Effect of Multi-Resonance Subband Structure on the Kerr Non-linearity of Quantum-Cascade Lasers

JING BAI, University of Minnesota Duluth — This work focuses on the investigation of the optical Kerr lensing effect in quantum-cascade lasers with multiple resonance levels. The Kerr refractive index $n_2$ is obtained through the third-order susceptibility at the fundamental frequency $\chi^{(3)}(\omega)$. Resonant two-photon processes are found to have almost equal contributions to $\chi^{(3)}(\omega)$ as the single-photon processes, which result in the predicted enhancement of the positive $n_2$, and thus may enhance mode-locking of quantum-cascade lasers. Moreover, an isospectral optimization strategy for further improving $n_2$ through the band-structure design is also demonstrated, in order to boost the multimode performance of quantum-cascade lasers. Simulation results show that the optimized stepwise multiple-quantum-well structure has a twofold enhancement on $n_2$ over the original flat quantum-well structure. This leads to a refractive-index change $\Delta n$ of about 0.01, which is at the upper bound of those reported for typical Kerr medium. This stronger Kerr refractive index may be important for quantum-cascade lasers ultimately to demonstrate self-mode-locking.