

PREFACE TO THE THIRD EDITION

Writing a preface for an edition almost 30 years after the original feels strange: First, because what topical subject (so it seemed in the mid-seventies) could ever have survived so long? Second, because the author of the original version has changed the focus of his scientific interest and the second edition has been prepared (20 years ago) at the very last possible moment. In fact, the only conceivable way a revised third edition could be attempted was to engage a physicist of a new generation, representing what was overlooked.

This new generation is represented by Dr. Martín-Mayor, who was suggested by Prof. Giorgio Parisi, and for which I (DJA), am profoundly grateful. The new part represents a veritable break within the approach to the subject matter. While the first two parts were written under the impact of the elegance of the perturbative-diagrammatic approach, they found a relatively narrow field of application. Real-space approach was less elegant yet, at the time, only superficially more useful. When the first section of the new part started reaching me (DJA), it became patently clear what enormous progress has been made in rendering the

Renormalization Group approach a real practical tool, way beyond low order expansions. It touched the “impossibles”, namely non-perturbative computations as well as non-universal quantities[†] wherever the underlying microscopic model is quantitatively known.

What is remarkable about this new phase is the unifying way in which it integrates such diverse approaches as real space renormalization, finite size scaling, lessons from perturbative field theory, and detailed numerical computation at the forefront of the art, to arrive at quantitative results for an unending variety of models. It is frankly a refreshing surprise to find out, after so many years, the nuisance once represented by finite-size scaling turned into a blessing. This brings two, once unapproachable beasts, into center scene: the critical point and numerical simulations. Furthermore, the advance of experimental techniques makes possible finite-size scaling experiments, which were inconceivable in the seventies. As a representative of the old generation, who chose pasture in other fields, I must confess a sense of a new passion at reading and learning of the recent developments and the aura of inexhaustible vigor in theoretical physics.

If the first two editions have been found useful to merit a third one, this edition will surely provide a radically new experience: The new part focuses on numerical field theory, not in order to suggest the superiority of simulations over the perturbative approach of parts I and II, but rather to underline the strength of their synthesis. Moreover, our selection of material does not exhaust the applications of the Renormalization Group developed in the last two decades. Important topics such as dynamical critical phenomena, conformal field theory, disordered systems, many-body systems, or the density matrix renormalization group (to mention only a few) are absent for finite size reasons. They remain a testimony of the infinite wealth of the enterprise. Yet, we believe that a mastery of the material presented should allow the reader to move with relative ease to any of the topics left out.

Although we have abundantly quoted modern research work, we do not claim to have exhausted the relevant bibliography. We feel that this is beyond human capability, although heroic colleagues periodically attempt the task of writing a (basically) complete review every few years.[‡] We have quoted work we were more familiar with. We would like to think that the offered abundance will allow the reader to retrace proper priorities. On both issues the readers will judge.

Thirty years have not gone by without leaving some traces: technology in publishing has changed profoundly, as well as some of our conceptions of how material should be presented. Most remarkable is the collocation of the Appendix

[†]For instance, amplitudes for irrelevant operators and the location of “perfect” actions.

[‡]At the time of writing, the most updated review is by Andrea Pelissetto and Ettore Vicari, see bibliography to Chap. III-1.

(or 4th chapter) on the website: www.worldscibooks.com/physics/5715.html. It is composed of four tested computer programs, each with an introduction to its use and operation. Those are accompanied by useful comments on programming at a detailed level. These same (directly downloadable) computer programs have been used to produce essentially all the figures in the first three chapters of Part III. They form an integral part of some of the exercises provided at the end of each chapter and the appendix contains also exercises specific to the numerical part. Our intention was to place the reader (young at heart) in a takeoff position for research. This process would be facilitated by some familiarity with simulation tools, though the theoretical thrust should be accessible without it. On the other hand, the availability of the tested programs, together with their graphical results, could serve as an opportunity for expanding computational skills.

Another aspect of the good news is that figure captions have become more informative (perhaps, the influence of biology). On the other hand, previous editions have been typed by hand, while the new part has been set in LaTeX. We have opted in favor of avoiding the retyping of the first two parts, and did our best (with the help of the Publisher) to adapt the LaTeX style to the old format. But if some discrepancies be perceived, we include our apologies. We have preserved the convention, introduced in Part II, that references within each part, devoid of part reference, point within that same part.

Finally, the pleasant part of acknowledgments: If the first two parts were basically inspired by Edward Brezin and Jean Zinn-Justin, Part III would not have been possible without the word as given us by Giorgio Parisi. VMM wishes to express his gratitude for the wonderful years spent in Rome. Two other people, Luis Antonio Fernández and Alan Sokal, had a strong impact on his views on these matters, and deserve gratitude. Much was also learnt from friends and collaborators: José Luis Alonso, Héctor García Ballesteros, Antonio Muñoz Sudupe, Andrea Pelissetto, Juan Jesús Ruiz Lorenzo, Alfonso Tarancón, Ettore Vicari, and is kindly acknowledged. There must be other fellow travelers who may have been forgotten. To them we owe not only thanks but also apologies.

The timetable required for the completion of Part III has been such that it called for admirable patience and support from Elena. If the first two editions were dedicated to Paris, Part III owes an homage to Madrid (perhaps also to Rome). Sandro Romani was helpful with solving problems of Latex formatting. Last but not least is our gratitude to Luis Antonio Fernández, and Marco Zannetti for taking the time to read the new part and guide us with their comments.

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