The Mathematics of Holography on asymptoticaly Anti-de Sitter Spacetimes

Supervisor: [Arick Shao]

Research Group: [Geometry, Analysis & Gravitation]

Project description:

An outstanding open problem in science is to reconcile the two major theories of modern physics—relativity and quantum mechanics. One influential idea in this pursuit is the AdS/CFT correspondence, which posits a correspondence between the gravitational dynamics of asymptotically Anti-de Sitter (AdS) spacetimes and a field theory on their conformal boundaries. As the matching boundary theory is of one dimension less than the aAdS spacetime, this is seen as a realisation of the holographic principle.

Though these ideas have led to novel insights in physics, there are nearly no rigorous mathematical statements on the AdS/CFT correspondence. Therefore, there is both a need and a timely opportunity to develop a mathematical understanding of these ideas. The first main theme of this project is to formulate and prove rigorous mathematical results pertaining to the holographic principle on aAdS spacetimes, and to understand the mathematical mechanisms driving such results.

In addition, many of the key questions are difficult and lie in unexplored mathematical territory, and their resolution would require new innovations in analysis, partial differential equations (PDEs), and differential geometry. Thus, the second theme of the project moves in the opposite direction, using the AdS/CFT correspondence as motivation to develop novel mathematical ideas and techniques with applications beyond holography.

Some key objectives within the project are as follows:

- Proving a one-to-one correspondence between conformal boundary theories and bulk aAdS spacetimes; this is mathematically formulated as a unique continuation problem for the Einstein-vacuum equations.
- Understanding the nature of these correspondences, by investigating which data on the conformal boundary give rise to a vacuum aAdS spacetime.
- Exploring how the boundary matter field can be leveraged to drive behaviour, such as black hole formation, in the bulk aAdS spacetime; this is formulated as a control problem for the Einstein-vacuum equations.

Further information:

How to apply

Entry requirements

Fees and funding