Spin properties of bright polariton solitons in a semiconductor microcavity : The effect of polariton polarisation multistability

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Solitons are localised nondiffractive wavepackets, which can occur in a variety of non-linear systems. Light only solitons were observed in optical fibers and lasers, whereas matter only solitons are realised in cold atom systems. Recently, hybrid light-matter dissipative solitons were reported in strongly coupled semi-conductor microcavities[1]. These structures, where strong exciton-photon coupling results in the formation of 2D polaritons, have already demonstrated rich phenomena such as bistability, superfluidity and nonequilibrium condensation.

A notable specific feature of exciton polaritons arises from the fact that polaritons with parallel spins repel, while polaritons with opposite spins attract. Such spin anisotropy leads to polarisation multistability[2] where for a linearly polarized pumping laser the internal polariton field can be polarized either σ^+, σ^- circular or linear. The polariton spin multistability combined with the the fast picosecond response of bright solitons could also find applications in all-optical digital information processing.

Fundamentally, the soliton formation originates from the coexistence of pump bistability and parametric instability. In our experiment we use a CW pump to drive the system into the required conditions, and a ps-pulsed writing beam to trigger on demand the solitons[1].

Here we report the spin behavior of polariton bright solitons (see Fig. 1). Under a circularly polarised pump only soliton with a co-circular polarisation can be excited. This complete determination of the soliton spin state by the pump polarisation is consistent with spin conservative polariton-polariton scattering. For the case of a linearly polarised pump, the soliton spin state is conditional on the writing beam polarisation :

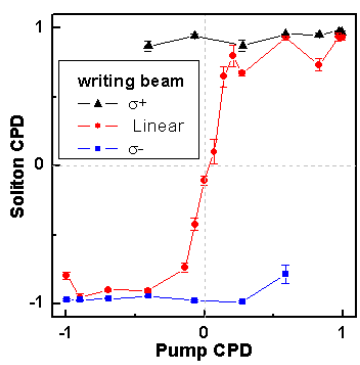

Fig 1. Soliton circular polairsation degree (CPD) as a function of pump circular polarisation degree recorded for the case of σ^+, σ^- and linearly polarized writting beam (triangles, squares and circles, respectively).

- $\sigma^{+(-)}$ solitons are turned on by a circular $\sigma^{+(-)}$ writing beam. The conversion of the linear polarisation of the pump to a circularly polarized soliton directly arises from the pump polarisation multistability, and opens the way for switch engineering with solitonic systems.
- With a linear writing beam, the solitons are found to be unpolarized. This could result either from a stochastic polarisation of the solitons pulse to pulse, or from the mixed nature of the soliton state. A statistical analysis, supported by correlation measurements, confirms the latter interpretation.

[1] M. Sich, D. N. Krizhanovskii *et al.*, Nature Photon. **6**, 50-55 (2012).
[2] N. A. Gippius, I. A. Shelykh *et al.*, Phys. Rev. Lett. **98**, 236401 (2007)