Spontaneous breaking of spin symmetry and fast spin switches in resonantly excited cavity-polariton condensates

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Abstract

Theoretical and experimental studies are performed of ultrafast spin transitions in strongly nonequilibrium exciton-polariton condensates formed under resonant and coherent optical driving in anisotropic microcavities. It is found that a combination of repulsive polariton-polariton interaction and spatial anisotropy leads to a spontaneous breaking of symmetry between right- and left-circularly polarized condensate states under a linearly polarized (spin-symmetric) pump wave. This effect enriches spin multistability of cavity-polariton systems ([1]) and opens the way for sharp transitions between linear and circular polarizations of intra-cavity field which occur in a threshold manner on the scale of picoseconds and micrometers [2].

Ultrafast transitions between opposite-spin states of a polariton condensate take place in a magnetic field. Spin-sensitive pair interactions enable fast and massive spin flips occurring at critical amplitudes due to the interplay between amplitude-dependent shifts of eigenstates and the Zeeman splitting. As a result, dominant spin of a condensate can be toggled back and forth by tuning of the pump intensity only, which was impossible in spin-degenerate cavity-polariton systems and cavities with weak exciton-photon coupling [3].

Fast spin transitions considered in [2] and [3] proceed “with blowup” [4] and are accompanied by switches in spatial distributions of both amplitude and average spin of polariton condensates in inhomogeneous systems [5]; they may be influenced by a long-lived exciton reservoir [6]. Similar effects of symmetry breaking lead to the internal Josephson oscillations between the spin components of a polariton condensate under pulsed excitation [7]. They open the possibility of the acousto-optic control of the condensate spin by means of fast perturbations of the exciton energy. It is predicted that in such a way the average spin of a polariton condensate can be toggled between +1 and -1 even under constant optical driving and without a magnetic field [8].

The considered phenomena open the way to create coherent light sources whose polarization can be controllably switched between linear and right- and left-circular on the scale of picoseconds.

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