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PREFACE

Recent Advances in Low-Dimensional Quantum Field Theories

Quantum field theory (QFT) is a rich and robust part of mathematical and theoretical physics, with a wide range of applications in statistical physics, condensed matter physics, particle physics and string theory. Many (if not most) of the applications in four space-time dimensions require some sort of systematic approximations. In contrast, quantum field theories in lower dimensions often display special properties which open the door, at least in principle, to their exact solution.

In many cases, the methods used to obtain exact solutions are peculiar to low-dimensional space-times, but the exact solutions thus obtained can teach us a great deal about more realistic QFTs in higher dimensions. Thus, lower-dimensional QFTs provide excellent models for exploring deep theoretical and computational issues, in addition to their direct applications to physical processes in reduced dimensions, which include polymers, boundary fluctuations, spin chains, and quantum Hall systems. Such models are also vital testing grounds for fundamental theoretical ideas such as integrability, phase transitions, collective and non-perturbative quantum behaviour, and non-equilibrium statistical mechanics. We should also mention the effective dimensional reduction which occurs in the high temperature limit, or is induced by disorder.

Low-dimensional quantum field theory thus sits at a unique intersection point of contemporary mathematics and physics, allowing many of these issues to be addressed rigorously and analytically. Surprising inter-relations continue to arise, from the ubiquitous nature of the Bethe ansatz and Calogero models, to the link between integrable spin chains and the anomalous dimensions of operators in gauge theories. Aspects of the latter connection have been known at least since the 1990s; they have recently received tremendous attention in connection with $N = 4$ supersymmetric Yang–Mills theory (in four space-time dimensions) and the AdS/CFT correspondence. One unifying idea is the Bethe ansatz, whose 75th anniversary we celebrate this year, and whose wide-ranging impact in diverse branches of modern mathematical physics is made abundantly clear in this special issue. In addition, new ideas and techniques of significance to both mathematics and physics have emerged: the recent and spectacular progress on geometrical aspects of phase transitions made possible through the ideas of stochastic (Schramm) Loewner evolution, or SLE, is a particularly noteworthy example.

All papers in this special issue are invited, refereed contributions from leading experts. Many are pedagogical reviews, capturing the current state of knowledge in a particular subject, putting the subject in context and outlining open challenges. Others are research papers, reflecting the rapid flux of new ideas and results in this rich and exciting field. Together, they represent a broad sample of the entire field. We would like to take this opportunity to thank all of the authors for their efforts in making this special issue possible, and Kazuhiro Hikami for his help in the early stages of this project. We hope it inspires many new developments!

Patrick Dorey, Gerald Dunne and Joshua Feinberg

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