Abstract
This project seeks to investigate a proposed solution to the longstanding discontinuity between the well tested theories of the Standard Model of Quantum Physics and Albert Einstein’s classical theory of General Relativity. Mark van Raamsdonk’s entanglement/connectedness hypothesis proposes that quantum entanglement is the geometric glue that holds spacetime together. To assess the claim we build a conceptual analysis of differing notions of entanglement (quantum entanglement, geometrical entanglement, topological entanglement), non-locality, and various measurements of entropy (entanglement entropy, black hole entropy, thermodynamic entropy). Finally we build a bridge between van Raamsdonk and Juan Maldecena and Leonard Susskind’s ER=EPR hypothesis, which proposes that quantum entangled particles are linked by wormholes in spacetime.

Mark van Raamsdonk’s Entanglement/Connectedness Hypothesis
Mark van Raamsdonk’s hypothesis claims that entanglement on the boundary of a region corresponds to connectedness in the bulk of the region. [1] One of his main motivations behind this is the Ryu-Takayanagi formula. [2]

Ryu-Takayanagi Formula
\[ S_A = \frac{\text{Area}(\gamma_A)}{4G} + \Gamma^* [2] \]

Notions of Entanglement

<table>
<thead>
<tr>
<th>Quantum Entanglement</th>
<th>Geometric Entanglement*</th>
<th>Topological Entanglement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundary</td>
<td>Bulk</td>
<td>Bulk</td>
</tr>
<tr>
<td>Spooky action at a distance</td>
<td>Emergent connectedness</td>
<td>Mechanism of entanglement</td>
</tr>
<tr>
<td>Entangled vector states of bipartite systems in tensor space</td>
<td>Entangling braid operator</td>
<td></td>
</tr>
</tbody>
</table>

*the notion of geometric entanglement is not as well understood as quantum or topological entanglement

Future Work
Now that we have created a conceptual framework of varying notions of entropy, entanglement, and non-locality, we can now use this, along with the van Raamsdonk hypothesis, to tackle the ER=EPR hypothesis. The ER=EPR hypothesis claims that wormholes and quantum entanglement are the same thing under differing viewpoints, much like electricity and magnetism. If the ER=EPR hypothesis holds up, this could have profound implications for all of physics, as the hypothesis unites a fundamental quantum mechanics concept with a fundamental general relativity concept.

Works Cited

Acknowledgement
The authors thank NYU Tandon School of Engineering’s Office of Undergraduate Academics for generous funding of the project.