Selective Pumping of Localized States in a Disordered Active Medium

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Abstract: Light can be trapped in strongly scattering medium by multiple scattering events, leading to the formation of localized modes [1]. When gain is added to scattering medium, localized resonances become lasing modes [2]. In a strongly scattering disorder medium, lasing modes has one to one correspondence with localized modes of the passive system [3, 4]. Previously non-uniform pumping has been proposed and demonstrated to control laser characteristic such as spectral control[5,6], power efficiency[7], emission directionality[8,9], threshold, frequency[10] and mode interactions[11,12,13]. Recently we shows numerically [14] and experimentally [15], partial pumping can excite individual lasing modes in a disorder gain medium. In this work, we demonstrate that partial pumping of random laser can provide a new path to study localization phenomenon. Effect of nonlinearities on localization phenomenon is still an unsolved problem. Numerical simulations based on tight-binding model revealed that Kerr-type nonlinearity strongly affect localization and leads to sub-diffusive transport. Experimental attempt by Schwartz [16] and Lahini [17] showed that localization is enhanced under self-focusing nonlinearity. To the best of our knowledge, we did not find any theoretical and experimental study, which shows the effect of gain-saturation on localization phenomenon.

Actively controlled multimode random lasing in strongly scattering disorder random media provides an ideal testbed to study Anderson localized modes in presence of nonlinearities. We show that, how real time spatial shaping of the pump profile imposed on a strongly scattering gain medium can be used to achieve single mode lasing at pre-selected target wavelength. Simultaneously, near field imaging of the sample surface from the top allow us to record field distribution of the target mode inside the sample. We show that slope efficiency of Anderson localized lasing mode enhanced by one order magnitude under selective pumping. We further study robustness of localized mode by varying the size and shape of spatial pump profile and conclude that lasing modes are localized modes of the passive system. We found that lasing wavelength and spatial field profile of localized lasing modes are not affected by the presence of gain and nonlinearities. This demonstrates that Anderson localized modes are not affected by the presence of gain saturation.

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