Scientific report

Purpose of the visit

The aim of my visit to CERN was to pursue a collaboration with Umut Gursoy, on the topic of the hydrodynamics flow in holographic non-conformal systems.

Description of the work and main results

Ever since the AdS/CFt duality was successfully applied to the description of the hydrodynamics fluctuations of the quark/gluon plasma, there has been much interest in extending the method in order to be closer to the real physical systems of interest.

Among the various developments, a remarkable paper of Janik and Peschanski [1] analyzed the holographic dual of a particularly simple setup, the so-called Bjorken flow, in which one assumes boost-invariance, and therefore it should be a good approximation to the evolution of the quark-gluon plasma created in a heavy-ion collision at very high energy. In this setup they were able to solve exactly the Einstein equations in a late-time expansion, and showed that perfect fluid hydrodynamics emerges naturally from the requirement of non-singularity of the bulk metric; this implies a particular rate of cooling for the expanding plasma; later they showed also that considering higher orders in the expansion a preferred value for the shear viscosity is obtained.

Naturally it would be of great interest to extend these results to models that are closer to real QCD. At present one of the best candidates is a bottom-up model constructed by Kiritsis and collaborators [2], that uses a scalar-Einstein theory in 5 dimension with a potential for a dilaton. Such a theory admits an AdS minimum and has solutions with a running coupling and a dynamically generated scale. Close to the boundary of AdS the dilaton is at the bottom of the potential, but far away in the infrared it is in a region where the potential can be approximated by a single exponential. One can therefore hope that questions about the IR dynamics can be explored in a simpler model where one keeps only the exponential potential. In this model one can construct exact black-hole (Chamblin-Reall) solutions and study their perturbations.

During my visit, Gursoy and I set up the computation of the perturbation of the CR solutions and analyzed the equations that result in the late expansion. Similarly to the AdS case, for a boost invariant flow at late times , the Einstein-dilaton equations reduce to a set of non-linear ordinary differential equations that presumably can be solved analytically; we were able to

[1] Asymptotic perfect fluid dynamics as a consequence of Ads/CFT , Phys.Rev. D73 (2006) 045013

[2] see Gursoy, Kiritsis, Mazzanti, Michalogiorgakis, Nitti, "Improved Holographic QCD", Lect. Notes Phys. 828 (2011)

solve them partially, even though in the short time-frame of this visit we did not succeed in finding the general solution. Even if the complete analytic solution turns out to be too difficult, we are in a position to analyze the equations numerically if needed in order to extract conclusions about the cooling rate of the plasma and the corrections to the viscosity.

Publications
The work in progress; we expect that we will be able to publish our results in the near future; we anticipate however that the completion of the work will require further exchange visits.

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