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Intersubband Antipolaritons

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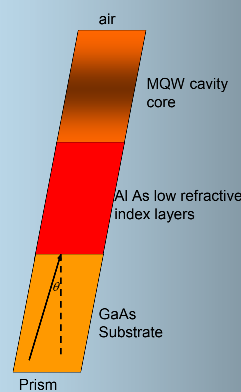
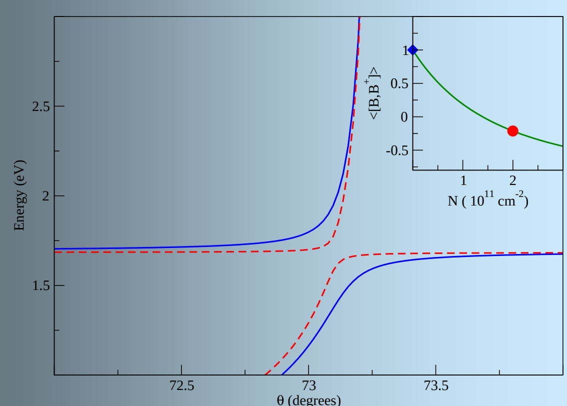
$$\hbar\omega_{\pm} = \sqrt{\frac{1+\Omega_c^2 - x^2 \pm \sqrt{\left(1+\Omega_c^2 - x^2\right)^2 + 4\left(2\lambda\Delta x^2 - \Omega_c^2\right)\left(1-x^2\right)}}{2\left(1-x^2\right)}}$$

$$\Delta_{\mu\nu} = \frac{4\pi}{L_w}\left|ed_{\mu\nu}\right|^2 \delta n_{\mu\nu} \sin^2\theta_b$$

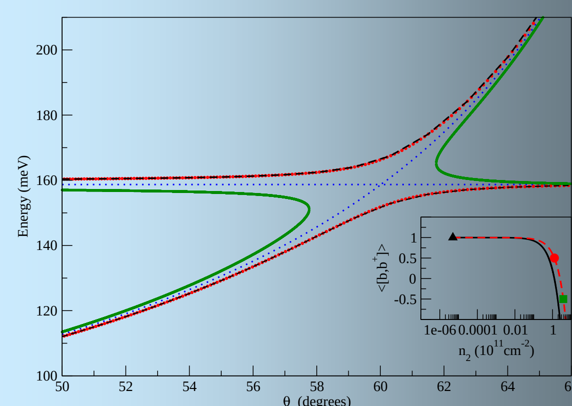
$$\hbar\omega_0 = \Delta E_{\mu\nu} + \delta e_{\mu\nu}, \omega_c^2 = \frac{c^2\pi^2}{\varepsilon_b L_c^2}$$

$$\Omega_c = \frac{\omega_c}{\omega_0}, \Delta = \frac{\Delta_{\mu\nu}}{\hbar\omega_0}, x^2 = \frac{\varepsilon_1}{\varepsilon_b}\sin^2\theta$$





Microcavity light-hole interband (exciton-) polariton with TM polarization dispersion as function of incidence defined in Fig. 1. The solid (blue) lines are for a pump-generated density N=0 and the dashed (red) curves are for N=2.51011 cm-2. The inset displays the commutator of the exciton operator as a function of injected carrier density. The diamond (blue) and circle (red) symbols correspond, respectively, to the commutator for the solid and dashed dispersions in the main part of the plot.



Intersubband antipolariton dispersion relations of a 2.9 μm microresonator with GaAs/AlGaAs quantum wells as active media as a function of incidence angle. The inset depicts the bright intersubband operator commutator as a function of upper subband occupation. The thin dotted lines are the zero density cavity photon and intersubband transition dispersions shown here for reference. The overlapping dashed (black) and dotted (red) curves were calculated with a population difference of $\delta n_{12}=2.5\times10^{11}$ cm^{-2}, thus yielding the same dispersion. However, the carriers are injected in different ratios. The upper and lower subband densities are given, respectively for the dashed (red) and dotted curves by $(n_1,n_2)=(2.500005,0.000005)$ and $(3.75,1.25)$. They correspond, respectively, to the triangle and circle in the inset, where the solid (black) and dashed (red) curves correspond to total carrier densities $n_1+n_2=2{,}5\times10^{11}$ and 5.0×10^{11} cm^{-2}. The solid (green) dispersions (unstable branches) were calculated with $\delta n_{12}=-2.5\times10^{11}$ cm^{-2}, and the corresponding value of the commutator is marked by the square in the inset.

The microscopic Keldysh Green's functions formalism of Ref. [1] leads to analytical expressions for the quasi-particle dispersion including many body effects under nonequilibrium conditions. It consistently reproduces dispersion relations found experimentally if light is absorbed due to intersubband transitions [2-3] and yields unique features not found in the literature so far:

➢ Anomalous dispersions under population inversion conditions that cannot be described a Hamiltonian theory based on bosonic approximations are predicted.

➢The limit of validity of the conventional polariton as a bosonic quasi-particle concept is demonstrated numerically for the intersubband case and a simple recipe to control bosonic effects and turn them on and off by selective excitation of the subbands is presented.

➢The influence of the dominating many body corrections on the dispersion of both passive (absorption) and active (inverted gain media) are explained.

References:

[1] M.F. Pereira Jr., Phys. Rev. B 75, 195301 (2007).

[2] D.Dini, R.Köller, A.Tredicucci, G.Biasiol, and L.Sorba, Phys.Rev.Lett. 90, 116401 (2003).

[3] A.A.Anappara, A.Tredicucci, G.Biasol and L.Sorba, Appl.Phys.Lett. 87, 051105 (2005).