Chemical Engineering Master's Defense

Surface Plasmon-polariton Enhanced Lasing: Numerical Studies

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abstract

The study of subwavelength behavior of light and nanoscale lasing has broad potential applications in various forms of computation i.e. optical and quantum, as well as in energy engineering. Although this field has been under active research, there has been little work done on describing the behaviors of threshold and saturation. Particularly, how the gain-molecule behavior affects the lasing behavior has yet to be investigated.

In this work, the interaction of surface-plasmon-polaritons (SPPs) and molecules is observed in lasing. Various phenomenologies are observed related to the appearance of the threshold and saturation regions. The lasing profile, as a visual delimiter of lasing threshold and saturation, is introduced and used to study various parametrical dependencies of lasing, including the number-density of molecules, the molecular thickness and the frequency detuning between the molecular transition frequency and the SPP resonant frequency. The molecular population distributions are studied in terminal and dynamical methods and are found to contain unexpected and theoretically challenging properties. Using an average dynamical analysis, the simulated spontaneous emission cascade can be clearly seen.

Finally, theoretical derivations of simple 1D strands of dipoles are presented in both the exact and mean-field approximation, within the density matrix formalism. Some preliminary findings are presented, detailing the observed behaviors of some simple systems.

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