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MY PAPERS ON QUANTUM PHYSICS

Широков М. И. E2-2010-149
Мои труды по квантовой физике

Представлен автобиблиографический список статей по квантовой физике, дополненный комментариями.

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Shirokov M. I. E2-2010-149
My Papers on Quantum Physics

This is an autobibliographical list of papers on quantum physics supplemented by comments.

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INTRODUCTION

This is a bibliography of scientific papers by M. I. Shirokov on quantum physics composed by M. I. Shirokov himself. A similar example of a bibliography like this is the book by ancient physician and philosopher Galen (the second century B.C., Rome) which he entitled «Book on my Books». The peculiarities of the present bibliography are the comments. The comments may contain explanations of the terms used in the papers, critical notes to the papers, etc.

The bibliography contains nearly 100 papers, they are divided into 8 sections. The end of each section contains references to the section and their abridged notation.

The majority of the bibliography papers are written by M. Shirokov without coauthors. Such papers are denoted in short by two ciphers in braces. For example, the paper

Shirokov M. Relativistic General Theory of Reactions of the $a+b \to c+d+e+\ldots$ Type // Sov. Phys. JETP. 1961. V. 13. P. 975.

is denoted as [61]. Here 61 means two last ciphers of the year of the paper publication. If more than one paper by M. Shirokov was published a year, then the notation, e.g., [57a], [57b],... is used.

If M. Shirokov has coauthors, e.g.,

Baldin A., Shirokov M. On the Theory of Reactions with Polarized Particles // JETP. 1956. V. 30. P. 734,

then the paper is abbreviated as [Baldin, Sh 56].

Note that this bibliography does not contain some papers published by M. Shirokov.

1. «COLLISIONS» (COLLISIONS OF POLARIZED PARTICLES)

I call «collisions» the process of scattering $a+b \to a+b$ or of more general types $a+b \to c+d$, $a+b \to c+d+e+\ldots$, etc. Instead of «collisions» other terms may be used, e.g., «reactions». The process is described by S-matrix. A. Baldin supposed that the matrix is diagonal over conserving total momentum $\mathbf{P}$, total angular momentum $\mathbf{M}$, parity and total energy, see [Baldin, Sh 56] and [57a]. This supposition was corrected in [2008].

Using the diagonality one may derive azimuthal symmetries in cascades of collisions $a + b \to c + d$, $c \to e + f$. One may deduce spins and particles of hyperons and K-mesons [Chou, Sh 57]. It is suggested using proton–antiproton annihilation in π-mesons in order to get the space and charge parities of the $\bar{p}p$-system [Okonov, Sh 61]. Verifications of PC- and PCT-parity conservation are reviewed in [62a, b].

In the usual presentation of the theory of collisions, the particle spin state is described in the Pauli nonrelativistic approximation (i.e., the description looks identically in all Lorentz frames). Different relativistic spin descriptions are possible, see, e.g., [Chou, Sh 58]. They correspond to different representations of the inhomogeneous Lorentz group. It is advantageous to consider representation using spin projections on particle momentum (helicity, spirality) [60], [61]. The experimental consequences of the described relativistic theory of collisions were discussed in [Chou, Sh 58].

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2. «DECAY» (DECAY OF UNSTABLE PARTICLES)

The stationary process of collision is described by S-matrix $U(+\infty, -\infty)$. The decay of an unstable system (excited atom, nucleus, etc.) is described by the probability amplitude $U(t, 0)$ which satisfies the Schrödinger equation $i\partial U(t, 0)/\partial t = \hat{H}U(t, 0)$, $U(0, 0) = 1$. Usually, one considers the survival (non-decay) amplitude $\langle\Phi_0|U(t, 0)|\Phi_0\rangle$. The theorem by L. Khalfin is known which states that the amplitude cannot be exponential when $t \to \infty$. But experiments show that the amplitude is $\sim \exp(-rt)$ at all large accessible t. In [75] and [77], this trouble is overcome by introducing another theoretical definition of the decay law, see [75], [77]. In [84], the behavior of the decay law as $t \to 0$ is investigated.

The decay of one unstable particle was considered above. It is known that the decay of $N = 3, 4, \ldots$ unstable particles localized in a volume is accelerated as compared to the decay of one particle (effect of superradiance). The effect is investigated in [83] in the framework of a simple solvable model of N oscillatory atoms.

In [90], the superradiance is considered using parafermion operators which generalize the known fermion operators. No advantage of this approach was found.

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3. «SIGNAL» (SIGNAL VELOCITY)

Let us clarify the term «signal velocity». Consider two atoms S (source) and D (detector) localized in volumes V_S and V_D separated by distance R which is much greater than the dimensions of V_S and V_D. At $t = 0$ atom S is excited, atom D is in its ground state. Let us consider the probability $W(t)$ that at $t > 0$ atom S is in its ground state and D is excited (the Fermi problem). In the lowest order of perturbation of the electromagnetic quantum theory, process of excitation exchange is realized by photon emission by atom S and its subsequent absorption by atom D, see [78]. This is the mechanism of the signal communication by means of the photon exchange, $W(t)$ being its probability.

The quantum-electromagnetic computation shows that $W(t)$ is not zero when $t < R/c$. This is true not only in the first nonvanishing order. The exact computation in a solvable model gives also this result, see [Eganova, Sh 69], [74]. It is also reproduced in some extended approaches to the signal communication [81], [70], [78]. The result contradicts the relativistic causality principle (atom D becomes excited earlier than S loses its excitation).

The trouble arises already in the simplest case of the spreading packet of a free scalar particle localized initially in a finite volume: It spreads instantly over the whole three-dimensional space [63].

Modification and generalization of the Fermi problem were considered in [Eganova, Sh 69], [70], [78], [81]. There are modifications giving causal results. They were discussed in [76a], [76b], [81].

The signal communication realized by means of the neutrino exchange (not by photon) was considered in [92].

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4. «DRESSING» (DRESSING OF PARTICLES)

Different names are used instead of «dressed particles», e.g. «clothed», «physical», and vice versa one uses the same name (e.g., physical) for different entities, e.g., see [69], [Eganova, Sh 69], [Visinescu, Sh 74], [94], [Shebeko, Sh 98], [Shebeko, Sh 2000], [Shebeko, Sh 2001].

The dressing approach by L. Faddeev (e.g., see [Visinescu, Sh 74]) is used here. It is suitable for any quantum field theory. The approach has two main properties: (1) the state without «dressed» particle (no-particle state) must coincide with physical vacuum, i.e., the lowest eigenstate of the total Hamiltonian $\hat{H}$; (2) the state «one dressed particle» must be $\hat{H}$ eigenvector. It was shown in [73] that the known Haag theorem does not hinder «dressing».

«Dressed» particles were expected to have theoretical advantages as compared to the «bare» ones. However, they fail to have essential useful applications. Paper [72] may be an example of an unsuccessful attempt of using «dressing» in quantum field theory.

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5. «MULTIPOLAR» (MULTIPOLAR FORM)

In the multipolar form of quantum electrodynamics the interaction Hamiltonian expands in a series over electric and magnetic multipoles (moments of atoms or molecules). The first term of the series is equal to the known expression $e(\mathbf{q}\,\mathbf{E})$ (Power, Zienau). This form is widely used, mainly in the electric approximation, see references in [80], [81], [92].

However, the form contains divergences which are additional to those that are known in the Lorentz or Coulomb gauge [90]. The divergences are regularized in [92] in a special manner.

An example of a multipolar form of non-Abelian theory is considered in [94] in an analogous manner.

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6. «RETRODICTION» (RETRODICTION, CAUSALITY PRINCIPLE, MEASUREMENT)

Causality principle (CP) states that «later event cannot influence the earlier one» or «the cause must precede the effect» or «effect cannot be in the pastcone of its cause», e.g., see [88]. Usually, CP is considered as a self-evident statement and is widely used in physics (in particular, in order to derive the dispersion relations (DR)). However, one is allowed to verify CP. This possibility of verification distinguishes scientific statements from the religious ones, e.g., the confirmation of DR does not mean the confirmation of CP: DR may be derived starting from premises which do not contain CP, e.g., see Sec. 3 in [91]. It is shown in [88]–[96a] that one needs quantum retrodiction (QR) in order to verify CP. However, the usual measurement of an observable destroys a quantum state. One may measure instead the wave function of the state. An example of such a measurement is considered in [96b], [98]. It is based on a device of the Stern–Gerlach type.

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7. «RETARDATION» (MOVING UNSTABLE SYSTEMS AND EINSTEIN RETARDATION)

In Sec. 2, the unstable particles at rest are considered. Here moving unstable systems are regarded. According to the classical special theory of relativity, any nonstationary system moving uniformly with velocity v must evolve (e.g., decay) $1/\gamma$ times slower than the system at rest, $\gamma = (1 - v^2)^{-1/2}$ (the Einstein retardation, ER). Quantum mechanics allows one to calculate the evolutions of the moving system and the system at rest separately. Comparing the evolutions one may verify the validity of ER in quantum mechanics.

It is shown in [2004], [2006], [2009a], [2009b] that under some specific premises ER does not hold. In particular, one may get speeded-up evolution instead of the Einstein retardation!

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8. «MISCELLANEA» (QUANTUM THEORY, MISCELLANEA)

It is noted in [62] that the scalar particle position operator must be Hermitian. This requirement rejects the covariant coordinate $\mathbf{x}$ in favor of the Newton–Wigner coordinate $\mathbf{q}$.

It is discussed in [65] when time may be considered as an operator and when it is a parameter.

The statistical interpretation of the wave function is considered in [81].

It is noted that paper [83] as well as [81] is of restricted methodological interest.

The operational definition of the parallelism of Lorentz frames is given in [99]. Nontransitivity of the parallelism, Thomas–Wigner rotation and its physical application are discussed.

It is noted in [2000] that one must use a special formfactor in order to obtain the standard mass renormalization.

The nonlocal theory which is relativistic in Dirac sense was discussed in [2002]. Some necessary conditions for the theory formfactors were obtained.

In order to obtain sum rules and spectral representations, one frequently uses Hermiticity property $\langle \psi, \hat{A}\phi \rangle = \langle \hat{A}\psi, \phi \rangle$ of an observable A. It is shown in [2003] that this property may be inconsistent with some commutation relations that contain $\hat{A}$. The known Schwinger paradox may serve as an example.

It is shown in [Naumov, Sh 2007] how the known change $T \to R/c$ in neutrino oscillation problem may be justified.

The known uncertainty relations (e.g., the Heisenberg ones) are generalized and discussed in [2004].

Two generalizations of uncertainty relations are obtained in [2006] for states described by density matrices.

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