Virtual Absorption and Gain Through Excitation at Complex Frequencies

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Exploiting the properties of the Fourier transform, in electromagnetics we are well versed to study the electromagnetic response of linear, time-invariant systems by expanding the excitation fields in the frequency domain. As such, we analyze the response of the system under study using a superposition of monochromatic excitations. In this context, it may be curious to explore how the response of a structure is modified when it is excited at complex frequencies. Since complex frequency excitations are generally not bounded, the usual properties of linear time-invariant systems do not hold, for instance a lossless structure can mimic full absorption when excited with an exponentially decaying excitation oscillating at the complex frequency corresponding to one of the zeros of its scattering matrix.

Conversely, by exciting a suitably tailored structure with an exponentially growing signal oscillating at a complex frequency corresponding to a pole of the scattering matrix it is possible to mimic gain, which may compensate the loss in the system, and enable reflection and transmission coefficients larger than unity. As I will show in my talk, these properties are not just mathematical curiosities, but may have a direct impact in several practical devices, for instance enhancing wireless power transfer, creating energy storage and memory devices, and enabling the unusual features of parity-time symmetric systems without the need of gain and loss.

In this talk, I will discuss the unusual electromagnetic properties of virtual absorption, gain and parity-time symmetry enabled by excitation of tailored resonators and metamaterials with non-monochromatic excitations oscillating at complex frequencies. I will provide physical insights for their counterintuitive responses, and discuss their implications for novel devices to tailor exotic electromagnetic and mechanical responses in a variety of platforms and implementations.