Lasing in perfect and disordered photonic quasi-crystals

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Photonic quasi-crystals are artificial dielectric inhomogeneous media, where scattering centers are located in the vertices of a quasi-periodic tiling of space. The eigenstates of quasi-crystals are critical: they are neither singular nor continuous. The criticality of the eigenstates of quasi-periodic structures has a major implication on light propagation and emission processes. Photonic quasi-crystals are unique optical materials, which can support both localized and extended standing waves in a defect-free lattice. That puts quasi-crystals by their optical properties between perfect periodic and strongly disordered materials. A laser is generally comprised of two components, a laser active medium, in which level population inversion can be achieved by pumping, and an optical element (resonator, periodic lattice, etc.), which provides necessary feedback to stimulate emission. Both localized and extended standing eigenstates can provide a necessary feedback to achieve lasing in a defect-free quasi-crystal. In this contribution, we study lasing action in perfect and disordered octagonal photonic quasi-crystal. An influence of transition from a perfect quasi-periodic structure to a disordered one on lasing properties is systematically addressed. Numerical calculations are performed using finite-difference time-domain method. Active media is modeled by the semi-classical laser equations. Because such a model couples electronic number equations at different levels with field equations, the amplification is non-linear and saturated, so stable state solution can be obtained after a long relaxation time.