B8 Integrable Structures in the Gauge/String Theory Correspondence

Dualities between ten-dimensional string theories on curved backgrounds and nonabelian gauge theories in four dimensions are of great relevance in modern attempts to develop a unified theory of quantum gravity. Here unification refers to the necessity to establish a link between the gravitational force and the electroweak and strong nuclear forces. The most important, if still conjectural, example of such a duality is the anti-de Sitter/conformal field theory (AdS/CFT) correspondence. Developments in the last five years have raised high hopes that one may be able to fully prove this particular duality by exploiting the existence of hidden integrable structures.

The project leaders have been key initiators and contributors to this exciting progress. As a result we have been moving much closer to an understanding of this duality. After completion of this project, we may hope to gain deep insights into the inner workings of string theory and quantum gravity.

A further motivation for the study of the integrability phenomenon is the perspective to apply string theory, and thus quantum gravity, to the analysis of the mathematically highly intricate Yang-Mills theories, and in particular to the theory of the strong nuclear forces, i.e. quantum-chromo-dynamics (QCD). For all encouraging success in the calculation of experimental consequences of the standard model of elementary particles, many questions remain where current methods, such as perturbation theory or lattice simulations, utterly fail. In addition, it is even possible that strings and quantum gravity will be helpful for a better understanding of certain long-standing theoretical problems of condensed matter theory.

Despite the significant progress detailed below, the exact solution of the AdS/CFT system has not yet been achieved. More work on this exciting subject is clearly needed. Here we propose three specific road maps towards further advances. Firstly, we plan to gain a deeper understanding of the algebraic structures underlying AdS/CFT integrability. Secondly, we aim at exploring new ways to unravel the structure of finite size effects of the system, the so-called wrapping problem. Thirdly, we propose to study the connections of the already obtained integrable structures to solvable structures in higher-point functions.