



Il Colle di
Galileo

Supersymmetric Quantum Field Theories in the Non-perturbative Regime

This workshop took place at the GGI Institute in Florence from April 2 to May 11, 2018. The organizers were L. F. Alday, Mathematical Institute, Oxford University; M. Billò, Dipartimento di Fisica, Università di Torino; G. Bonelli, SISSA, Trieste; F. Fucito, INFN, Tor Vergata, Rome; A. Hanany, Theoretical Physics Group, The Blackett Laboratory, Imperial College, London; Z. Komargodski, Weizmann Institute of Science, Rehovot, IL; J. F. Morales, INFN Tor Vergata, Rome; J. Russo, Istitucio Catalana de Recerca i Estudis Avancats (ICREA), Barcelona, Spain

Abstract. This workshop focused on the study of non-perturbative aspects and exact results in Supersymmetric Field Theories. It was attended by 101 participants and included a focus week and a final conference. The outcome was successful due to a considerable amount of interaction among the participants, leading to fruitful discussions and actual collaborations, with many papers being started or even completed in this stimulating environment.

Keywords. Quantum Field Theory, Non-perturbative aspects, Supersymmetry.

Introduction

Quantum Field Theory (QFT) represents a successful paradigm for describing the microscopic interactions of elementary particles. While QFTs are substantially under control in the perturbative regime, where the couplings are small, they are extremely hard to study analytically at strong coupling. Devising ideas and techniques to tackle the strong coupling regime, to learn how to deal with non-perturbative corrections and to find exact results is clearly of the utmost importance in Theoretical Physics. A possible strategy is to focus on theories with a high degree of symmetry that helps tame the dynamics, without making them trivial. In this sense, Supersymmetric Quantum Field Theories are an interesting theoretical laboratory for studying generic QFTs; they are central to contemporary Mathematical Physics and have deep connections to String Theory. They allow

us to check standard expectations in such different fields as High Energy Physics, Statistical Mechanics and Condensed Matter Physics against closed, analytic formulae that include perturbative and non-perturbative contributions. In particular, in recent years the study of the non-perturbative regime in such theories has received considerable attention, starting from the seminal work of Seiberg and Witten. This led to various areas of progress that have radically changed the way we look at gauge and gravity theories and have spurred a host of new ideas and methods to investigate gauge theories. These areas of progress include the role of S-dualities, relations to integrable theories, localization techniques for evaluating path integrals; and new connections to String Theory, M-theory and Topological String Theory. Much attention has recently been devoted also to theories which, in addition to supersymmetry, enjoy conformal symmetry.

Scientific motivations

This workshop focused on Supersymmetric and Superconformal Field Theories in different dimensions, viewed as playgrounds for developing non-perturbative techniques that make it possible to obtain exact results in Quantum Field Theories. Its main purposes were the following. First, to review progresses in this field giving participants ample time to illustrate their work and discuss their results. Second, to gather some of the most distinguished researchers in this field to let them discuss and interact with a view to striking up new collaborations and inspiring new developments. Lastly, to contribute to the research training of the younger researchers among the participants.

The workshop

During each “regular” week there were three seminars, in which selected participants presented their most recent work. In addition, every week a “gong show” was held, in which each participant could briefly introduce her/himself and her/his current research. During the focus week, the three Simons fellows of the workshop, G. Korchemsky, K. Zarembo and L. Rastelli, gave three long lectures in which they described in detail an on-going computation, in subjects related directly to the workshop main focuses; this represented an opportunity for the participants to have an almost “hands-on” update on some of the progress at the forefront of the field. The conference which took place in the last week of the workshop comprised twenty-one talks. All in all, almost forty talks were delivered during the workshop, presenting many of the latest results in the main areas of interest for the workshop: localization techniques, exact results in 3D theories (regarding in particular their dual structure, the description of Higgs branches and the properties of Chern-Simons theories), results in 6D theories, connections to brane

systems, to topological string theory and to geometric and non-geometric String Theory backgrounds, applications of holography, relations between correlation functions in supersymmetric theories and integrability, properties of Superconformal Theories, and other innovative and stimulating ideas such as, for instance, the unexpected emergence of free field sectors in strong coupling regimes and the usefulness of studying large charge sectors of certain theories.

Results of the activity

The attendance was very satisfactory, ranging between 20 and 30 participants each week, and was well-distributed between senior scientists and young postdocs or PhD students. In total, there were 101 participants. As the workshop was quite focused, the participants largely shared a common background which made mutual interactions rather easy. There were of course also differences, for instance in being more or less mathematically oriented, which allowed useful contaminations. The atmosphere was positive, with frequent discussions and exchange of ideas among the participants. Many of the participants seized the opportunity offered by the GGI hospitality to pursue pre-existing collaborations and/or start new ones. In fact, at least 20 papers have already been written, and they explicitly acknowledge the support of the GGI in occasion of the workshop itself.