Preface to the Second Edition

Preparing the new edition we have preferred first of all to improve the existing text. Expanding it was not our priority because we would like to preserve the compact size of the book. We have removed a number of misprints and mistakes. Sections devoted to the Majorana field and to path integral approach to $U(1)$ anomaly have been revised. There are two new sections: on anticommuting (bi)spinor fields, and on more advanced supersymmetric models. Several new problems are added.

We would like to thank Thomas Williams for careful reading of the manuscript and helpful comments, Łukasz Marszałek for pointing out several mistakes, and Anna Gagatek for the help in preparation of figures.

The picture on the front cover is by courtesy of Dr. Tomasz Romańczukiewicz. It illustrates scattering of two solitonic objects in 1+1 dimensional space-time.The horizontal direction represents the time, and the vertical one the one dimensional space. The two objects are the kink, discussed in Chap. 3, and an oscillon which is a kind of breather, see Exercise 1.1(c). Before the scattering, the oscillon is at rest (then its world-line coincides with the horizontal dark dashed line), while the kink approaches it with a constant velocity (then its world-line coincides with the white continuous line).

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Preface to the First Edition

This textbook on field theory is based on our lectures which we delivered to students beginning their specialization in theoretical physics at Jagiellonian University in Cracow. The lectures were accompanied by problem-solving classes. The goal was to give a presentation of the basics of field theory.

Field theory plays a fundamental role in many branches of contemporary physics, from cosmology, to particle physics, and condensed matter physics. Plenty of successful applications testify to its importance. On the other hand, there still remain unanswered questions about its foundations. For example, it is not clear what is the proper mathematical framework for its formulation. Nor do we know how to exactly solve its equations in the case of interacting fields. This state of field theory—many successful applications vs. hidden in a mist foundations—makes the task of preparing an introductory course rather challenging.

Before attending our course, the students had taken theoretical physics courses on classical mechanics, non relativistic quantum mechanics, classical electrodynamics, statistical physics, as well as mathematical courses on algebra, calculus, and differential equations. They also had a general introduction to particle physics. Concurrently with our lectures, or subsequently, they attended specialized lectures on advanced quantum mechanics including the relativistic formulation, the standard model of particle physics, statistical field theory, and the quantum theory of condensed matter. Such a curriculum has of course influenced the content of our lectures. We have entirely omitted applications of field theory, and the emphasis has been put on basic ideas. Furthermore, because of the limited time available both for the lectures and for the students, we have not at all attempted to make the course comprehensive. Our intention has been to offer a slow, step by step introduction to the main concepts of field theory. The method we have chosen consists of a carefully detailed explanation of the selected material. We hope that such a textbook can be useful, and that it is a helpful supplement to the vast amount of existing literature.

This textbook consists of three parts: classical fields are discussed in Chapters 1 to 5, an introduction to the quantum theory of fields is given in Chapters 6 to 10, and a selection of relatively modern developments is presented in Chapters 11 to 14.

We presented most of this material in three semesters using traditional tools: chalk and a blackboard. At the end of each chapter there are exercises with hints for solutions. Some are strictly tied up with the lectures, others deal with topics which were discussed at length only during the problem-solving classes. We have also included a short Appendix in which we have collected some basic facts about generalized functions. Interested students can find hundreds of books on field theory. Our list of literature includes only those books or original papers which are explicitly mentioned in this text.

Many students commented on parts of our lecture notes. We are very grateful to them all. We are particularly indebted to P. Balwierz, M. Eckstein, T. Rembiasz and P. Witaszczyk for providing lists of mistakes and unclear points. Needless to say, the full responsibility for mistakes and shortcomings still present lies entirely with us. Errata, very likely necessary in spite of our efforts, will be posted on the web page http://th-www.if.uj.edu.pl/ztp/Edukacja/index.php belonging to the Department of Field Theory of the Marian Smoluchowski Institute of Physics, Jagiellonian University.

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