Friday 08/09, Sebastian Diehl

Title: Non-equilibrium O(N) models: Critical exceptional points, Goldstone limit cycles, and new non-equilibrium universality

Abstract: In thermal equilibrium the dynamics of phase transitions is largely controlled by fluctuation-dissipation relations: On the one hand, friction suppresses fluctuations, while on the other hand the thermal noise is proportional to friction constants. Out of equilibrium, this balance dissolves and one can have situations where friction vanishes due to antidamping in the presence of a finite noise level. We study a wide class of O(N) field theories where this situation is realized at a phase transition, which we identify as a critical exceptional point. In the ordered phase, antidamping induces a continuous limit cycle rotation of the order parameter with an enhanced number of $2N-3$ Goldstone modes. Close to the critical exceptional point, however, fluctuations diverge so strongly due to the suppression of friction that in dimensions $d<4$ they universally either destroy a preexisting static order, or give rise to a fluctuation-induced first order transition. This is demonstrated within a non-perturbative approach based on Dyson-Schwinger equations for $N=2$, and a generalization for arbitrary N, which can be solved exactly in the long wavelength limit. We show that in order to realize this physics it is not necessary to drive a system far out of equilibrium: Using the peculiar protection of Goldstone modes, the transition from an xy magnet to a ferrimagnet is governed by an exceptional critical point once weakly perturbed away from thermal equilibrium. We furthermore identify a second order phase transition connecting disordered and limit cycle phase directly, which presents a new O(N)xO(2) non-equilibrium critical point. Here, O(2) associates to the spontaneous breakdown of time translations.