RANDOM LASING AND NONLINEAR PHENOMENA IN DISORDERED MEDIA

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Abstract: In random lasers, light is confined within the gain medium by means of multiple scattering. We discuss the nature of the lasing modes in different regime of scattering, from systems where light is disorder-confined to weakly diffusive media, and for different degree of laser pumping. Recent experimental realizations are presented.

In conventional lasers, the optical cavity that confines the photons also determines essential characteristics of the lasing modes such as wavelength, emission pattern, directivity, and polarization. In random lasers, which do not have mirrors or a well-defined cavity, light is confined within the gain medium by means of multiple scattering. The sharp peaks in the emission spectra of semiconductor powders, first observed in 1999 [1,2], has therefore lead to an intense debate about the nature of the lasing modes in these so-called lasers with resonant feedback.

In this paper, we review numerical and theoretical studies aimed at clarifying the nature of the lasing modes in disordered scattering systems with gain [3]. We will discuss in particular the link between random laser modes near threshold (TLM) and the resonances or quasi-bound (QB) states of the passive system without gain. For random lasers in the localized regime, QB states and threshold lasing modes were found to be nearly identical within the scattering medium. These studies were later extended to the case of more lossy systems such as random systems in the diffusive regime where differences between quasi-bound states and lasing modes were measured.

New theoretical developments are however required to describe the multimode regime. Indeed, much above threshold, mode competition as well as nonlinear effects can lead to complex laser dynamics. We observe numerically new lasing peaks generated by four-wave-mixing as well as mode suppression in the steady state regime due to mode competition as the pumping rate is increased.

Finally, we present experimental realizations of random laser we are currently investigating. Low dimensional (1D or 2D) random active media are of particular interest in this context where the possibility to image the lasing modes provides with an experimental probe of the theoretical predictions. Beyond the fundamental questions addressed, the proposed random lasing devices lead to interesting and unexpected innovative devices.

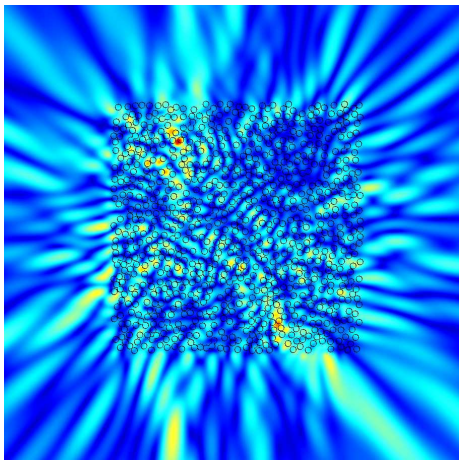

Figure 1 : Numerical simulation of random lasing just above threshold in a weakly diffusive scattering medium, constituted by a random collection of dielectric cylinders (black circles) of index 1.25 in a host matrix of index 1.

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