$\mathcal{P}\cdot\mathcal{T}\cdot\mathcal{D}$ Symmetric Metasurfaces

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Recently, there has been considerable interest in the research of novel paradigms that enable a wave-guiding more immune to the undesired effects of reflections due to disorder, imperfections, obstacles or deformations of the propagation path. In particular, topological systems have received considerable attention both in the engineering and physics communities, and it has been shown that topological photonic materials may enable the realization of novel edge-type waveguides that support topologically protected unidirectional edge states immune to backscattering.

In a recent work [M. G. Silveirinha, Phys. Rev. B, 95, 035153 (2017)] an alternative path was put forward, which does not directly rely on topological concepts but rather on *symmetry*. Specifically, based on an analogy with electronics it was shown that when a generic photonic waveguide is invariant under the combined action of the operators parity ($\mathcal{P}$), time-reversal ($\mathcal{T}$) and duality ($\mathcal{D}$) it may be possible, under some conditions, to have *bi-directional* light propagation totally insensitive to the specific shape of the propagation path and robust to a particular class of defects. Remarkably, such a solution does not require any mechanism to break the time-reversal symmetry, and hence the $\mathcal{P}\cdot\mathcal{T}\cdot\mathcal{D}$ symmetric photonic platforms may be formed only by reciprocal media.

Building on these ideas, in this talk we develop the novel concept of $\mathcal{P}\cdot\mathcal{T}\cdot\mathcal{D}$ symmetric metasurfaces. We present the detailed conditions under which a given non-uniform metasurface stays invariant under a $\mathcal{P}\cdot\mathcal{T}\cdot\mathcal{D}$ transformation. We propose novel "edge-type" guides formed by the junction of two metasurfaces, showing that in some scenarios it is possible to have bi-directional propagation along the metasurface edge highly robust to any form of scattering.