Probing mode connectivity in photonics using two classical or quantum nanosources

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Probing unambiguously the transition from diffusion to localization of light in multiple scattering media remains an open issue. We introduce the mode connectivity, an observable defined from the cross and local densities of states [1], as a measure of the number of eigenmodes connecting two points at a given frequency in a structured environment. An important feature of the connectivity is that it takes a value 1 when the two observation points are connected by exactly one mode, and vanishes in the absence of modes connecting the observation points. In a disordered medium, this property can be used to discriminate between diffusive transport or localization. Indeed, in the diffusive regime, the eigenmodes overlap both in frequency and space. At a given frequency, eigenmodes are spatially extended, and any point in the medium is covered by a large number of modes. Conversely, in the localized regime, at a given point and for a given frequency, no more than one mode has a non-negligible contribution. In this work, we support this qualitative picture is by numerical simulations of light scattering in two dimensions, and show that the connectivity discriminates between the diffusive and the localized regime. For practical implementation, a strategy could rely on the measurement of intensity fluctuations in the emission by two nanosources placed inside the medium (or close to its surface). For both classical dipole emitters [2] and quantum single-photon sources [3], we show that the connectivity is encoded in the second-order coherence of the emitted light, providing clear signatures of the presence of localized modes (Fig. 1) [4].

References

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Figures

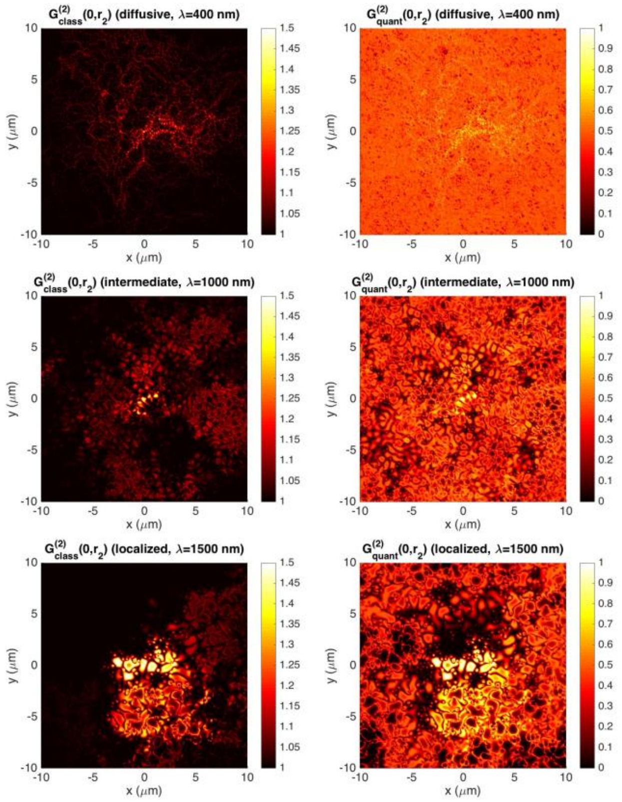

Figure 1: Calculated maps of the second-order coherence function $G^{(2)}$ of the light emitted by a dipole source placed at the center of a 2D disordered medium, while the second source is scanned inside the medium. Left column: Classical dipole sources. Right column: Quantum single-photon sources. Top row: Diffusive regime. Middle row: Intermediate regime. Bottom row: Localized regime.