Development of an Automated Platform for Pearson Correlation Analysis in the Context of Random Lasers

G H G Silva[1] and L Boni[2]

[1]*Photonics Group, São Carlos Institute of Physics, R. Miguel Petroni, 168 - Jardim Bandeirantes, São Carlos, Brazil. Contact Phone: +5513981593854*

[2]*Photonics Group, University of São Paulo, São Carlos Institute of Physics, R. Miguel Petroni, 168 - Jardim Bandeirantes, São Carlos, Brazil. Contact Phone: +551633738085*

Contact Email: gustavohgs@usp.br

The Random Laser (RL) is a type of laser based on multiple dispersions of photons inside a certain material (gain medium), which permits consecutive energy acquisitions. A conventional laser needs an optical cavity to enable a prolonged interaction between the photons that come from spontaneous emission, by giving energy pumps to the gain medium, and the atoms from the medium itself. On the other hand, the RL uses scattering particles inside the material to deflect the photons and, for a longer time, keeping their interaction, increasing the chances of stimulated emissions occurring and, consequently, the laser effect. The RL is characterized by two main states: the incoherent, wherein the emission spectrum it is possible to see one main Gaussian-like curve with Full Width at Half Maximum (FWHM) at the nanometers scale, and the coherent, in contrast, with a great number of peaks with subnanometer scale FWHM. The whys that explain when we see these two types of RLs depend on a lot of factors, such as the size of the scattering particles, the formation of photon trajectories in loops inside the medium, and Anderson localization [1]. In the work of Leonetti, M. et al. [2] correlated the transition from a coherent RL to an incoherent one to the increasing interactions between the directional modes of the electromagnetic waves, according to the Maxwell equations solutions, making the diverse peaks in the emission spectrum to get more and more correlated as these modes interact by a technique using Pearson correlation coefficient. In this sense, another work [3], showed that the transition of states of the RLs is highly sensitive to factors like temperature and chemical modifications in the medium, carving a path to effective sensors based on the correlation dynamics. This work presents the development of an automatized platform capable of receiving data from different pulses of a conventional laser focusing on a gain medium introduced with a certain scattering particle and then giving us a color map that indicates the correlation of any two wavelengths present in the emission spectrum, enabling us to analyze the dynamics of change of the correlation in the RL in the most diverse environments and consequently the developing of automatized sensors. For the experimental setup, we used a Q-switched Nd:YAG laser at a wavelength of 532 nm, with a frequency of 20 Hz and temporal width of 10 ns focalized in a gain medium of Rhodamine 6G doped with TiO_2 particles for photon scattering, the emission is captured by spectrometer that gives us the emission spectrum for each pulse of the laser.

References

[1] A L S Romero, Sistema experimental automatizado para estudos de Laser Aleatório em plataformas poliméricas flexíveis combinadas a biomateriais. Dissertation (Master's Degree) - Engineering School of São Carlos, University of São Paulo, São Carlos, 2023

[2] M Leonetti, C Conti and C Lopez, Nat. Photonics **5**, 615 (2011); DOI: 10.1038/nphoton.2011.217

[3] L F Sciuti, L A Mercante, D S Correa and L De Boni, J. Lumin. **224**, 117281 (2020); DOI: 10.1016/j.jlumin.2020.117281