Conformal boundary field theory for 3d loop quantum gravity

Wolfgang M. Wieland

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The simplest gravitational Dirac observables for asymptotically flat boundary conditions are the total mass and angular momentum, which are two-dimensional surface (charge) integrals at infinity. In quantum gravity, such charge integrals are challenging, because a typical spin network boundary state represents the quantum geometry of a *finite portion of space*, which makes it difficult to speak about *asymptotic boundary conditions* at the quantum level. A possible strategy to resolve this difficulty is to consider a *quasi-local* approach, where the gravitational field is quantised in a compact region with boundaries at finite distance. The limit to infinity would be performed then at the quantum level by selecting an appropriate family of coherent states representing larger and larger regions of space.

In my talk, I will explain this strategy in the context of three-dimensional euclidean gravity with vanishing cosmological constant. At a technical level, the starting point is the Hamiltonian formalism for general relativity in regions with boundaries at finite distance. At these finite boundaries, I choose specific conformal boundary conditions (the boundary is a minimal surface). These boundary conditions are then viewed themselves as part of the dynamical problem, and derived from a coupled bulk plus boundary action, which defines a conformal field theory with vanishing central charge. On the resulting boundary Hilbert space an infinite tower of gravitational observables is found. I will show, in particular, that the length of a one-dimensional cross section of the boundary turns into a counting operator on the Hilbert space of the conformal boundary field theory. The resulting discrete length spectrum agrees with what we know form three-dimensional loop gravity. In addition, there is an infinite tower of quasi-local observables representing quasi-local expressions for energy and angular momentum.