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A Quasi-local Approach to Gravitational Thermodynamics

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Ideas like anti-de Sitter/conformal field theory correspondence and the membrane paradigm have illuminated many aspects of string and field theory, giving insights into field ranging from quantum gravity to condensed matter. In essence, these ideas are a statement of the holographic principle: the observation that all of the information contained in a bulk region of space-time can be encoded on the boundary of that region. However, these approaches are restricted to situations where knowledge of the boundary of space or the end of time are required. From a practical point of view this is unsatisfactory. As local observers, we are generally not able to access these boundaries.

To overcome these limitations, we use 'gravitational screens', two-dimensional hypersurfaces that can surround arbitrary regions of space. Projecting Einstein's equations onto the screen results in the equations of non-equilibrium thermodynamics for a viscous fluid, which encode all of the information about gravitational dynamics inside the screen in terms of a holographic fluid on the surface, without being restricted to a particular choice of boundary. We study the dynamics and equations of state for screens in various space-times, and determine the properties of the fluids that arise from different evolution/geometries, as well as clarifying the deep relationship between the gravitational degrees of freedom in the bulk, and the thermodynamic degrees of freedom on the screen.

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