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Giant gain enhancement in photonic crystals with a degenerate band edge

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We propose a new approach leading to giant gain enhancement. It is based on unconventional slow-wave resonance associated with a degenerate band edge (DBE) in the dispersion diagram for a special class of photonic crystals supporting four modes at each frequency. We show that the gain enhancement in a Fabry-Pérot cavity (FPC) when operating at the DBE is several orders of magnitude stronger when compared to a cavity of the same length made of a standard photonic crystal with a regular band edge (RBE). The giant gain condition is explained by a significant increase in the photon lifetime and in the local density of states. We have demonstrated the existence of DBE operated special cavities that provide for superior gain conditions for solid-state lasers, quantum cascade lasers, traveling wave tubes, and distributed solid-state amplifiers. We also report the possibility to achieve low-threshold lasing in FPC with DBE compared to RBE-based lasers.

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