

Exact Results and Holographic Correspondences

1 Executive summary

We hosted a one-week workshop in July 2023 at MITP. The topic of our workshop was conformal field theories and quantum field theories, with a focus on holography. We brought together 22 researchers with expertise on different aspects of the holographic duality. The two main themes of the workshop was the AdS/CFT correspondence and the flat space holography. We had both pedagogical introductions as well as talks on recent advances in each topic. As a result, together with the participants we learned about the methods, achievements, and challenges in each topic. In addition to informal discussions during the breaks, we scheduled daily discussion sessions in the afternoons, which were very lively and productive. Our program was very successful in initiating fruitful discussions between people from different fields, finding interesting connections and common interests, and generating new ideas and research questions.

We hosted a diverse body of participants from different gender, background and seniority level. More than half of the talks were presented by junior researchers. Our participants were very satisfied with the scientific content and the structure of the workshop. They were very grateful to the MITP staff for their excellent support. They were very happy with their accommodations, office spaces and the vibrant atmosphere for scientific interactions. Some of our participants were also very excited to find out about programs on mathematical physics taking place at MITP, and expressed their interests to apply at the next call to host their own events.

2 Annual report

We hosted the one-week thematic program “*Exact Results and Holographic Correspondences*” at MITP in July 2023. We brought together 22 participants from various areas in quantum field theory, conformal field theory (CFT) and quantum gravity. The goal of our program was to advance our understanding of holographic conformal field theories in lower dimensions. This was motivated by substantial recent progress in different areas in holography. Various mathematical methods and approaches have played crucial rôles in formulating new instances of holographic dualities. While these new areas seem to be disconnected, there are common features between them which deserve a deeper understanding. Our goal was to find connections between the different approaches to holography and to explore how one approach can shed light on others.

The workshop was focussed on two main topics: (1) the *AdS/CFT correspondence* and (2) the *twisted holography*. The AdS/CFT correspondence is a vast area of research. We had talks and discussions on various modern aspects of AdS/CFT which are topics of intensive current research. There is a concrete formulation of the AdS/CFT duality in the context of string theory. There has been a breakthrough recently in exact formulation of this holographic duality in lower dimensions, namely AdS₃/CFT₂. *Symmetric product orbifold CFTs and worldsheet CFTs* play a prominent rôle in this context. Furthermore, there has been great recent progress made in understanding universal properties of families of holographic symmetric product orbifold CFTs, their moduli spaces, and conformal perturbation theory on these moduli spaces. We had many exciting and fruitful discussions on the interplay between these subjects.

Another novel aspect of symmetric product orbifold CFTs and holography is the formulation of topological symmetric product orbifold CFTs. This is obtained by topologically twisting the symmetric product orbifold, and has led to the formulation of the *topological AdS/CFT correspondence*. Due to its inherent simplicity, topological AdS/CFT offers another promising framework for an exact derivation of the duality. Moreover, topological AdS/CFT has interesting connections with the second topic of our workshop, namely twisted holography. Our discussions led to interesting new ideas and research problems. In particular, concrete computations in topological AdS₃/CFT₂ shed light on the non-topological AdS₃/CFT₂ correspondence, and make predictions for new bulk and boundary computations, as well as for the conformal perturbation theory of the symmetric product CFT.

We had very interesting talks and discussions on other novel instances of the AdS₃/CFT₂ correspondence which are *not* formulated in string theory context. In particular, we had fruitful discussions on *ensemble average holography* and a recent application of it to symmetric product orbifolds. Furthermore, the newly developed framework of *approximate CFTs* was presented. In this framework, ensembles of CFT data are defined, and a new holographic dual for pure gravity

in AdS_3 spacetime is proposed. The discussions around this topic, and its connections to more conventional holographic dualities, led to interesting insights and questions.

The second theme of our program is the twisted holography. Twisted holography is a recent development that builds on a proposal by Costello and Li on twisted supergravity. Most notably, it opens the door for mathematical applications and incarnations of the AdS/CFT correspondence and opens the way for new mathematical constructions in SUGRA theories. In the framework of our workshop we had two introductory lectures targeted at non-experts that introduced the basic formalism in mathematical approaches to supergravity, elaborating also on the pure spinor formalism for the construction of supermultiplets and supersymmetric actions. In a designated discussion session, the new perspectives were discussed in connection with other approaches to the AdS/CFT correspondence. Here, the diverse expertise and different background of the various participants sparked new interest in the topic as well as overlapping and related research areas.

Among the recent progress on 11-dimensional supergravity in a twisted formalism is the idea that higher symmetries and in particular W -algebras might play a role in the context of the yet-to-be-formulated theory on M5 branes. We therefore organized talks on how these symmetries and more general VOA symmetries arise and are constructed in the context of integrability and CFT in general. Indeed, topics ranging around W -symmetries were much pursued during coffee breaks and brought together people from different fields.

In addition to the talks and discussions on the two main themes of the program, we also had a few talks on other exciting developments in holography and string theory. This includes: von Neumann algebras and their relation to geometric phases in AdS/CFT, microstate counting for black holes in AdS/CFT from both gravitational bulk and boundary CFT perspectives, and new type IIB string theory compactification on non-spin manifolds and their duals.

All in all, together with the participants, we had a fruitful and productive week, in a stimulating environment. We learned a lot about the current status of research in holography and gained new insights into connections between areas which seem to be disconnected. The relaxed format of the workshop, with few talks and ample discussions, allowed for good progress on current research projects and on defining future problems.