Spontaneous emission of light in complex media:
Probing disorder with dipole emitters and *vice versa*

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Randomly or periodically structured materials strongly influence spontaneous emission of light by dipole emitters (molecules, quantum dots). Modifications of the spontaneous decay rate can be understood from changes in the local density of photonic states (LDOS). We will discuss the behavior of the decay rate of a single dipole emitter inside a disordered scattering medium, in view of imaging applications (the emitter probes the surrounding medium) or in view of the design of photonic materials with unconventional properties (the medium controls the spontaneous emission dynamics).

In the nanoscopic regime, in which the interaction between the emitter and the scatterers is domintaed by near fields, we show that the decay rate exhibits substantial fluctuations. These fluctuations are highly sensitive to the scattering and absorption properties of the environment at the local scale, and to the correlation of disorder. This suggests that decay rate (or fluorescence lifetime) fluctuations can be used as an efficient local probe in a complex medium or material.

In the multiple scattering regime, we also show that the probability of observing a decrease of the decay rate is substantial. It originates from a reduction of the LDOS due to collective interactions and interferences. In the strong scattering regime, signatures of recurrent scattering are visible in the behavior of the averaged decay rate. Finally, we show that a fundamental relationship exists between the averaged LDOS and the extinction mean free path, both quantities being connected by dispersion relations and a frequency sum rule. These results suggest novel approaches in the analysis of wave transport through complex media and in the design of photonic materials with specific transport properties.

Related references

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