PREFACE

Gauge–string duality and integrability: progress and outlook

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PREFACE

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The AdS/CFT correspondence, proposed a little more than a decade ago, has become a major subject of contemporary theoretical physics. One reason is that it suggests the exact identity of a certain ten-dimensional superstring theory, and a specific supersymmetric four-dimensional gauge field theory. This indicates that string theory, often thought of as a generalization of quantum field theory, can also lead to an alternative and computationally advantageous reformulation of gauge theory. This establishes the direct, down-to-earth relevance of string theory beyond loftier ideas of finding a theory of everything. Put differently, strings definitely lead to a theory of *something* highly relevant: a non-abelian gauge theory in a physical number of dimensions! A second reason for recent excitement around AdS/CFT is that it uncovers surprising novel connections between otherwise increasingly separate subdisciplines of theoretical physics, such as high energy physics and condensed matter theory. This collection of review articles concerns precisely such a link.

About six years ago evidence was discovered showing that the AdS/CFT string/gauge system might actually be an exactly *integrable model*, at least in the so-called planar limit. Its spectrum appears to be described by (a generalization of) a Bethe ansatz, first proposed as an exact solution for certain one-dimensional magnetic spin chains in the early days of quantum mechanics. The field has been developing very rapidly, and a collection of fine review articles is needed. This special issue is striving to provide precisely that.

The first article of the present collection, by Nick Dorey, is a pedagogical introduction to the subject. The second article, by Adam Rej, based on the translation of the author's PhD thesis, describes important techniques for analysing and interpreting the integrable structure of AdS/CFT, mostly from the point of view of the gauge theory. The third contribution, by Gleb Arutyunov and Sergey Frolov, explains in great detail the state-of-the-art of quantizing the $AdS_5 \times S^5$ string theory's sigma model, gathering evidence for the conjectured integrability from the string side of the correspondence. The ensuing article by Nikolay Gromov starts with the full set of conjectured asymptotic Bethe equations of the model, and indicates how they relate to the firmly established classical integrabiliity of the string sigma model. The article by Benjamin Basso and Gregory Korchemsky discusses the issue of non-perturbative corrections in strong-coupling expansion and connections to the O(6) sigma model. The final article, by Fernando Alday, provides a link between the main topic of this special issue—the integrability of the spectrum of AdS/CFT—and other important observables of the model, such as the set of gluon scattering amplitudes, which may also lead to an exactly solvable problem.

We feel that the whole subject of AdS/CFT integrability is still in its infancy, and that much remains to be understood, proved, and extended. It is furthermore quite possible that the underlying structures will prove important for progress on cutting-edge problems in condensed matter theory. This collection of articles by experts in the field should serve as an important assessment of the incomplete status quo of the subject. As such, we hope it will inspire further research activity by ambitious theorists!

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