Lectures from the European RTN Winter School on Strings, Supergravity and Gauge Fields, CERN, 15–19 January 2007

2007 Class. Quantum Grav. 24

(http://iopscience.iop.org/0264-9381/24/21/E01)

IOP PUBLISHING CLASSICAL AND QUANTUM GRAVITY

Class. Quantum Grav. **24** (2007) doi:10.1088/0264-9381/24/21/E01

PREFACE

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This special issue is devoted to the proceedings of the conference 'Winter School on Strings, Supergravity and Gauge Theories', which took place at CERN, the European Centre for Nuclear Research, in Geneva, Switzerland, from the 15 to the 19 of January 2007.

This event was organized in the framework of the European Mobility Research and Training Network entitled 'Constituents, Fundamental Forces and Symmetries of the Universe'. It is part of a yearly series of scientific schools, which represents what is by now a well established tradition. The previous conferences have been held at SISSA, in Trieste, Italy, in February 2005 and at CERN in January 2006. The next will again take place at CERN, in January 2008.

The school was primarily meant for young doctoral students and postdoctoral researchers working in the area of string theory. It consisted of several general lectures of four hours each, the notes of which are published in the present proceedings, and seven working group discussion sessions, focused on specific topics of the network research program. It was attended by approximatively 250 participants. The topics of the lectures were chosen to provide an introduction to some of the areas of recent progress, and to the open problems, in string theory.

String theory is a compelling candidate for a theory of all interactions. A basic challenge in this field is therefore to explore the connection of string theory models and the laws of physics in different realms, like high-energy particle physics, early cosmology, or physics of strongly coupled gauge theories.

Concerning the exploration of string theory compactifications leading to realistic models of particle physics, one of the main obstacles in this direction is the proper understanding of supersymmetry breaking. The lecture notes by Nathan Seiberg review the realization of spontaneous breaking of supersymmetry in field theory, including recent developments via the use of meta-stable long-lived vacua. It is possible that such an understanding proves crucial in the realization of supersymmetry breaking in string theory. A second long-standing obstacle, which is being tackled with recent techniques, is moduli stabilization, namely the removal of unwanted massless scalar fields from string models. The present status of this problem, and its prospects of solution via the introduction of general sets of fluxes in the compactification space, were covered in the lectures by Brian Wecht.

Application of these ideas to connect string theory to particle physics will require a good understanding of the experimental situation at the forthcoming collider LHC at CERN, and the detection tools for signals of new physics, as reviewed in the lectures by Joe Lykken (not covered in the present issue).

Along a different line, the role of moduli fields in string theory is expected to provide a natural explanation of models of inflation, and thus of the origin of the cosmological evolution of our universe. The lecture notes by Cliff Burgess provide a review of big bang cosmology, inflation, and its possible explanation in terms of string theory constructions, including some of the most recent results in the field (these notes also appear in the proceedings of two other schools held in the same period).

A surprising recent application of string theory is the description, via the ideas of holography and duality between string theories and gauge theories, of physical properties of quantum chromodynamics at high temperature. Indeed experimental data on the physical properties of the quark–gluon plasma, produced in heavy ion collision at the RHIC experiment in Brookhaven (and soon at the LHC at CERN) can be recovered, at a semi-quantitative level, from computations in a string theory dual of the system. These applications are reviewed in the lectures by David Mateos.

The conference was financially supported by the European Commission under contract MRTN-CT-2004-005104 and by CERN. It was jointly organized by the Physics Institute of the University of Neuchâtel and the Theory Unit of the Physics Division of CERN.

It is a great pleasure for us to warmly thank the Theory Unit of CERN for its very kind hospitality and for the high quality of the assistance and the infrastructures that it has provided. We also acknowledge helpful administrative assistance from the Physics Institute of the University of Neuchâtel. A special acknowledgement also goes to Denis Frank, for his very valuable help in preparing the conference web pages.

The organizers,

J-P Derendinger, C A Scrucca and A Uranga