

# PhD Thesis: SIMULATION AND OPTICAL CHARACTERIZATION OF RANDOM MEDIA WITH GAIN - 3D RANDOM LASERS

**Theme** Laser, Matter, Nanoscience - University of Bordeaux (France), Doctoral School of Physics and Engineering

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**Project Description** Random lasers are original and promising light emitters for applications such as displays or security. These systems are attracting an increasing interest among many industrial groups due to the demonstration of the phenomenon of stimulated emission of photons in low cost manufacturing environments.

A heterogeneous medium (such as a powder, a colloidal suspension, or biological tissues) diffuses light. Such highly scattering and randomized disordered media, when infiltrated with a gain medium and subjected to optical pumping, can give rise to amplified spontaneous emission and, under favourable conditions, stimulated emission by light amplification in the material. At a given fluence threshold, a lasing effect occurs, which is random in this case since the emission peaks depend on the local configuration of the portion of the material enlightened by the optical beam.

We have demonstrated in recent years that such materials doped with a suitable fluorescent organic dye can give rise to either a **random lasing** type of emission, or **stimulated Raman scattering**. A competition between these two nonlinear effects was also demonstrated in these materials. The physical origin of this competition and the appearance of the resulting effect are still poorly understood (quantified) at the present time.

We propose to the candidate to determine, using dedicated simulations, the optimal parameters allowing the appearance of one or the other of these effects. Based on these simulations, new materials will be synthesized in the laboratory. A second task is then to study the correlations between the physical and chemical characteristics (typical size and mono-dispersity of the pores, doping rate, typical size of the interconnection windows between pores, etc.) and optical properties (transport mean free path, emission characteristics, ...) of these new materials.

**Profile and skills required** The candidate will be trained as a physicist, with very good knowledge in optics, lasers physics and condensed-matter physics. He will be led to realize both simulations (theory) and optical characterizations (experiments). The enthusiasm he will put into achieving these two tasks will be decisive for the project. A good knowledge of English will be an asset, as well as good communication skills, among others with material chemists and physicists with who he will interact.

## Bibliographical references

- 1) "Photon transport in cylindrically-shaped disordered meso-macroporous materials", P. Gaikwad, S. Ungureanu, R. Backov, K. Vynck, and R. A. L. Vallée, *Opt. Express*, (2014) 22, 7503.
- 2) "Disorder as a Playground for the Coexistence of Optical Nonlinear Effects: Competition between Random Lasing and Stimulated Raman Scattering in Complex Porous Materials", N. Bachelard, P. Gaikwad, R. Backov, P. Sebbah, and R. A. L. Vallée, *ACS photonics*, (2014), 1, 1206.
- 3) "Scalability of transport parameters with pore sizes in isodense disordered media", S. W. Reginald, V. Schmitt, and R. A. L. Vallée, *Europhysics Lett.*, (2014), 107, 64003.
- 4) "Competition and Coexistence of Raman and Random Lasing in Silica-/Titania-Based Solid Foams", P. Gaikwad, N. Bachelard, P. Sebbah, R. Backov and R.A. L. Vallée, *Adv. Opt. Mater.*, (2015), 3, 1640.

