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Modelling The Gravitational Collapse Of Scalar Fields In Anti-de Sitter Space

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For phases like quark-gluon plasmas, the strong-coupling nature of the system means that perturbative approximations are invalid, and therefore conventional solution methods break down. However, using a duality first established by string theory, we are able to relate strongly coupled quantum field theories to weakly coupled gravitational systems (in one higher dimension). The most common use of this hidden relationship is to map between special quantum field theories —known as Conformal Field Theories (CFTs) —and general relativity in anti-de Sitter (AdS) space. As a consequence of the AdS/CFT correspondence, the more strongly coupled a CFTs is, the more weakly curved (*i.e.*, classically solvable) the gravitational dual is.

Motivated by the AdS/CFT correspondence, we examine the conditions that lead to the formation of a black hole in 4D AdS as a dual to the thermalization of a 3D CFT under an initial energy perturbation. We numerically evolve the full Einstein equations in the presence of both massless and massive scalar fields for a variety of initial momentum profiles. The curvature of AdS is such that massless fields are able to travel to spatial infinity and back in finite time, and therefore these fields have multiple opportunities to collapse. Massive fields do not travel to infinity, but do undergo periodic motion that may lead to horizon formation at long times.

The interplay between the initial conditions and the geometry of the space lead to a landscape of collapse behaviour that will be explored in this talk. Using the highest resolution available, we are able to extend our numerical results into amplitude regimes that are described by a perturbative theory. For certain initial profiles, the prediction of the perturbative theory —that AdS space is stable to black hole formation in this regime —is at odds with the numerical data. We will make preliminary comments on how this discrepancy may be resolved, and how the resolution could bring about significant improvements in modelling the formation of black holes from massless and massive scalar fields.

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