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Non-equilibrium and information: the role of cross correlations

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At mesoscopic level, every description is characterized by a coarse-graining process and, as a consequence, by a loss of information. The customary example in this direction is the Langevin equation for the motion of a Brownian particle in a fluid. This reduction scheme implies that the nature of the description changes, from deterministic to stochastic. My research plan is to study this projection process in a more general non-equilibrium context. Different kinds of projections can be applied also when some currents are already present into the system. In this case, the projection to a non-Markovian representation is detected through a decrease in mean entropy production. This change can be dramatic, leading to the false conclusion that the system is in equilibrium.
I will present a collection of works that study this aspect, with some experimental results to granular gases. In particular:

- I will consider a stochastic system where two degrees of freedom X_1 and X_2 - in contact with two different thermostats - are coupled together. The production of entropy and the violation of equilibrium fluctuation-dissipation relations are both related to the cross-correlation between X_1 and X_2. Such an information may be lost when single-variable reduced models, for X_1, are considered [1,2,3].

- I will describe the motion of a massive intruder in a granular gas, namely a gas of macroscopic particles that collide inelastically. By combining generalized response theory and fluctuation relations, it is possible to identify a local velocity field, generated by the particles surrounding the intruder [4,5].

- I will describe an experiment on a quasi-2D granular fluid which allows one to define and measure a non-equilibrium coherence length, confirming the presence of the correlation in the velocity field [6,7,8].

We will show how a general lesson can be learnt from all these situations: the main "non-equilibrium channel" is given by a cross-correlation among different degrees of freedom. Then, the search for the appropriate correlation function which is linearly related to the response can be more insightful than a definition of effective temperatures or other equilibrium-like approaches.

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