properties could recently be understood within the framework of a non-equilibrium model of photons in terms of a steady state solution [2,3]. Here we utilize this non-equilibrium model in order to study in detail the stationary photon distribution in the respective modes of the dye-filled cavity. It turns out that, depending on the dye pumping rate and the cavity decay rate, different modes become macroscopically occupied. In particular, we present the corresponding phase diagrams and describe the transitions between the phases analytically. Using a linear stability analysis we demonstrate that the stationary states are always unconditionally stable. Finally, we examine how the relaxation times toward equilibrium depend on the respective system parameters and compare them with the thermalization times obtained experimentally from the corresponding transient dynamics [4].

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Modeling of Light Emitters Based on Nitride Quantum Dots and Nanowires

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Nanostructures based on III-nitride semiconductors offer certain advantages for realization of single-photon sources and classical light emitters. Larger band offsets and effective masses lead to strong quantum-confinement effects which enable the operation of devices at higher temperatures. Wide band gap of III-nitrides leads to the emission in the blue and ultraviolet spectral range, which is not accessible with most of the other materials. In this work, simulation insights into the light emitting properties of III-nitride quantum dots and nanowires will be presented.

We performed the calculations of excitonic and biexcitonic states in self-assembled GaN/AlN quantum dots with special emphasis on the use of these dots for single-photon source applications [1]. Theoretical methodology for calculation of single-particle states was based on 8-band strain-dependent envelope function Hamiltonian, with the effects of spin-orbit interaction, crystal-field splitting, and piezoelectric and spontaneous polarizations taken into account. Exciton and biexciton states were found using the configuration-interaction method. Optimal dot heights for their use in single-photon emitters were determined for various diameter-to-height ratios.

Next, we investigated the electronic properties of InGaN quantum structures embedded in site controlled GaN nanowires [2]. The InGaN structures under consideration consist of two sections: the middle one, which is formed on the polar c-facet, and the side one, which is formed on the semi-polar r-facets. These structures exhibit two-color emission at 384 nm and 488 nm. We identified that the main origin of two-color emission is higher In incorporation on the nanowire polar c-facet, while the influences of internal electric field and strain are less significant.

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Bounded dark-state polaritons in atom-cavity arrays

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The investigation of coupled atom-cavity systems, known as Jayne's-Cummings Hubbard (JCH) lattices, provides insight in the behaviour of strongly interacting photons and polaritons. Strongly interacting polaritons in JCH lattices possess some of the features typically present in strongly correlated condensed-matter systems, among them Mott-insulator to super-fluid quantum phase transition [1]. In case of two excitations in the JCH lattice, two-polariton bound states may be possible [2].

We theoretically investigate the nature of eigenstates in the two-excitation subspace of an array of coupled cavities, where each contains a three-level atom in a Λ-configuration. One of the atomic transitions is driven by an external classical field, while another is influenced by a far off-resonant cavity mode field. The two fields are in two-photon Raman resonance. Atom-cavity coupling leads to the formation of three bands, whose width increases with inter-cavity hopping. In addition, we find two bounded dark-state polaritons (BDSPs). Since the energies of the BDSPs lie within the band gaps, we show that due to the presence of BDSPs the system behaves as an extrinsic semiconductor with them as dopants. Without inter-cavity hopping, analytical expressions for two band gaps are provided. It shows that the size of band gaps can be tuned by the Rabi-frequency of the classical field and the common detuning from the respective atomic transitions. In the presence of hopping, three regimes are identified with respect to the Rabi-frequency where the system behaves either as a semiconductor or as a conductor. In case of semiconducting behaviour, we have determined critical effective atom-cavity coupling strength above which one or both gaps vanish.

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