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Limit cycles and resonances in asymmetric laser dimers: New oscillatory phenomena in photonic arrays

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Abstract: Coupled semiconductor laser dimers possess fascinating dynamics with numerous applications in photonics. In this lecture, we first review our results on the existence and stability of asymmetric phase-locked states of the fundamental dimer consisting of two coupled semiconductor lasers with carrier density dynamics. We show that stable phase-locked states of arbitrary asymmetry exist whose field amplitude ratio and phase difference can be dynamically controlled by appropriate current injection. We emphasize the importance of Exceptional Points, with large stability domains and Hopf bifurcations, beyond which small-signal modulations allow for the onset of resonances and anti-resonances at surprisingly high frequencies. We obtain limit cycles with frequencies ranging from a few to more than 100 GHz that can be controlled via differential pumping and optical frequency detuning between the two lasers. Finally, we describe our recent findings on optically coupled arrays of externally driven dimers, with radically complex dynamics that may prove useful for numerous applications in beam forming and beam shaping. We find that very small localized oscillations can coexist with large amplitude variations that are robust under time evolution and can be dynamically controlled by appropriate gain values and pumping rates.

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