Physics Seminar: Jorge Santos (on Zoom)
Thursday, October 3 · 10:00 – 11:00am
On Zoom

Title: New Well-Posed Boundary Conditions for Semi-Classical Euclidean Gravity

Abstract: We consider four-dimensional Euclidean gravity in a finite cavity. Dirichlet conditions do not yield a well-posed elliptic system, and Anderson has suggested boundary conditions that do. Here we point out that a one-parameter family of boundary conditions exists, parameterised by a constant p, where a suitably Weyl-rescaled boundary metric is fixed, and all give a well-posed elliptic system. Anderson and Dirichlet boundary conditions can be seen as the limits $p \to 0$ and ∞ of these. Focussing on static Euclidean solutions, we derive a thermodynamic first law. Restricting to a spherical spatial boundary, the infillings are flat space or the Schwarzschild solution and have similar thermodynamics to the Dirichlet case. We consider smooth Euclidean fluctuations about the flat space saddle; for $p > 1/6$ the spectrum of the Lichnerowicz operator is stable - its eigenvalues have a positive real part. Thus we may regard large p as a regularisation of the ill-posed Dirichlet boundary conditions. However, for $p < 1/6$ there are unstable modes, even in the spherically symmetric and static sector. We then turn to Lorentzian signature. For $p < 1/6$ we may understand this spherical Euclidean instability as being paired with a Lorentzian instability associated with the dynamics of the boundary itself. However, a mystery emerges when we consider perturbations that break spherical symmetry. Here we find a plethora of dynamically unstable modes even for $p > 1/6$, contrasting starkly with the Euclidean stability we found. Thus we seemingly obtain a system with stable thermodynamics, but unstable dynamics, calling into question the standard assumption of smoothness that we have implemented when discussing the Euclidean theory.