PT-Symmetric Leaky-Wave Metasurfaces

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Highly directive antennas have been studied for many decades because of its numerous applications in beam-steering, beam-forming and microwave imaging, to name a few. Typically, leaky-wave antennas are based on slotted waveguide structures and transmission lines with periodic grids, which can excite fast leakage waves that continuously radiate electromagnetic energy into free space. By engineering the complex wavenumber dispersion, the directional beam can be swept by varying the carrier frequency or by tuning the effective phase constant or periodicity of radiative apertures. Recently, leaky waves excited in metamaterial structures, such as the ε-near-zero (ENZ) artificial medium have been proposed to achieve the leaky-wave antenna applications with enhanced frequency agility and directivity. However, there are still several limitations associated with the fabrication complexity of bulky metamaterials and the resonant absorption in the ENZ frequency band.

In this talk, we will present a new type of leaky-wave structure based on the parity-time (PT)-symmetric metasurfaces, which may ease the implementation and provide more directive radiation patterns. The proposed leaky-wave structure comprises a pair of active and passive metasurfaces with balanced gain and loss, satisfying the PT-symmetry condition. By varying the effective non-Hermiticity (or gain-loss parameter) of such system, namely tuning surface resistances of metasurfaces, we observe the PT phase transitions that give different guided-wave and leaky-wave properties. In this talk, we will analyze in detail the modal transitions and the optimal operation conditions for the leaky-wave antenna. Further, we will present a practical infrared leaky-wave antenna based on the PT-symmetric metasurfaces, of which gain and loss are sourced from the patterned population-inverted graphene and the resistive metal film/microstructure. We will also propose potential applications of such PT-symmetric metasurfaces in making infrared antennas, beamformers, and sensors.