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标题: Coherent Amplification and Noise in Gain-Enhanced Nanoplasmonic Metamaterials: A Maxwell-Bloch Langevin Approach
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摘要: Nanoplasmonic metamaterials are an exciting new class of engineered media that promise a range of important applications, such as subwavelength focusing, cloaking, and slowing/stopping of light. At optical frequencies, using gain to overcome potentially not insignificant losses has recently emerged as a viable solution to ultra-low-loss operation that may lead to next-generation active metamaterials. Maxwell-Bloch models for active nanoplasmonic metamaterials are able to describe the coherent spatiotemporal and nonlinear gain-plasmon dynamics. Here, we extend the Maxwell-Bloch theory to a Maxwell-Bloch Langevin approach a spatially resolved model that describes the light field and noise dynamics in gain-enhanced nanoplasmonic structures. Using the example of an optically pumped nanofishnet metamaterial with an embedded laser dye (four-level) medium exhibiting a negative refractive index, we demonstrate the transition from loss-compensation to amplification and to nanolasing. We observe ultrafast relaxation oscillations of the bright negative-index mode with frequencies just below the THz regime. The influence of noise on mode competition and the onset and magnitude of the relaxation oscillations is elucidated, and the dynamics and spectra of the emitted light indicate that coherent amplification and lasing are maintained even in the presence of noise and amplified spontaneous emission.
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