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Unidirectional Reflectionless Transmission of Light with and without PT Symmetry

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Generically the only time-independent solutions to open electromagnetic problems are scattering states, consisting of an input wave and a scattered wave, which typically contains flux in all physically accessible channels. If restrictions are placed on which scattering channels may contain outgoing flux, in general no solutions exist. However, in certain circumstances such solutions may exist at discrete frequencies. Familiar examples are resonances of 1D scattering structures at discrete real frequencies for which there is no reflected wave. Generically, both parity symmetry and hermitian symmetry are required in order for such steady-state resonances to exist, which then exist simultaneously for both left-going and right-going inputs. Recently both theory and experiment on PT-symmetric electromagnetic scattering structures have revealed that they can support unidirectional resonances of this type, reflectionless from one input direction, but not from the other.
We have recently shown that this behavior generalizes beyond one dimension, by considering scattering structures with an arbitrary number of scattering channels in any dimension. If one divides the input-output channels into two sets and imposes zero reflection on one set and purely outgoing boundary conditions on the complementary set, this defines a well-posed electromagnetic eigenvalue problem with a countably infinite number of solutions at discrete complex frequencies. If the wave equation is non-hermitian, but has PT-symmetry, then these solutions occur on the real axis and represent steady-state physical solutions (up to some PT-symmetry breaking transition). This statement holds even if the scattering system is not naturally divided into left and right spatial channels.
If the system doesn't have Hermitian and Parity symmetry or PT-symmetry, then generically these reflectionless solutions do not occur for real frequencies, but can be engineered to reach the real axis by adding gain or loss to the system or by tuning geometric parameters of the scattering structure. This opens up exciting new possibilities for designing structures which allow perfect impedance matching or mode conversion of electromagnetic waves at specific resonance frequencies. We have developed codes to find such structures and will present examples in this talk.

Content of the contribution

Theory

Primary authors: Prof. STONE, A. Douglas (Yale University, Dept of Applied Physics); Dr SWEENEY, William R. (Yale University, Dept of Physics); Dr HSU, ChiaWei (Yale University, Dept of Applied Physics)

Presenter: Prof. STONE, A. Douglas (Yale University, Dept of Applied Physics)

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