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Optical Sensing with Structured Wavefronts

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Tailoring the properties of light opens up new opportunities for both sensing and manipulating matter. In many cases, however, the effectiveness is limited because the exquisite phase and polarization properties degrade when light interacts with random material systems. Even though they were expected to be less sensitive to distortions, fields carrying orbital momenta are also altered upon propagation, for instance, through inhomogeneous media. This problem was recognized for a long time but, so far, it has been tackled only qualitatively in a more or less heuristic fashion.

We will describe how this phenomenology can be placed on a rigorous physical basis. A fundamental statistical relationship between local properties and global descriptors of perturbed vortex fields establishes the limits over which such beams maintain the memory of their initial state.

We will illustrate how, based on understanding the evolution of statistical properties, one can tackle novel, optimized applications and develop new sensing protocols. We will also demonstrate how robustness against disorder can be a valuable attribute for optical sensing in material sciences and biology applications.