Glass and pseudo-localization transitions in the mode-locked p-spin model for random Lasers

Jacopo Niedda
Sapienza, Italy

Optical waves in active disordered media display the typical phenomenology of complex systems. Several spectral shots taken from the same piece of material in the lasing regime display strong fluctuations in the position of the intensity peaks, suggesting that there is no specific mode which is preferred in the amplification, but depending on the initial state, with the disorder kept fixed, the modes gaining the highest intensity change every time. In order to explain this behaviour, a spin-glass model has been developed, where the light modes are described as non-linearly interacting phasors on the so-called mode-locked diluted graph [1]. The specific mode-coupling selection rule, which naturally emerges in the study of lasing modes dynamics, impairs the analytical solution of the model out of the narrow bandwidth limit, where the interaction network is fully connected. In this talk we present recent results from numerical simulations of the mode-locked glassy random laser. A phenomenology compatible with a glass transition is revealed from the divergence of the specific heat and the non-trivial structure of the Parisi overlap distribution function [2]. By means of a refined finite-size scaling analysis of the critical region, the transition is assessed to be compatible with a mean-field universality class [2]. A pseudo-localization transition to a phase where the intensity of light is neither properly localized on a single mode nor equiparted among all the modes is revealed from the measure of the inverse participation ratio and of the spectral entropy [3]. The two transitions occur at the same temperature as different manifestations of the same underlying phenomenon, the breaking of ergodicity.

References

[1] F. Antenucci, C. Conti, A. Crisanti, L. Leuzzi, Phys. Rev. Lett. 114, 043901 (2015).
[2] G. Gradenigo, F. Antenucci, L. Leuzzi, Phys. Rev. Research 2, 023399 (2020).
[3] J. Niedda, G. Gradenigo, L. Leuzzi, G. Parisi, arXiv:2210.04362, (2022).
[4] J. Niedda, L. Leuzzi, G. Gradenigo, arXiv:2212.05106 (2022).