Bringing Holography to the Lab:
Explaining Strange Metals with Virtual Black Holes

7 – 11 January @ Snellius

Understanding the puzzling features of high temperature superconductors and in particular their strange metallic phase remain one of the hardest challenges in modern physics of Condensed Matter. The need for the novel theoretical frameworks has been clearly identified and a recent discovery of the AdS/CFT duality (holography) presents an opportunity to build such a novel framework, which would be capable to address these unconventional phenomena. However the application of holographic methods to Condensed Matter systems requires considerable effort aimed in particular at overcoming the differences of backgrounds in the holographic community, having a lot to do with gravity, black holes, string theory and supersymmetry, and the condensed matter community, dealing a lot with quasiparticles and features of real materials. One of the goals of the workshop was to develop the common language between these scientific communities, make them interact with each other and find the points of contact between the seemingly different fields, where the new cross-disciplinary collaborations may emerge.

The invited participants represented evenly the holographic and condensed matter communities. The workshop has undoubtedly reached the goal initiating the interaction at the social level. We managed to create the comfortable atmosphere of mutual interest and openness, and the inclusive environment of the Lorentz Center Snellius venue has clearly facilitated this task. On top of that we arranged a lot of free time for private discussions during the coffee breaks and lunch. It was delightful to see that the speakers were sharing not only their published results, but also their unpublished work and personal views on the future developments. They didn't hesitate to point out the current research problems which has not been understood yet.
We deliberately asked all the speakers to pay a special attention to the introductory material which was necessary to make the talks accessible to the whole broad audience. Many participants noted in private conversations that they learned a lot during the workshop and have finally started to understand the other party better. This mutual understanding was a key for the workshop and it has definitely been reached.

In the program we were quite liberally mixing the talks by gravity/holography experts and condensed matter/experiment experts, arranging the talks by the object of the study, not by the approach used. This tactic has proven to be successful since this motivated the people to stay throughout all the talks and indeed the attendance was always high. Every day we had a discussion session summarizing the main points and questions raised during the day. These discussion sessions delivered the main scientific results of the workshop. Among them the most spectacular ones:

- It has been realized that the current state of the art in the experimental study of the non-equilibrium phenomena provides a good application for the Numerical Relativity methods of computing the evolution of the black holes in holographic models, which have just reached the state of applicability to the realistic setups. Surprisingly, in both cases the non-thermal fixed points of the evolution have been observed, which will be in the focus of the future studies.
- The experimental studies of transport in strange metals seem to confirm the hypothesis arisen in holographic models that there is an additional "critical" transport channel which is totally insensitive to the disorder or other momentum relaxation mechanisms. It contributes most strongly near the optimal doping regime, but is seen everywhere throughout the phase diagram. The features of this "critical" sector were reported to be seen in magneto-resistance measurements, hall angle studies and M-EELS spectroscopy experiments.

- The fresh results of the ARPES fermionic spectroscopy were reported and these match well with the generic expectations arising from holographic approach. The future directions of studying holographic Fermi arcs have been outlined.

Overall, based on the feedback from the participants and our own feeling, we understand that the workshop was extremely successful and served as a starting point of many professional and, even more importantly, personal interactions between the representatives of the fields of science which were widely separated before. We believe this synergy and enthusiasm of both parties will last and will result in novel scientific achievements in the field of quantum matter.

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