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String-Math 2012

July 16–21, 2012
Universität Bonn, Bonn, Germany

Ron Donagi
Sheldon Katz
Albrecht Klemm
David R. Morrison
Editors

American Mathematical Society

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Preface

The conference 'String-Math 2012' was held on July 16–21, 2012 at the Hausdorff Center for Mathematics, Universität Bonn. This was the second in a series of large meetings exploring the interface of mathematics and string theory. This volume presents the proceedings of that conference.

The nature of the interactions between mathematicians and physicists has been thoroughly transformed in recent years. String theory and quantum field theory have contributed a series of profound ideas which gave rise to entirely new mathematical fields and revitalized older ones. The influence flows in both directions, with mathematical techniques and ideas contributing crucially to major advances in string theory. By now there is a large and rapidly growing number of both mathematicians and physicists working at the string-theoretic interface between the two academic fields.

For mathematics, string theory has been a source of many significant inspirations, ranging from Seiberg-Witten theory in four-manifolds, to enumerative geometry and Gromov-Witten theory in algebraic geometry, to work on the Jones polynomial in knot theory, to recent progress in the geometric Langlands program and the development of derived algebraic geometry and n-category theory. In the other direction, mathematics has provided physicists with powerful tools, ranging from powerful differential geometric techniques for solving or analyzing key partial differential equations, to toric geometry, to K-theory and derived categories in D-branes, to the geometry of special holonomy manifolds as string compactifications, to the use of modular forms and other arithmetic techniques. The depth, power and novelty of the results obtained in both fields thanks to their interaction is truly mind-boggling.

The annual String-Math conferences are becoming the central venue for these profound and wide-ranging interactions. They bring together leading mathematicians and mathematically minded physicists working in this interface. These meetings promote and publicize such interactions, giving attendees greater opportunities to cross cultural boundaries, learn aspects of other fields relevant for their research, and advertise important developments to audiences that might not otherwise hear of them or appreciate their importance.

The 2012 conference was organized by Sergei Gukov, Daniel Huybrechts, Hans Jockers, Albrecht Klemm, Wolfgang Lück, Hans-Peter Nilles, Catharina Stroppel, Peter Teichner, and Don Zagier. The Steering Committee consisted of Dan Freed, Nigel Hitchin, Maxim Kontsevich, David Morrison, Karen Uhlenbeck, Edward Witten, and Shing-Tung Yau.

The meeting covered a wide array of topics at the interface of mathematics and high energy physics, including

- Topological field and string theory in various dimensions
- Homological mirror symmetry
- String topology
- Arithmetic of strings
- Gromov-Witten theory and enumerative geometry
- BPS state counting and Wall crossing formulas
- Geometric Langlands program
- A-twisted Landau-Ginzburg models
- Compactifications, special holonomy and special structure manifolds
- Heterotic strings, gauge bundle construction and (2,0) mirror symmetry
- Elliptic cohomology
- Large N dualities and integrability
- Non-perturbative dualities, F-theory
- Topological T-duality
- String measures
- Chiral de Rham complexes
- Noncommutative geometry

Altogether, this conference brought together nearly 200 mathematicians and physicists. There were 34 invited plenary talks given by leaders in both fields. Additionally, there were 39 contributed talks given in parallel sessions on the Wednesday of the meeting. All the talks are available at the conference website: http://www.hcm.uni-bonn.de/events/eventpages/2012/string-math-2012/. The conference also included a public lecture on 'Quo Vadis LHC?' by Christophe Grojean of CERN. The conference was preceeded by the Bethe Forum 'Lecture Series on Mathematical String Theory,' intended as a preparation to String-Math 2012 for graduate students and researchers alike.

Friedrich Hirzebruch, the founder and longtime director of the Max Planck Institute for Mathematics who encouraged and developed the interaction between mathematics and string theory over many years, passed away less than two months before the conference. Hirzebruch was renowned for his early work on the Riemann-Roch theorem, which became crucial for the understanding of many physical anomalies. In the early nineties, along with T. Höfer, he explained the relation between the Euler number of orbifolds, as introduced by string physicists, and the formulas of his student Lothar Göttsche for the Betti numbers of the Hilbert schemes of points on algebraic surfaces. The latter became decisive in the microscopic interpretation of black hole entropy by Strominger and Vafa. In the last years of his life, Hirzebruch explored elliptic genera and their connections with physics. He wrote a beautiful book on the subject with Thomas Berger and Rainer Jung. At the end of the interview that he gave for the Simons Foundation, one can hear him say that he "would not mind to be an expert in string theory." The venue of the conference was the main lecture hall of mathematics, where Hirzebruch had directed the famous Arbeitstagung for many years. His absence in the audience of eminent researchers in this field, so close to his heart, was keenly felt. A number of the papers in this volume are dedicated to his memory.

The string/math collaboration is clearly here to stay, and we expect this conference series to continue as long as the subject remains active and exciting. The venues and years of the first seven conferences of the String-Math series are:

- String-Math 2011, Philadelphia (Penn), June 6–11, 2011
- String-Math 2012, Bonn (Hausdorff Center for Mathematics), July 16–21, 2012
- String-Math 2013, Stony Brook (Simons Center for Geometry and Physics), June 17–21, 2013
- String-Math 2014, Edmonton (U. of Alberta), June 9–13, 2014
- String-Math 2015, Sanya (Tsinghua Sanya International Mathematics Forum), Dec. 31, 2015 – Jan. 5, 2016
- String-Math 2016, Paris (Institut Poincaré), June 27–July 2, 2016
- String-Math 2017, Hamburg

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