JOINT TUFTS/MIT COSMOLOGY SEMINAR

Strongly coupled first-order phase transitions in early Universe

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The first-order phase transition (FOPT) is ubiquitous in nature from the gas-liquid PT in daily life to the counterpart in the early Universe, the latter of which plays an indispensable role in probing new physics via the associated stochastic gravitational-wave (GW) backgrounds as well as the induced large curvature perturbations or even the produced primordial black holes. Despite the success of modeling GW spectra from numerical simulations, a key parameter usually left undetermined is the terminal wall velocity for a steady-state bubble expansion, before which the initially nucleated static bubble starts to accelerate under a driving fore that could be eventually balanced by a backreaction force. Whether the bubbles had reached the terminal wall velocity when they largely collide with each other crucially determines whether the GWs are dominated by wall collisions or fluid motions. For weakly coupled FOPT, the bubble wall velocity could be estimated by solving the full Boltzmann equation. However, for a strongly coupled FOPT, it is barely feasible to write down the exact collision terms. Remarkably, it was recently found in holographic numerical simulations of strongly coupled systems that there is a novel linear correlation between the phase pressure difference of false and true vacua and the terminal velocity of the planar wall.Furthermore, the holographic numerical simulations also suggest a non-relativistic terminal wall velocity. In this talk, I will adopt simple hydrodynamics to analytically derive the non-relativistic limit of bubble expansion at strong coupling for all different wall geometries with planar, cylindrical, and spherical symmetries, not only reproducing the pre-mentioned linear relation for the planar wall but also predicting new relations for the cylindrical and spherical walls that can be directly tested in future holographic numerical simulations. Once confirmed, these relations can be used to express the bubble wall velocity purely in terms of the hydrodynamics without turning to the underlying microphysics.

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