Preface

In the late twentieth and the early twenty-first centuries, the most intensive progress was observed in the sciences, that develop at the junction of two sciences. The most interesting among them, seem to be those that combine the branches most distant from each other. If so, then it is easy to identify the leader of such sciences. It is one that connects the smallest objects available for research, elementary particles, and these giant objects like stars, and has the name of *Particle Astrophysics*. It is not difficult to identify the major milestones in the life of this relatively young, but very rapidly developing science. The birth is most likely to be dated to the beginning of the 1930s. Just then, after the discovery of a neutron by J. Chadwick in 1932, the concept of a neutron star was proposed by L. D. Landau, and independently by W. Baade and F. Zwicky. The start of the maturation of this science can be more or less confidently dated to 1987 when extragalactic neutrinos were registered for the first time from the supernova SN1987A explosion in the Large Magellanic Cloud, a satellite galaxy of our Milky Way. For the date of the endpoint of the maturation period for particle astrophysics, one can propose 2001 when the solar-neutrino puzzle was solved in a unique experiment at the heavy-water detector installed at the Sudbury Neutrino Observatory. This experiment confirmed B. Pontecorvo's key idea concerning neutrino oscillations and, along with experiments that studied atmospheric and reactor neutrinos, thereby proved the existence of a nonzero neutrino mass and the existence of mixing in the lepton sector. The Sun appeared in this case as a natural laboratory for investigations of neutrino properties.

There exist some books on the topic where the basics of this new science can be studied. However, new facts and ideas appear so fast that it is necessary for specialists to follow not only journal papers but also electronic preprints, in order to keep abreast of the latest developments.

A page of this new science, which on the one hand is rather difficult and on the other hand is not covered enough by books or reviews, deals with the particle processes under the extreme conditions of the stellar interior—hot dense plasma and strong electromagnetic fields. This discipline, which can be called *Quantum Field Theory in an External Active Media*, was founded in the 1970s, and now it continues in motion. As an attempt to set some milestone, the objective of our previous monograph [1] was to give a systematic description of the methods of calculation of the quantum processes, both at the tree and loop levels, in external

electromagnetic fields. The aim of the present monograph is to consider the quantum processes under an influence of, along with a magnetic field, one more external active media which is hot dense plasma.

The review is based in part on the special lecture course given to the second-year master-course students studying at the Theoretical Physics Department of the Yaroslavl State University, Yaroslavl, Russia. It can be used by graduate and postgraduate students specializing in theoretical physics and being familiar with the basics of the Quantum Field Theory and the Standard Model of the Electroweak Interactions. The authors make a great effort to give all the details that will make this book a valuable text for students. The monograph can be also useful for specialists in the Quantum Field Theory and particle physics, who are interested in the problems of physics of quantum phenomena in external active media.

We have obtained a part of the results presented in this monograph in co-authorship with our colleagues and with our graduate and postgraduate students at the Department of Theoretical Physics of Yaroslavl State University. We thank L. A. Vassilevskaya, A. A. Gvozdev, A. Ya. Parkhomenko, M. V. Chistyakov, I. S. Ognev, E. N. Narynskaya, D. A. Rumyantsev, A. A. Okrugin, R. A. Anikin, A. M. Shitova, and M. S. Radchenko for collaboration and helpful discussions.

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Reference

1. A.V. Kuznetsov, N.V. Mikheev, *Electroweak Processes in External Electromagnetic Fields* (Springer, New York, 2003)

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