "The maximal invariance group of the harmonic oscillator", Helvetica Physica Acta, vol. 46, no. 2, pp. 191-200, 1973.
313. U. Niederer, "Massless fields as unitary representations of the Poincaré group", Fortschrite der Physik, vol. 27, no. 4, pp. 191-207, 1979.
314. U. Niederer and L. O'Raifeartaigh, "Covariant wave equations, the Galilei group and the magnetic moment of electron", Ann. Inst. H. Poincaré (N.S.), vol. 26, no. 3, pp. 313-321, 1977.
315. A.G. Nikitin, "Relativistic equations of motion for a system with variable spin", Ukrainskii Fizicheskii Zhurnal, vol. 18, no. 10, pp. 1605-1614, 1973.
316. A.G. Nikitin, "On the nonrelativistic limit of equations without 'superfluous' components Ukrainskii Fizicheskii Zhurnal, vol. 19, no. 6, pp. 1000-1005, 1973.
317. A.G. Nikitin, "On an additional symmetry of the Dirac-Fierz-Pauli equation", Group-Theoretical Methods in Mathematical Physics [in Russian], pp. 96-102, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1978.
318. A.G. Nikitin, "On the invariance group of the Kemmer- Duffin-Petiau equation for a particle with anomalous moment", Group-Theoretical Methods in Mathematical Physics [in Russian], pp. 81-95, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1978.
319. A.G. Nikitin, "First order differential equations invariant under the Galilei group Algebraic-Theoretical Studies in Mathematical Physics [in Russian], pp. 90-104, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1981.
320. A.G. Nikitin, "Galilean invariant equations with anomalous interaction", Ukrainskii Fizicheskii Zhurnal, vol. 26, no. 3, 394-402, 1981.
321. A.G. Nikitin, "Non-relativistic equations of motion for arbitrary spin particles with anomalous interaction", Acta Physica Polonica, B, vol. 14, no. 5, pp. 369-374, 1982.
322. A.G. Nikitin, "Relativistic particle of arbitrary spin in the Coulomb and plane wave fields", Teoreticheskaya i Matematicheskaya Fizika, vol. 57, no. 2, pp. 257-264, 1983.
323. A.G. Nikitin, "Separation of variables in systems of partial differential equations invariant under the group O(3)", Algebraic-Theoretical Methods in Problems of Mathematical Physics [in Russian], pp. 87-98, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1983.
324. A.G. Nikitin, "Non-relativistic particle of arbitrary spin in the Coulomb field", Acta Physica Polonica, B, vol. 16, no. 1, pp. 3-11, 1985.
325. A.G. Nikitin, "Symmetry operators of the Weyl equation", Group-Theoretical Studies of Equations of Mathematical Physics [in Russian], pp. 34-39, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1985.

326. A.G. Nikitin, "Second order symmetry operators admitted by Weyl's equation", Symmetry Analysis of Equations of Mathematical Physics [in Russian], pp. 47-53, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1987.
327. A.G. Nikitin, "Superalgebras of symmetry operators of the Dirac equation", Algebraic Theoretical Analysis of Equations of Mathematical Physics [in Russian], pp. 43-46, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1990.
328. A.G. Nikitin, "Generalized Killing tensors of arbitrary valence and order", Ukrainskii Matematicheskii Zhurnal, vol. 43, no. 6, pp. 786-795, 1991; [English translation, edited in the U.S.] Ukrainian Mathematical Journal, vol. 43, no. 6, pp. 734-743, 1991.
329. A.G. Nikitin, "Complete set of symmetry operators of the Dirac equation", Ukrainskii Matematicheskii Zhurnal, vol. 43, no. 10, pp. 1388-1398, 1991; [English translation, edited in the U.S.] Ukrainian Mathematical Journal, vol. 43, no. 10, pp. 1287-1296, 1991.
330. A.G. Nikitin, "Complete set of symmetry operators of the Schrödinger equation", Ukrainskii Matematicheskii Zhurnal, vol. 43, no. 11, pp. 1521-1527, 1991; [English translation, edited in the U.S.] Ukrainian Mathematical Journal, vol. 43, no. 11, pp. 1413-1418, 1991.
331. A.G. Nikitin and W.I. Fushchich, "Poincaré-invariant differential equations for particles of arbitrary spin", Teoreticheskaya i Matematicheskaya Fizika, vol. 34, no. 3, pp. 319-333; [English translation, edited in U.S.] Theoretical and Mathematical Physics, vol. 34, no. 3, pp. 203-212, 1978.
332. A.G. Nikitin and W.I. Fushchich, "Galilean invariant equations of motion with spin-orbit interaction", Group- Theoretical Methods in Physics, in 2 volumes [in Russian], Vol. 2, pp. 35-41, Nauka, Moscow, 1980.
333. A.G. Nikitin and W.I. Fushchich, "The equation of motion for particles of arbitrary spin invariant under the Galilei group", Teoreticheskaya i Matematicheskaya Fizika, vol. 44, no. 1, pp. 34-46, 1980; [English translation, edited in the U.S.] Theoretical and Mathmatical Physics, vol. 44, no. 1, pp. 584-592, 1980.
334. A.G. Nikitin and W.I. Fushchich "Non-Lie constants of motion for particles of arbitrary spin and systems of coupled particles", Teoreticheskaya i Matematicheskaya Fizika, vol. 88, no. 3, pp. 406-416, 1991; [English translation, edited in the U.S.] Theoretical and Mathematical Physics, vol. 88, no. 3, pp. 960-967, 1992.
335. A.G. Nikitin, W.I. Fushchich and V.A. Vladimirov, "New symmetries and conservation laws for electromagnetic field", Group-Theoretical Methods in Physics, pp. 497-505, Harwood Academic Publishers, Harwood, 1985.
336. A.G. Nikitin, W.I. Fushchich and I.I. Yurik, "Reduction of irreducible unitary representations of generalized Poincaré groups by their subgroups", Teoreticheskaya i Matematicheskaya Fizika, vol. 26, no. 2, pp. 206-220, 1976; [English translation, edited in U.S.] Theoretical and Mathematical Physics, vol. 26, no. 2, pp. 138-147, 1976.
337. A.G. Nikitin and A.L. Grishchenko, "Poincaré-invariant equations for particles of zero mass and arbitrary spin", Ukrainskii Fizicheskii Zhurnal, vol. 19, no. 10, pp. 1666-1669, 1974.
338. A.G. Nikitin and V.V. Nakonechnii, "On invariance algebras of the Dirac and Schrödinger equations", Ukrainskii Fizicheskii Zhurnal, vol. 25, no. 4, pp. 618-621, 1980.
339. A.G. Nikitin and S.P. Onufryichuk, "On diagonalization of the generalized Kemmer-Duffin equation with proper time", Ukrainskii Fizicheskii Zhurnal, vol. 22, no. 5, pp. 713-716, 1977.
340. A.G. Nikitin and S.P. Onufryichuk, S.P., "On diagonalization of the Bhabha equations", Ukrainskii Fizicheskii Zhurnal, vol. 22, no. 9, pp. 1353-1357, 1977.
341. A.G. Nikitin, S.P. Onufryichuk, and A.I. Prilipko, "Symmetry operators of the Breit equation", Doklady Akademii Nauk Ukrainy, no. 6, pp. 28-31, 1990.
342. A.G. Nikitin and A.I. Prilipko, "Solution of determining equations for symmetry operators of arbitrary order", Symmetry and Solutions of Equations of Mathematical Physics [in Russian], pp.40-44, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1989.
343. A.G. Nikitin and A.I. Prilipko, Generalized Killing Tensors and Symmetry of the Klein-Gordon-Fock Equation [in Russian], Preprint/Inst. of Math. Acad. Sci. of Ukraine, IM.27.90, Kiev, 1990.
344. A.G. Nikitin and V.A. Salogub, "On transformation of the Hagen-Hurley equations to a form not containing superfluous components", Ukrainskii Fizicheskii Zhurnal, vol. 20, no. 10, pp. 1730-1732, 1975.
345. A.G. Nikitin, Yu.N. Segeda, and W.I. Fushchich, "On additional invariance of the Kemmer -Duffin and Rarita-Schwinger equations", Teoreticheskaya i Matematicheskaya Fizika, vol. 29, no. 1, pp. 82-94, 1976; [English translation, edited in U.S.] Theoretical and Mathematical Physics, vol. 29, no. 1, pp. 943-951, 1977.
346. A.G. Nikitin, V.A. Vladimirov, and W.I. Fushchich, "On new symmetry and conservation laws for the electromagnetic field", Group-Theoretical Methods in Physics, in 2 volumes [in Russian], vol. 2, pp. 421-428, Nauka, Moscow, 1983.
347. L. Nikolova, "Relativistically invariant equations $(b^m p_m + b_5 m)Y=0$ with singular b^m and b_5 ", Reports on Mathematical Physics, vol. 18, no. 2, pp. 183-196, 1983.
348. Yu.V. Novozhilov and I.A. Terent'ev, "Unitary representations of the generalized Poincaré groups", Journal of Mathematical Physics, vol. 6, no. 10, pp. 1517-1526, 1968.
349. Yu.V. Novozhilov and E.V. Prohvatilov, "Representations of the Poincaré group in the E(2)-basis", Teoreticheskaya i Matematicheskaya Fizika, vol. 1, no. 1, pp. 101-113, 1969.
350. P.J. Olver, "Applications of Lie Groups to Differential Equations, Springer-Verlag, New York, 1986.
351. P.J. Olver and Ph. Rosenau, "The construction of special solutions to partial differential equations", Physics Letters, A, vol. 114, no. 3, pp. 107-112, 1986.
352. S.P. Onufryichuk, "On compatibility of manifestly-covariant equations for particles of arbitrary spin", Symmetry Analysis and Solutions of Equations of Mathematical Physics [in Russian], pp. 56-59, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1988.
353. S.P. Onufryichuk, "Infinite component systems of equations of the Dirac type", Teoreticheskaya i Matematicheskaya Fizika, vol. 84, no. 3, pp. 323-338, 1990.
354. H. Osborn, "Relativistic center-of-mass variables for two-particle systems with spin", The Physical Review, vol. 176, no. 5, pp. 1514-1522, 1968.
355. L.V. Ovsyannikov, Group analysis of differential equations [in Russian], Nauka, Moscow, 1978.
356. O.S. Parasyuk, "Stationary localized solutions of equations describing interaction of fields in two-dimensional space-time", Doklady Akademii Nauk Ukrainy (Ser.A), no. 9, pp. 838-842, 1976.

357. W. Pauli, "On the conservation of the lepton charge", Il Nuovo Cimento, vol. 6, no. 1, pp. 204-215, 1957.
358. B.F. Plybon, "Observation on the Bessel-Hagen conservation laws for electromagnetic fields", American Journal of Physics, vol. 42, no. 3, pp. 998-1001, 1974.
359. A.K. Pogrebkov and M.K. Polivanov, "On interaction of particles and fields in classical theory", Fizika Elementarnykh Chastits i Atomnogo Yadra, vol. 14, no. 5, pp. 1073-1091, 1983.
360. J. Pohjanpelto, "First order generalized symmetries of Maxwell's equations", Physics Letters, A, vol. 129, no. 3, pp. 148-150, 1989.
361. H. Poincaré, "Sur la dynamique de l'electron", Comptus Rendus de Academie de Science, vol. 140, pp. 1504-1506, 1905.
362. H. Poincaré, "Sur la dynamique de l'electron", Rediconti Cir. Mathematical Palermo, vol. 21, pp. 129-160, 1906.
363. M.K. Polivanov, G.P. Jordjadze, and A.K. Pogrebkov, "Global solution of the Cauchy problem for the Liouville equation", Doklady Akademii Nauk SSSR, vol. 273, no. 2, pp. 318-320, 1978.
364. D.L. Pursey and J.F. Plebansky, "Symmetries of the Dirac equation", The Physical Review, D, vol. 29, no. 8, pp. 1848-1850, 1984.
365. I.I. Rabi, "Das freie Electron in homogenen Magnetfeld nach der Diracschen Theorie", Zeitschrift für Physik, vol. 49, no. 7-8, pp. 507-511, 1928.
366. A.F. Radyuk and F.I. Fedorov, "Meson with anomalous magnetic and electric quadrupole moment in the field of plane electromagnetic wave", Doklady Akademii Nauk Belorusskoi SSR, vol. 18, no. 2, pp. 111-121, 1974.
367. A.F. Radyuk and F.I. Fedorov, "A particle of spin 3/2 in the field of a plane electromagnetic wave", Izvestia Akademii Nauk Belorussii (Ser. Fiz.-Mat.) no. 4, 64-71, 1976.
368. G.J. Rainich, "Electrodynamics in the general relativity theory", Trans. Am. Mathematical Soc., vol. 27, pp. 106-136, 1925.
369. Rarita and J. Schwinger, "On a theory of particles with half-integer spin", The Physical Review, vol. 60, no. 1, pp. 61-62, 1941.
370. P.J. Redmond, "Solution of the Klein-Gordon and Dirac equations for a particle with a plane electromagnetic wave and a parallel magnetic field", Journal of Mathematical Physics, vol. 6, no. 7, pp. 1163-1169, 1965.
371. G. Rosen, "Conformal transformation matrix for fields", Annals of Physics (N.Y), vol. 77, no. 1-2, pp. 452-453, 1973.
372. V.A. Rubakov and V.P. Spiridonov, "Parasupersymmetric quantum mechanics", Modern Physics Letters, vol. 3, no. 14, pp. 1337-1347, 1988.
373. J. Rubin and P. Winternitz, "Point symmetries of conditionally integrable nonlinear evolution equations", Journal of Mathematical Physics, vol. 31, no. 9, pp. 2085-2090, 1990.
374. Yu.B. Rumer and A.N. Fet, Theory of unitary symmetry [in Russian], Nauka, Moscow, 1970.
375. L.H. Ryder, "Physical and nonphysical representations of the Galilei group", Il Nuovo Cimento, A, vol. 52, no. 3, pp. 879-892, 1967.
376. S. Salamo, "On massive electromagnetism in the null-plane, their limit and "dual" invariance", Journal of Mathematical Physics, vol. 24, no. 3, pp. 702-704, 1983.
377. S. Sakata and M. Taketani, "On the wave equation of the meson", Proceedings of Physical and Mathematical Society of Japan, vol. 22, pp. 757-762, 1940.
378. T.S. Santhanam and A.R. Tekumalla, "CP and CPT noninvariant relativistic wave equations of the 2-component neutrino", Lettere al Nuovo Cimento, vol. 6, no. 3, pp. 99-102, 1973.
379. D.H. Sattingers and O.L. Weaver, "Lie groups and algebras with applications to physics, geometry and mechanics, Springer, New York, 1986.
380. E. Schrödinger, "Quantisierung als Eigenwetprobleme. IV", Annalen der Physik, vol. 81, no. 18, pp. 109-139, 1926.
381. M. Seetharaman, M.T. Simon, and P.M. Mathews, "Wave equations for zero-mass particles with invariant helicities", Il Nuovo Cimento, A, vol. 12, no. 3, pp. 788-802, 1972.
382. V.N. Shapovalov and G.G. Ekle, Algebraic properties of the Dirac equation, Kalmyk. Univ., Elista, 1972.
383. R. Shaw, Linear algebra and group representations, in 2 volumes, Acad. Press, London etc., 1982, 1983.
384. L.A. Shelepin, "Covariant theory of relativistic wave equations", Trudy FIAN im. Lebedeva, vol. 38, pp. 253-321, 1964.
385. D.V. Shirkov, "Quantum symmetries in particle interactions", Fizika Elementarnykh Chastits i Atomnogo Yadra, vol. 14, no. 5, pp. 1063-1072, 1985.
386. Yu.M. Shirokov, "Group-theoretic considering of foundations of relativistic quantum mechanics", Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki (JETP), vol. 33, no. 4, pp. 861-872, 1957; no.5, pp. 1196-1207, 1208-1214, 1957; vol. 34, no. 3, pp. 717-724, 1958; vol. 36, no. 3, pp. 879-888, 1959.
387. V.M. Shtelen, Non-Lie symmetry and nonlocal transformations [in Russian], Kiev, 1987, Preprint/ Inst. of Math. Acad. Sci. of Ukraine, IM.87.6.
388. V.M. Shtelen, On connection between solutions of the Maxwell and Dirac equations [in Russian], Symmetry and Solutions of Equations of Mathematical Physics, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1989, 110-113.
389. M.W. Shul'ha, Symmetry and some exact solutions of the d'Alembert equation with nonlinear condition, Group- Theoretical Studies of Equations of Mathematical Physics [in Russian], pp. 36-38, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1985, 36-38.
390. C. Swartz, "Some improvements in the theory of faster-than-light particles", The Physical Review, D, vol. 25, no. 2, pp. 356-364, 1982.
391. L.P.S. Singh and C.R. Hagen, "Light-cone pathology of theories with noncausal propagation", The Physical Review, D, vol. 27, no. 4, pp. 837-840, 1982.
392. G.B. Smith and L.I. Tassie, "Exited states of mesons and quark-antiquark interaction", Annals of Physics, vol. 65, no. 1-2, pp. 352-366, 1971.
393. A.A. Sokolov and I.M. Ternov, Relativistic electron [in Russian], Nauka, Moscow, 1974.
394. S.N. Sokolov, "Hamiltonian relativistic quantum description of system of particles with direct interaction", Doklady Akademii Nauk SSSR (N.S.), vol. 233, no. 4, pp. 575-578, 1977.
395. L.P. Sokur and W.I. Fushchich, "On equations of motion invariant under the group P(1,n)", Teoreticheskaya i Matematicheskaya Fizika, vol. 6, no. 3, pp. 348-362, 1971.
396. P. Sorba, "The Galilei group and its connected subgroups", Journal of Mathematical Physics, vol. 17, no. 6, pp. 941-953, 1976.
397. H. Steinwedel, "Galilei-Invarianz", Fortschrite der Physik, vol. 24, no. 4, pp. 211-235, 1974.

398. E. Stueckelberg, "Die Wechselwirkungckracfte in der Electrodynamic und der Feldtheorie der Kernkraefle", Helvetica Physica Acta, vol. 11, pp. 225-236, 1938.
399. E.C.G. Sudarshan and N. Mukunda, Classical dynamics: a modern perspective, John Wiley and Sons, 1974.
400. V.M. Susloparov, "Relativistic particle with arbitrary spin in electric and magnetic fields", Ukrainskii Fizicheskii Zhurnal, vol. 29, no. 8, pp. 1265-1267, 1984.
401. I.E. Tamm, "Movement of mesons in electromagnetic fields", Doklady Akademii Nauk SSSR (N.S.), vol. 29, no. 8-9, pp. 551-554, 1940.
402. I.E. Tamm, Generalized spherical functions of electron in the field of magnetic pole, Collected Papers, in 2 volumes [in Russian], vol. 2, pp. 161- 195, Nauka, Moscow, 1975.
403. W. Tsai, "Energy eigenvalues for charged particles in homogeneous magnetic field. - An application of Foldy-Wouthuysen transformation", The Physical Review, D., vol. 7, no. 6, pp. 1945-1948, 1973.
404. H. Umedzawa, Quantum field theory, Inostrannaya Literatura, Moscow, 1958.
405. G. Velo and D. Zwanzinger, "Propagation and quantization of Rarita-Schwinger waves in an external electromagnetic potential", The Physical Review, vol. 186, no. 5, pp. 2218-2226, 1969.
406. N.Ya. Vilenkin, Special functions and theory of group representations [in Russian], Nauka, Moscow, 1965.
407. D.M. Volkov, "Uber eine Klasse von losungen der Diracshen Gleichung", Zeitschrift für Physik, vol. 94, no. 3-4, pp. 250-260, 1935.
408. M. Walker and R. Penrose, "On quadratic first integrals of the geodesicequations", Communications in Mathematical Physics, vol. 18, no. 4, pp. 265-274, 1970.
409. D.A. Warshalovich, A.N. Moskalev, and V.K. Hersonskii, Quantum theory of angular momentum [in Russian], Nauka, Leningrad, 1975.
410. D.L. Weaver, C.L. Hammer, and R.H. Good, "Description of a particle with arbitrary mass and spin", The Physical Review, vol. 135, no. 1, pp. 241-248, 1964.
411. P. West, Introduction to supersymmetry and supergravity, World Scientific, 1986.
412. A.S. Wightman, Invariant wave equations: general theory and applications to the external field problem, Lecture Notes in Physics, vol. 73, Springer, Berlin, 1978, 1-101.
413. E.P. Wigner, "Unitary representations of Lorentz group", Annals of Mathematics, vol. 40, no. 1, pp. 149-204, 1939.
414. E.P. Wigner, Unitary representations of Lorentz group including reflections, Theoretical concepts and methods in elementary particle physics, Lectures of the Istanbul School of Theoretical Phys., 1962, Gordon and Breach, 1964.
415. P. Winternitz, Ya.A. Smorodinskii, M. Uhlir, and I. Frish, "On symmetry groups in classical and quantum mechanics", Yadernaya Fizika vol. 4, no. 3, pp. 625-635, 1966.
416. E. Wild, "On first order wave equations for elementary particles without subsidiary conditions", Proceedings of the Royal Society London, A, vol. 191, pp. 253-268, 1947.
417. E. Witten, "Supersymmetric quantum mechanics", Nuclear Physics, vol. 188, no. 3, pp. 513-520, 1981.
418. K. Yano and S. Bochner, Curvature and Betti numbers, Annals of Mathematical Studies, vol. 32, Princeton Univ. Press, 1953.
419. R.P. Zaikov, "Hidden symmetries and their group structure for some two-dimension models", Fizika Elementarnykh Chastits i Atomnogo Yadra, vol. 16, no. 5, pp. 1053-1090, 1985.
420. G.A. Zajtsev, "Relativistic equation for electron replacing the Dirac equation", Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki (JETP), vol. 28, no. 1, pp. 530-540, 1955.
421. Zhelobenko, D.P., Transvector algebras in representations theory and dynamical symmetries, Group-Theoretical Methods in Physics [in Russian], in 2 volumes, Proceedings of the third seminar, Yurmala, May 24-26, 1985, vol. 2, pp. 5-21, Nauka, Moscow, 1986.
422. R.Z. Zhdanov, On application of the Lie-Bäcklund method for investigation of symmetry properties of the Dirac equation, Group-Theoretical Studies of Equations of Mathematical Physics [in Russian], pp. 70-73, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1985.
423. R.Z. Zhdanov and W.I. Fushchich, "On non-Lie symmetry of the Galilei-invariant equation for particle with spin s=1/2", Teoreticheskaya i Matematicheskaya Fizika, vol. 89, no. 12, pp. 413-419, 1991.

Additional list of references

1. J. Beckers, N. Debergh, and A.G. Nikitin, "Extended Dirac symmetries and hidden supersymmetry", Physics Letters, B, vol. 279, no. 2, pp. 333-335, 1992.
2. A.G. Nikitin, W.I. Fushchych, and S.P. Onufryichuk, "Higher symmetries of the Shchrödinger equation", Teoreticheskaya i Matematicheskaya Fizika, vol. 91, no. 2, pp. 268-278, 1992.
3. J. Beckers, N. Debergh, and A.G. Nikitin, "On supersymmetries in nonrelativistic quantum mechanics", Journal of Mathematical Physics, vol. 33, no. 1, pp. 152-160, 1992.
4. J. Beckers, N. Debergh, and A.G. Nikitin, "More on supersymmetries of the Schrödinger equation", Modern Physics Letters, A, vol. 7, no. 18, pp. 1609- 1616, 1992.
5. J. Beckers, N. Debergh, and A.G. Nikitin, "More on parasupersymmetries of the Schrödinger equation", Modern Physics Letters, A, vol. 8, no 5, pp. 435-444, 1993.
6. W.I. Fushchych and V.M. Shtelen, "On linear and nonlinear systems of differential equations, invariant in respect with the Schrödinger group", Teoreticheskaya i Matematicheskaya Fizika, vol. 56, no. 3, pp. 387-394, 1983.
7. L.E. Gendenshtein, I.V. Krive, "Supersymmetries in quantum mechanics", Uspechi Fizicheskich Nauk, vol. 146, no. 4, pp. 553-590,

1985.
8. J. Beckers, N. Debergh, and A.G. Nikitin, "Lie extended symmetries and relativistic particles", Journal of Physics A: Mathematical and General, vol 25, pp. 6145-6154, 1992.
9. W.I. Fushchych[1] and A.G. Nikitin, "The complete set of conservation laws for the electromagnetic field", Journal of Physics A: Mathematical and General, vol. 25, no. 5, pp. L231-L233, 1992.
10. W.I. Fushchych, W.M. Shtelen, and N.I. Serov, Symmetry Analysis and Exact Solutions of Equations of Nonlinear Mathematical Physics, D.Reidel, Dordrecht, 1993.
11. W.I. Fushchych and R.Z. Zhdanov, Nonlinear Spinor Equations: Symmetry and Exact Solutions, Naukova Dumka, Kiev, 1992.
12. Symmetry Analysis of Equations of Mathematical Physics (editor W. Fushchych), Inst. of Mathem. of Acad. Sci. of Ukraine, Kiev, 1993.
13. P. Basarab-Horwath, W. Fushchych, and M. Serov, "A simple method of finding solutions of the nonlinear d'Alembert equation", Journal of Physics A: Mathematical and General, vol. 25, no 17, pp. L871-L877, 1992.
14. W.I. Fushchich and R.M. Cherniha, "Galilei-invariant nonlinear equations of the Schrödinger type and their exact solutions. I, II", Ukrainskii Matematicheskii Zhurnal, vol. 41, no. 10, pp. 1349-1357, 1989; vol. 41, no. 12, pp. 1687-1694, 1989.
15. W.I. Fushchich, W.M. Shtelen, and S.V. Spichak, "On the connection between solutions of Dirac and Maxwell equations, dual Poincaré invariance and superalgebra of invariance of nonlinear Dirac equation", Journal of Physics A: Mathematical and General, vol. 24, no. 8, pp.1683-1690, 1991.
16. W.I. Fushchich and W.M. Shtelen, "Merons and instantons as products of self- interaction of the Dirac-Gürsey spinor field", Journal of Physics A: Mathematical and General, vol. 23, no.11, pp. L517-L520, 1990.
17. A.F. Barannik, V.A. Marchenko, and W.I. Fushchich, "On the reduction and exact solutions of nonlinear multidimensional Schrödinger equations", Teoreticheskaya i Matematicheskaya Fizika, vol. 87, no. 2, pp. 220-234, 1991.
18. W.I. Fushchich, R.Z. Zhdanov, and I.A. Yegorchenko, "On the reduction of the nonlinear multi-dimensional wave equations and compatibility of the d'Alembert-Hamilton system", Journal of Mathematical Analysis and Applications, vol. 161, no. 2, pp. 352-360, 1991.
19. W.I. Fushchich, "Conditional symmetry of equations of nonlinear mathematical physics", Ukrainskii Matematicheskii Zhurnal, vol. 43, no. 11, pp. 1456-1470, 1991.
20. W.I. Fushchych, "New nonlinear equations for electromagnetic field having velocity different from c", [in English] Dopovidi Akademii Nauk Ukrainy, no. 4, pp. 24-27, 1992.
21. W.I. Fushchych, W.M. Shtelen, M.I. Serov, and R.O. Popowych, "Q- conditional symmetry of the linear heat equation", [in English] Dopovidi Akademii Nauk Ukrainy, no. 12, pp. 28-33, 1992.
22. W.I. Fushchych, R.Z. Zhdanov, and I.V. Revenko, "On the new approach to variable separation in the wave equations with potential", [in English] Dopovidi Akademii Nauk Ukrainy, no. 1, pp. 27-32, 1993.
23. W.I. Fushchych, V.I. Chopyk, and V.P. Cherkeshenko, "Symmetry and exact solutions of multidimensional nonlinear Fokker-Planck equation, [in English] Dopovidi Akademii Nauk Ukrainy, no. 2, pp. 32-41, 1993.
24. R.M. Miura, "Korteveg-de Vries equation and generalizations. I. A remarkable explicit nonlinear transformation", Journal of Mathematical Physics, vol. 9, no. 7, pp. 1202-1213, 1968.
25. W.I. Fushchich and N.I. Serov, "Conditional invariance and exact solutions of the Boussinesq equation", Symmetry and Solutions of Equations of Mathematical Physics [in Russian], pp.96-103, Inst. of Math. Acad. Sci. of Ukraine, Kiev, 1989.
26. M. Boiti and F. Pempinelli, "Similarity solutions and Bäcklund transformations of the Boussinesq equation", Il Nuovo Cimento, B, vol. 56, no. 1, pp. 148-156, 1980.
27. J. Beckers, N. Debergh, and A.G. Nikitin, On Parasupersymmetries and Relativistic Description for Spin One Particles, Preprint, Liège Univ., 1993.
28. B. Vijayalakshmi, M. Seetharaman, and P.M. Mathews, "Consistency of spin-1 theories in external electromagnetic fields", Journal of Physics A: Mathematical and General, vol. 12, no. 5, pp. 665-677, 1979.
29. W.I. Fushchych, "New nonlinear equations for electromagnetic field having velocity different from *c*", [in English] Dopovidi Akademii Nauk Ukrainy, no. 4, pp. 24-27, 1992.
30. W.I. Fushchych, W.M. Shtelen, and P. Basarab-Horwath, A New Conformal- Invariant Non-Linear Spinor Equation, Preprint/Linköping Univ. LTh-MAT- R-93-05, Sweden, 1993.
31. L.A. Tachtadjian and L.D. Faddeev, Hamiltonian Approach in Soliton Theory Nauka, Moscow, 1986.
32. W.I. Fushchych and W.I. Chopyk, "Symmetry and nonlinear reduction of the nonlinear Schrödinger equation", Ukrainskii Matematicheskii Zhurnal, vol. 45, no. 4, pp. 539-551, 1993.
33. W.I. Fushchych and W.I. Chopyk, "Symmetry Analysis and Ansäzes for Schrödinger Equation with Logarithmic Nonlinearity, Preprint/Linköping Univ. LTh-MAT-R-93-08, Sweden, 1993.
34. W.I. Fushchych, "Conditional symmetries of the equations of mathematical physics", Modern Group Analysis: Advanced Analytical and Computational Methods in Mathematical Physics, pp. 231-239, Kluwer Academic Publ., 1993.
35. W.I. Fushchych and I.A. Yegorchenko, "The symmetry and exact solutions of the nonlinear d'Alembert equation for complex fields", Journal of Physics A: Mathematical and General, vol. 22, 2643-2652, 1989.
36. W.I. Fushchych and W.M. Shtelen, "The symmetry and some exact solutions of the relativistic eikonal equations", Lettere all Nuovo Cimento, vol. 34, no. 16, pp. 498-502, 1982.
37. P. Winternitz, "Nonlinear equations invariant under the Poincaré, similitude and conformal groups in two-dimensional space-time", Journal of Mathematical Physics, vol. 31, no. 9, pp. 1095-1105, 1990.
38. I.A. Yegorchenko, "Nonlinear representations of the Poincaré algebra and invariant equations", Symmetry Analysis of Equations of Mathematical Physics (editor W.Fushchych), pp. 62-65, Inst. of Mathem. of Acad. Sci. of Ukraine, Kiev, 1993.
39. W.I. Fushchych, V.I. Lahno, and R.Z. Zhdanov, "On nonlinear representations of the conformal algebra *AC(2,2)*", [in English] Dopovidi Akademii Nauk Ukrainy, no. 9, pp. 44-47, 1993
40. H.C. Corben and J. Schwinger, The Physical Review, vol. 58, p. 953

41. W.I. Fushchych and R.Z. Zhdanov, "Conditional Symmetry and Reduction of Partial Differential Equations", Ukrainskii Matematicheskii Zhurnal, vol. 44, no. 7, pp. 970-982, 1992; [in English] Ukrainian Mathematical Journal, vol. 44, no. 7, pp. 875-886, 1992.

Footnotes:

[1] Fushchych = Fushchich (the first version is closer to the Ukrainian transcription)

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Symmetries of Equations of Quantum Mechanics. Vilgelm Ilich Fushchich, A. G. Nikitin, W. I. Fushchich. Download (djvu, 2.64 Mb) Donate Read. Symmetry in Quantum Theory: Implications for the Convexity Formalism, the Measurement Problem, and Hidden Variables. [REVIEW] F. E. Schroeck - 1997 - Foundations of Physics 27 (10):1375-1396. Quantization of Space-Time and the Corresponding Quantum Mechanics. M. Banai - 1985 - Foundations of Physics 15 (12):1203-1245. Quantum Mechanics and the Nature of Reality. Thomas Greenlee - 2010 - In Science and Religion in Dialogue.Â The Transitions Among Classical Mechanics, Quantum Mechanics, and Stochastic Quantum Mechanics. Franklin E. Schroeck - 1982 - Foundations of Physics 12 (9):825-841. Quantum Equilibrium and the Role of Operators as Observables in Quantum Theory. Sheldon Goldstein - manuscript.