Coherent Perfect Absorption and Lasing in "Energy-Balanced" Zero-Index Media

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We investigate a unique type of "energy-balanced" zero-index media. The effective permittivity and permeability of such media are purely imaginary with opposite signs, indicating coexistence and balance of loss and gain. We show that such media can support non-evanescent propagation, coherent perfect absorption (CPA) and lasing under different circumstances. Especially, when the permittivity and permeability have the same modulus, the so-called "CPA laser", previously proposed in parity-time (PT) symmetric systems, is realized which can switch from total absorption to lasing by tuning the coherence of incident waves. By designing a photonic crystal composed of core-shell rods with loss in cores and gain in shells, we have numerically demonstrated such an "energy-balanced" zero-index medium as well as its unique functionality as a CPA laser. Our work reveals unique and intriguing characteristics induced by balanced gain and loss in different physical parameters of media.