Final Report, ESF Exchange Grant: D. Patanè

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The purpose of the visit was to work with prof. Fernando Sols and Luigi Amico at the Universitad Complutense of Madrid. The tight collaboration during the stay was extremely useful and fruitful: a preprint was already submitted and other two papers are at an advanced stage. Based on these studies several aspects have emerged that I plan to investigate in the next future.

The project has been focused on the effect of dissipation on quantum critical system and it was developed addressing two complementary problems.

- Quench dynamics

Study of non-equilibrium dynamics of phase transitions is one of the central issue of statistical mechanics. A paradigmatic scenario that has been investigated extensively is the quench of the control parameter at a constant speed across the critical point. The so-called Kibble-Zurek mechanism provides a general theory relating the density of defects (non adiabatic excitations created during the quench) as function of the velocity of the quench, in a universal way.

We considered the problem of a system weakly coupled to a thermal bath. Due to the interaction with the bath also incoherent excitations are generated. We thus clarified the interplay between coherent and incoherent excitation mechanism. The off equilibrium dynamics is found to be influenced by the thermal equilibrium phase diagram of the system. General scaling laws were derived and verified for the specific example of the quantum Ising model coupled to a thermal bath.
This work was based on an initial collaboration with R. Fazio (SISSA), G. E. Santoro (SISSA) and A. Silva (ICTP) and has already led to a letter submitted for publication:
"Adiabatic quenches in open quantum critical systems: Coherent vs incoherent defect production" with A. Silva, L. Amico, R. Fazio and G. E. Santoro.
A much longer article with details on the previous paper will also be submitted soon.

On the basis of the results obtained in the previous work, a new project was started in collaboration with prof. Sols to further analyze the effect of dissipation on the off equilibrium dynamics. The aim is to study how spatial correlations develop dynamically in presence of a quantum bath. We are addressing correlation functions, but also entanglement measures to show their interplay and the fragility

of the latter with respect to thermal noise. This work is still at a preliminary stage and we plan to complete it in the following months.

- Dissipation driven phase transitions

The first part of the project was focused on the dynamics of a system weakly coupled to a thermal bath. A very relevant limit is also the strong coupling. It is well known f.i. for the problem of a single spin in a bosonic environment (spin boson model) that the bath can induce a dissipation driven phase transition. Thus it is intriguing to investigate what are the effects of strong dissipation on a many body system especially in connection with criticality.
We thus addressed the specific example of a quantum XY model coupled to a bosonic bath. Interesting results have already been obtained using a variational technique. In particular the equilibrium dissipative phase diagram of the model was outlined. Besides a scaling analysis has been shown promising, but it still needs to be further studied. This work was performed in close collaboration with Prof. Sols and also benefit useful discussions with prof. Francisco Guinea. We plan to submit a preprint in the following months.

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