NONLINEAR DYNAMICS OF DIPOLARITONIC OPTICAL PARAMETRIC OSCILLATOR

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Mixed exciton–photon states in planar semiconductor microcavities with quantum wells in the active layer belong to a new class of quasi two dimensional states with unique properties. They arise due to a strong coupling of excitons with eigenmodes of electromagnetic radiation of a microcavity, as a result of which upper and lower exciton–polariton microcavity modes are formed. Large interest is drawn to polariton–polariton scattering, due to which the exciton–polariton system demonstrates strongly nonlinear properties. Along with exciton–polaritons, a new bosonic quasi-particle (dipolariton), is formed in coupled double quantum wells (QWs) in a microcavity and was observed for the first time in [1]. In comparison with an exciton–polariton, a dipolariton is a superposition of microcavity photon and direct and indirect excitons. Here, the direct exciton is a bound state of a pair of electron and hole from the same well, and the indirect exciton is formed by coupling an electron and a hole from neighboring wells. The coupling of microcavity photon with direct and indirect excitons leads to the formation of eigenmodes of the system with three dispersion branches: lower, intermediate, and upper dipolariton branches [2]. Due to the large dipole moment of dipolariton, the latter has been proposed as an ideal quasi-particle for generating THz radiation. However, despite the significant progress in the experimental study of dipolaritons, rigorous theoretical consideration of their physical properties is absent. Therefore, further studies in this field are urgent.

We report the results of investigation of the dynamics of dipolariton excitations in the parametric oscillator mode for the times shorter than the excitation relaxation time. The behavior of dipolaritons in the time-dependent mode, when pumping is performed by a femtosecond laser pulse, is of great interest. In this case, one can assume that ultrashort excitation pulses serve only to form initial densities of dipolaritons. Then the system is left on its own and evolves in time. We believe ultrashort pulses of resonant laser radiation to form a system of coherent dipolaritons in a microcavity. The microcavity spatially limits the domain of existence of dipolaritons. A QW is inserted in a Bragg structure, which is characterized by certain transmittance, reflectance, and loss. Specific features of the evolution of the system will manifest themselves in the generation of secondary subpulses.

We will consider the situation in which dipolaritons with a high density are excited on the intermediate dispersion relation branch by a high-power laser pulse (pumping). As a result, parametric conversion of pump dipolaritons and generation of signal and idler dipolaritons occur. There are two conversion channels in this case [3]. One of them is the conversion of a pair of pump dipolaritons into a signal dipolariton on the lower branch and an idler dipolariton on the upper branch. The other channel is conversion of a pair of pump dipolaritons into signal and idler dipolaritons on the intermediate branch. Both conversion channels satisfy the laws of conservation of energy and momentum .

The above results indicate that pumping of the intermediate branch of the dipolariton dispersion relation under exact resonance conditions results in only aperiodic irreversible complete conversion of pump dipolaritons into idler and signal dipolaritons.

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