

Statistical mechanics of spatial beam cleaning in nonlinear multimode optical fibers

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The spontaneous power-induced transformation of the transverse intensity profile at the output of graded-index multimode optical fibers from speckles into a bell-shaped beam sitting on a low intensity background is known as spatial beam self-cleaning. Its remarkable properties are the output beam brightness improvement and robustness to fiber bending and squeezing. These properties permit to overcome the limitation of multimode fibers in terms of low output beam quality, making them very promising for a host of technological applications where high-energy pulses should be transported. In this talk, we overview recent progress in the characterization and modeling of spatial beam self-cleaning, which can be seen as a state of thermal equilibrium for the mode population, emerging from complex modal four-wave mixing processes. In other words, the associated nonlinear redistribution of the mode powers which typically favors the fundamental mode of the fiber can be described in the framework of statistical mechanics applied to the gas of photons populating the fiber modes. This description has been corroborated by a series of independent experiments by different groups around the world. However, several open issues remain which are unexplained by the thermodynamic approach, such as the phase-sensitivity of the beam cleaning effect, that is associated with the preservation of the spatial coherence of the beam even after its cleanup. Moreover, new variants of spatial beam cleaning have recently been observed, where for example the output mode distribution spontaneously evolves towards the highest-order guided mode of the fiber. Ultimately, we would like to offer our perspectives for future studies in this emerging and controversial field of research.

