TATA-INFOSYS LECTURE SERIES:

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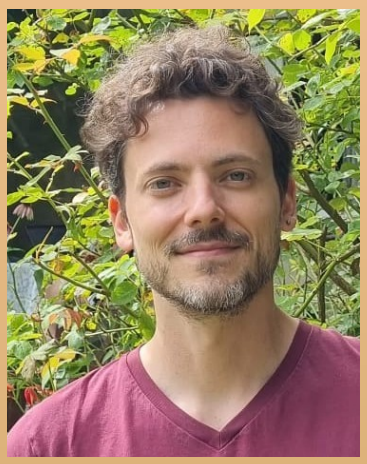

The Wilson spool : quantum matter as an extended operator in quantum gravity

Abstract:

Because of diffeomorphism invariance, gravity is a constrained system with essential long-range physics. This is exemplified in low dimensions where it can be expressed as a topological quantum field theory. In these lectures I will introduce and discuss Wilson spool, a recently developed (and still developing) technique for discussing quantum matter coupled to low-dimensional quantum gravity, namely expressing the exact one-loop determinants of matter as an extended line operator acting within the gravitational path integral.

Lecture 1 (Monday, 3 Nov, 11:00am – 1:00pm, A 304):

I will provide some background and some motivation. I will focus the discussion on two-dimensional AdS JT-gravity and its relation to a topological BF theory. I will show that the one-loop determinant of minimally coupled scalar fields can be expressed as an integral over a Wilson loop wrapping a non-trivial cycle of a background. In deriving this result I will also review the quasi-normal mode method for one-loop determinants developed by Denef, Hartnoll, and Sachdev. I will finish with a discussion about quantum gravitational effects.

Lecture 2 (Tuesday, 4 Nov, 11:00am – 1:00pm, A 304):

I will move the discussion to three-dimensional AdS gravity, which is expressed as a pair of Chern-Simons field theories. In complete analogue with the 2d result, will describe how the exact one-loop determinants of massive spinning fields can be expressed as an integral of Wilson loops of the Chern-Simons connections. This result applies to any smooth, cusp-free, hyperbolic three-manifold and I will show how it reproduces and, in some cases, extends the results of Giombi, Maloney, and Yin. In deriving the Wilson spool, I will review the classification of hyperbolic three-manifolds and the Selberg trace formula. I will also make concrete contact with the expression of one-loop determinants as worldline quantum mechanics.

Lecture 3 (Thursday, 6 Nov, 11:00am – 1:00pm, AG 66):

I will reinterpret the previous results in the context of de Sitter spacetime. Euclidean dS is compact which leads to interesting subtleties with the formulation of quantum gravity as a topological field theory as well as the representation theory of massive matter. I will illuminate these subtleties and show how the Wilson spool encapsulates them and correctly reproduces the one-loop determinants of massive spinning fields propagating on a Euclidean sphere. I will then describe how TQFT techniques allow for efficient calculation of quantum gravitational effects, illustrating this with an explicit calculation of the three graviton loop mass renormalization of the matter. This provides concrete, testable, predictions for quantum matter coupled to quantum gravity. I will finish up with an outlook, open questions, and speculations.

(Click here for the zoom link)