New Paradigm in Coherent Radiating Oscillators Based on Waveguides With Exceptional Points of Degeneracy

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Electromagnetic guiding structures or resonators are described by their evolution equations in terms of the eigenstates (eigenvalues and eigenvectors). Evolution of waves in periodic structures may encounter some peculiar characteristics related to unique dispersion properties. Among many features of the evolution of these eigenstates, we explore the conditions in the parameter space of such system at which eigenwaves coalesce into a single degenerate eigenwave. Here, we present a novel paradigm and a unified theory for realizing coherent radiating array oscillators based on exceptional point of degeneracy (EPD). An EPD is associated with a coalescence of four eigenwaves into one degenerate eigenwave in engineered guided waves structures leading to unique wave propagation properties. We experimentally verify the existence of the EPD for the first time through dispersion and transmission measurements in microstrip-based coupled transmission lines (CTLs) at microwave frequencies.

Coherent radiation from power efficient sources at microwaves and mm-wave frequencies is an essential feature that is required for various applications. We report that the EPD features are still measurable in radiating structures based on experimental observation even in the presence of fabrication tolerances. We show that gain and loss balance in a CTL, up to a desired threshold lead to recovering the EPD and therefore ensuring the capability of utilizing the radiating scheme in designing array oscillators. The EPD based radiating antenna array oscillator demonstrates unique properties and unprecedented scaling of its threshold that could be used in various devices requiring coherent emission. Our technique also promises high efficiently and low phase noise, and can provide a unique framework for various applications also at mm-wave and THz frequencies.