Spectral Singularities in Cylindrical Non-Hermitian Structures

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In electromagnetics and optical engineering, the use of *active* (gain) material constituents is typically exploited as a device to compensate for the unavoidable dissipation effects, and/or to attain signal amplification. Nevertheless, the combination of spatially modulated gain and loss can yield much more intriguing effects. Within this framework, originally inspired by the concept of *parity-time symmetry* in quantum physics (C. M. Bender and S. Boettcher, Phys. Rev. Lett., 80, 5243-5246, 1998), the possibility to mix optical gain and losses in unconventional ways has given rise to a new, emerging discipline typically referred to as *non-Hermitian optics* (L. Feng, R. El-Ganainy, and L. Ge, Nat. Photonics, 11, 752-762, 2017).

With only few exceptions, most studies of non-Hermitian optical structures deal with Cartesian geometries. Here, we consider cylindrical non-Hermitian structures, and focus our attention on the so-called “spectral singularities”, intended as *real-frequency* poles of the scattering coefficients in a Mie-type series expansion. It is well known that such resonances are not attainable in lossless or lossy scenarios, but can be exhibited by simple structures such as a homogeneous cylinder with optical gain embedded in a lossless medium (M. Kerker, Appl. Opt. 18, 1180-1189, 1979; A. Mostafazadeh and M. Sarısaman, Phys. Rev. A, 87, 063834 2013).

In our study, we revisit this concept in a more general framework, featuring non-Hermitian core-shell geometries or cylindrical metasurfaces. In particular, we show that implied additional degrees of freedom allow a fine tailoring of such resonant phenomena, so as to engineer exotic scattering responses. For example, it is possible to simultaneously attain the conditions of zero forward and backward scattering, and to control in a broader fashion the scattering and extinction efficiencies.