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Kardar Parisi Zhang universal scaling in the coherence of polariton condensates

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The Kardar–Parisi–Zhang (KPZ) equation[1], originally derived to describe the kinetic roughening of growing interfaces is a stochastic non-linear differential equation that applies to a large class of non-equilibrium systems, ranging from the growth of nematic liquid crystal clusters, of bacterial colonies, or the propagation of a combustion front. The shape of such an interface h(r,t) is described by the following stochastic equation: $\partial_t h=v\nabla^2 h+\lambda/2 (\nabla h)^2+\eta$, where the first term is a smoothening diffusion, the second term is a crucial non-linear contribution that leads to critical roughening of the interface and η is a Gaussian noise. Interestingly the spatial and temporal correlation functions of h(r,t) show universal scaling laws, with critical exponents that only depend on the dimensionality whatever the system .

Recently, it was discovered that the phase dynamics in the coherent emission of out of equilibrium condensates of light (named polariton condensates) also obeys the celebrated KPZ equation [2-4]. Interestingly, since the phase is a compact variable, periodically defined between 0 and 2⊠⊠⊠ the physics is enriched by the possible emergence of vortices. Actually even in 1D, where usually vortices are excluded, exotic spatio-temporel vortices have been predicted to play a role [5].

In the present talk, after a general introduction to the cavity polaritons, I will explain how we could generate extended 1D polariton condensates [6] and probe their first order coherence. We demonstrate that the spatio-temporal decay of the first order coherence presents universal scaling laws characteristic for the KPZ universality class in 1D [7]. The influence of vortices in these experiments will be discussed as well as the extension of this work in 2D [2].

Our work highlight the profound difference between driven-dissipative out of equilibrium condensates and their equilibrium counterparts. We anticipate that this physics should also be relevant in extended vertical cavity lasers.

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