Exciton Polaritons In Resonant Bragg Gratings

F. Biancalana[1] , L. Mouchliadis[2*], C. Creatore[3], S. Osborne[4] and W. Langbein[2]

[1] *Max Planck Institute for the Science of Light, 91058 Erlangen, Germany*
[2] *School of Physics and Astronomy, Cardiff University, Cardiff, United Kingdom*
[3] *Department of Physics "A. Volta", Universita degli Studi di Pavia, I-27100 Pavia, Italy*
[4] *Tyndall Institute "Lee Maltings", Prospect Row, Cork, Ireland*

**mouchliadisl@cf.ac.uk*

Photonic crystals are characterized by frequency regions where the propagation of light is suppressed, i.e. photonic bandgaps. When such a structure is resonantly coupled to a semiconductor supporting an exciton resonance, novel intragap modes arise due to the strong light-matter interaction [1].

We investigate the dispersive features of a 3D exciton resonance embedded in a 1D Bragg grating and find that the dispersion relation of the new modes resembles that of a *doublet* of microcavity polaritons [MC1 and MC2 in Fig. 1(a)]. We analyze the interaction between the electromagnetic field in the Bragg grating and the exciton-polarization wave by means of a set of *polaritonic coupled-mode equations*, properly accounting for the large nonlinear optical response of excitons [2].

Calculation of the Bragg polariton group velocity suggests that they can be used for slow-light-enhanced nonlinear propagation, while their extremely small effective mass (of the order of the cavity photon mass) renders them good candidates for the observation of macroscopic coherence phenomena in solid state systems. In analogy with MC polaritons [3], Bragg polaritons (or *Braggoritons*) exhibit an efficient mechanism for strong parametric amplification at two "*magic frequencies*". This is due to the existence of two inflection points in the UB and LB branches (see Fig. 1(b)). For numerical calculations we use ZnO as the excitonic material and propose a structure of alternating ZnO and ZrO_2 layers (see Fig. 1(c)).

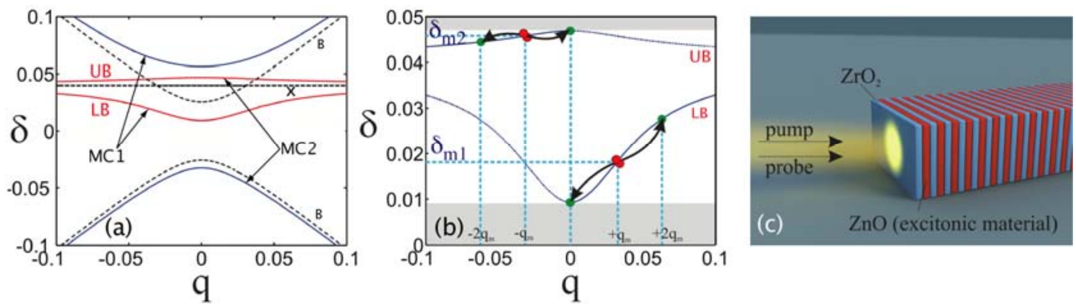

Figure 1: (a) Bragg polariton dispersion for non-zero detuning between the Bragg and exciton frequencies (dimensionless units). Dashed lines indicate the bare exciton and Bragg photon dispersions. (b) Schematics of the parametric scattering process occuring at two magic frequencies δ_{m1} and δ_{m2}. (c) Sketch of the proposed design based on a ZnO/ZrO_2 grating.

[1] A. Yu. Sivachenko, M. E. Raikh and Z. V. Vardeny, Phys. Rev. A **64**, 013809 (2001).
[2] F. Biancalana, L. Mouchliadis, C. Creatore, S. Osborne and W. Langbein, arXiv:0904.0758 (2009).
[3] P. G. Savvidis, J. J. Baumberg, R. M. Stevenson, M. S. Skolnick, D. M. Whittaker, and J. S. Roberts, Phys. Rev. Lett. **84**, 1547 (2000).

Acknowledgments Financial support from MPG, EPSRC and WIMCS is gratefully acknowledged.