Universidade Federal da Paraíba
Centro de Ciências Exatas e da Natureza
Programa de Pós-Graduação *Stricto Sensu* em Física

Ciclo de Colóquios 2018.2

Colóquio nº 15

"Photonics in disordered media: Localization of light; Random lasing"

RESUMO: Disordered optical media have seen a growing interest in recent year due to their potential applications in solar collectors, random lasers, light confinement and other advanced photonic functions. Anderson localization is one of the most interesting phenomena in solid-state physics. Particularly, localization of light is an open research frontier which, besides being a fundamental topic it also could present significant applications. Optics seems an ideal framework to study localization and associated phenomena, due to non-interacting nature (seeming) of photons. In fact, various pioneering experiments that studied the transmission of electromagnetic waves through strongly disordered media have claimed the observation of Anderson localization of light. However, these works were questioned firstly by opponents and later refuted by their authors. The inelastic scattering processes (residual absorption or nonlinear phenomena) can lead to a decrease in the photon coherence length, hampering the interference effects (localization). In recent works, published at Nanoscale cover [1],[2] and photonics Research, [3],[4]reports several pieces of experimental evidence of localization of light in a colloidal suspension of core–shell nanoparticles (TiO2@Silica). We demonstrate the crossover from a diffusive transport to a localization transition regime as nanoparticle concentration is increased, and that a striking phenomenon of enhanced absorption arises at localization transition from which an enhancement of effective refractive index was proposed (enhancement light-mater interaction). A decrease of optical conductance and an

increase of absorption near the input border are reported when the incidence angle is increased. The specular reflection, measured for the photons that enter the sample, is considerably lower than the effective internal reflection undergone by the coherently backscattered photons in the exact opposite direction, indicating a non-reciprocal propagation of light (parity-symmetry breaking). A strong correlation in the scatterers position, due to particles interaction (repulsion) has been proposed as a precursor for enhancing interferences processes. This strongly disordered optical opens new avenues in the photonics field, ranging from the designing and manufacture of powerful sensing tools, random lasers [5] and other advanced photonic devices, to investigations into fundamental topics, such as the light quantum nature and other phenomena involving photon interactions. In a recent study about random lasing at localization, published at ACS Omega (Random lasing at localization transition in a colloidal suspension (TiO2@Silica)), we provided a novel approach in order to understand the complex physics involved in a random laser operating at the phase transition to localization. A very low random laser threshold was reached. A suppression of interaction between localized modes was observed, which becomes to this laser in a novel light source. In other work, also published at the cover of Part. Part. Syst. Charact.,[6] we have developed a new kind of ultra-efficient random laser (Polydispersed powders (Nd3+:YVO4) for ultra-efficient random lasers). In this study, gain and light diffusion were separately controlled, achieving a record random laser efficiency of 50%. The latter makes this laser competitive with conventional lasers.

[1] *Anderson Localization of light in a colloidal suspension (TiO_2@Silica)* E.. Jimenez-Villar *et al.* **Nanoscale 2016,** *8(21)***,** 10938-10946.

[1] *Core-shell TiO_2@Silica nanoparticles for light confinement.* E. Jimenez-Villar *et al.* **Materials Today: Proceedings 2017,** *4(11)* P. 2, 11570.

[1] *Anomalous transport of light at the phase transition to localization: Strong dependence with incident angle"* **E. Jimenez-Villar*** *et al.***, Photonics Research** *6(10)*, 929-942 **(2018)**

[1] *Localizatioin of light: Begining of a new optic"* E. Jimenez-Villar, *et al.* **Proc. SPIE** *10549*, Complex Light and Optical Forces XII; 1054905 **(2018)**.

[1] *Random lasing at localization transition in a colloidal suspension (TiO_2@Silica)"* E. Jimenez-Villar *et al.* **ACS Omega 2017,** *2*, 2415–2421.

[1] *Polydispersed powders* (Nd^{3+}:YVO_4) *for ultra efficient random lasers"* N. U. Wetter, J. M. Giehl, F. Butzbach, D. Anacleto, E. Jimenez-Villar. **Part. Part. Syst. Charact.** *35(4)*, 1700335 **(2018)**.

Prof. Dr. Ernesto Jimenez Villar

UFPB

14/dez/2018	16:00
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