The Wonderful World of Random Lasers and Random Fiber Lasers

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Random Lasers (RLs) are coherent light sources whose feedback mechanism relies on light scattering in a strongly scattering media in the presence of a gain medium, instead of a pair of fixed mirrors. Upon appropriate pumping, inversion population and amplification precede the optical feedback such as the gain overcomes the loss as in conventional lasers. As reviewed in [1], where most of the historical background and theoretical/experimental developments until June 2021 can be read, RLs, as well as Random Fiber Lasers (RFLs) have become an important tool for photonic studies. As light sources, RLs and RFLs have been demonstrated in all 1D, 2D and 3D configurations, and well characterized regarding threshold, line narrowing/emitted intensity versus excitation intensity, polarization, spatial and temporal coherence, photon statistics (which has been shown to be Poissonian) and operation in the continuous wave or pulsed regime. Regarding RL materials, as long as there is a suitable gain medium (dye, rare earth doped glasses and crystals, semiconductors, quantum dots, etc.) and a scattering medium (which can be the same as the gain medium or external to it) a myriad of RLs/RFLs have been demonstrated [1]. As for RFLs, even the Rayleigh scattering in a few kms fiber length is enough to provide optical feedback, and intrinsic Raman or Brillouin processes provide the gain for laser action. Recently, we have demonstrated a transform limited mode-locked random fiber laser [2]. Flexible RLs in 2D have also been exploited using biomaterials as hosts, and of course RFLs (1D) are intrinsically flexible by nature. Regarding applications, RLs and RFLS have been exploited for speckle-free imaging, which is an important feature for diagnostic by imaging. A variety of sensing devices based on RLs/RFLs have been reported, including biosensors, powder delivery rate sensor, dopamine detection, among others. In optical communications, RFLs optical amplifiers have been demonstrated to perform better than conventional optical fiber amplifiers, as reviewed in [1] and refs therein. Finally, RLs and RFLs have been exploited as a photonic platform to study, by analogy, turbulence, photonic spin glass, Lévy statistics, Floquet states and extreme events. The connection between photonic turbulence and spin glass behavior of light has shown to bridge the two subjects and, through experiments using RFLs, have been highlighted in connection with the recently awarded 2021 Nobel Prize in Physics [3]. All these exciting features of the wonderful world of RLs and RFLs will be touched upon during this lecture.

References

[1] Anderson S L Gomes, André L Moura, Cid B de Araújo and Ernesto P Raposo, Prog. Quant. Electron. **78**, 100343 (2021)

[2] Jean Pierre von der Weid, Marlon M. Correia, Pedro Tovar, Anderson S L Gomes and Walter Margulis, Nat. Commun. **15**, 177 (2024)

[3] A S L Gomes, C B de Araújo, A M S Macêdo, I R R González, L de S Menezes, P I R Pincheira, R Kashyap, G L Vasconcelos and E P Raposo, Light Sci. Appl. **11**, 104 (2022)