

Resonance-driven random laser

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A random laser^{1,2} is a system formed by a random assembly of elastic scatters dispersed into an optical gain medium. The multiple scattering of light replaces the standard optical cavity of traditional lasers and the interplay between gain and scattering determines its unique properties.

All random lasers studied so far, consisted of irregularly shaped or polydisperse scatters, with some average scattering strength that is constant over the frequency window of the laser. We consider the case where the scattering is resonant. Our system, a photonic glass,³ can sustain scattering resonances over the gain frequency window,⁴ since it is formed by equal shape and equal size particles (monodisperse spheres) of relatively high refractive index contrast that are randomly assembled. The unique resonant scattering of this material allows, for the first time, to control the laser emission via the diameter of the particles and their refractive index. Our system is therefore a random laser with a-priori designed lasing peak within the gain curve⁵ (figure 1).

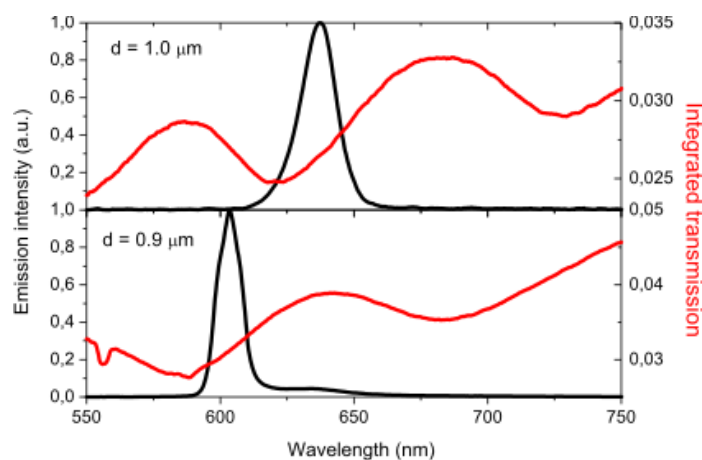


Figure 1. Emission intensity (black curves) and total transmission (red curves) for photonic glasses with $d = 0.9 \mu\text{m}$ and $1.0 \mu\text{m}$, respectively. Lasing occurs close to the transmission minimum.

¹ Letokhov, V.S. *Generation of light by a scattering medium with negative resonance absorption*. Sov. Phys. JETP **26**, 835, (1968).

² Lawandy, N. M., Balachandran, R. M., Gomes, A. S. L., & Sauvain, E. *Laser action in strongly scattering media*. Nature **368**, 436, (1994).

³ P. D. García, R. Sapienza, Á. Blanco and C. López, *Photonic glass: a novel random material for light* Adv. Mater. **19**, 2597, (2007).

⁴ R. Sapienza, P. D. García, J. Bertolotti, M. D. Martín, A. Blanco, L. Viña, C. López, D.S. Wiersma, *Observation of Resonant Behavior in the Energy Velocity of Diffused Light* Phys. Rev. Lett. **99**, 233902, (2007).

⁵ S. Gottardo, R. Sapienza, P. D. Garcia, A. Blanco, D. S. Wiersma and C. Lopez, *Resonance-driven random laser* Nature Photonics, **2**, 429, (2008).