Preface

Random matrix theory was introduced into physics by E.P. Wigner in 1955, and consolidated with deeper and wider ranging investigations in the last three decades, it has become an integral part of quantum physics. As aptly stated by H.A. Weidenmüller in a recent commentary: "although used with increasing frequency in many branches of physics, random matrix ensembles sometimes are too unspecific to account for important features of the physical system at hand. One refinement which retains the basic stochastic approach but allows for such features consists in the use of embedded ensembles." This new class of random matrix ensembles, the embedded random matrix ensembles, were introduced in the context of the nuclear shell model in early 1970. As stated by J.B. French: "the GOE, now almost universally regarded as a model for a corresponding chaotic system, is an ensemble of multibody, not two-body interactions. This difference shows up both in one-point (density of states) and two-point (fluctuations and smoothed transition strengths) functions generated by the nuclear shell model. For a better a priori model we can choose an ensemble of k-body interactions ($k = 2$ is an interesting case) by generating a GOE in k-particle space and using it in the space of m-particles. For most purposes the resulting embedded GOE (or EGOE) is very difficult to deal with, but by good luck, we can use it to study the questions we have posed and the answers are different from, and much more enlightening than, those which would come from GOE."

Research over the last two decades in particular has produced a large body of new results for embedded ensembles and it is clear that these random matrix ensembles are indispensable in the study of finite many-particle quantum systems such as atoms, nuclei, quantum dots, small metallic grains, lattice spin models for quantum computers, and so on. In this book, starting with an easy-to-read introduction to general random matrix theory, all the necessary concepts for embedded random matrix ensembles are developed from scratch and the reader is then carried to the frontiers of present-day research. The first chapter gives a general introduction and the next two chapters deal with some general aspects of classical random matrix ensembles. Eight chapters in the remaining part of the book give results for a variety of embedded ensembles, mainly classified according to the Lie symmetries of the

Hamiltonian of a finite many-body quantum system, while four chapters are devoted to applications. The last chapter provides a summary and future prospects.

The starting point for this book was a series of lectures given by the author at Andhra University, Visakhapatnam (India) in 2002. Efforts have been made to give enough detail in every chapter to ensure that an advanced graduate student can follow the mathematics and understand the results of 'computer experiments' for embedded ensembles. On the other hand, the book gives an exhaustive review of the field so that a research student can use the material to start working on new questions in the subject of embedded ensembles itself and in their application to many-body quantum physics.

Over the last three decades I have had the pleasure of collaborating with many people, and discussed the topics of this book with many others. First of all, I would like to specially thank the late J.B. French for a long and profitable collaboration on statistical nuclear spectroscopy. Embedded random matrix ensembles have grown out of this subject and the present work is complementary to the book *Statistical Spectroscopy and Spectral Distributions in Nuclei* by R.U. Haq and myself, published in 2010 by World Scientific. The influence of J.B. French on my way of thinking about random matrix theory in physics is surely visible in several parts of the present book.

I was fortunate in having A. Pandey, J.C. Parikh, V. Potbhare, and S. Tomsovic as collaborators in my early years of research on random matrix theory. Regarding the topics discussed in several chapters of this book, I have collaborated intensively with R. Sahu, N.D. Chavda, and my former Ph.D. student Manan Vyas. Without that collaboration, this book would not have been possible. I have also benefited from collaboration and discussions with many colleagues, friends, and students, and in particular with Dilip Angom, B. Chakrabarti, J.M.G. Gomez, R.U. Haq, K. Kar, D. Majumdar, the late J. Retamosa, S. Sumedha, and Y.M. Zhao. I am especially indebted to H.A. Weidenmüller and the late O. Bohigas for discussions and encouragement. I am thankful to N.D. Chavda and Manan Vyas for preparing some of the figures and thank Manan Vyas once again for typing some parts of the book. Thanks are also due to the directors of the Physical Research Laboratory (Ahmedabad, India) for facilities and support. There are many others who have directly or indirectly contributed to my work on embedded ensembles and I sincerely thank them. Copyright permission for using some of the figures, from the American Physical Society, the American Institute of Physics, Elsevier Science, the Institute of Physics, Springer-Verlag, and World Scientific is gratefully acknowledged. I am also thankful to all the authors who have given permission to use figures from their publications. Special thanks are due to the editors at Springer-Verlag for their efforts in bringing out this book. And lastly and most importantly, I am indebted to my wife Vijaya for her unfailing support since 1980.

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