Nonlinear dynamics of polariton scattering in semiconductor microcavity: bistability vs stimulated scattering

N.A.Gippius, S.G.Tikhodeev,
A.M.Prokhorov General Physics Institute, Russian Academy of Sciences, Vavilova, 38, Moscow 119991, Russia

V.D.Kulakovskii, D.N.Krizhanovskii, A.I.Tartakovskii,
Institute of Solid State Physics, RAS, Chernogolovka, 142432 Russia

L.V.Keldysh
P.N.Lebedev Physical Institute, RAS, Prospect Lenina 55, 119991, Russia

We demonstrate experimentally an unusual behavior of the parametric polariton scattering in a semiconductor microcavity under a strong cw resonant excitation. The maximum of the scattered signal above the threshold of stimulated parametric scattering does not shift along the microcavity lower polariton branch with the change of pump detuning or angle of incidence but is stuck around the normal direction [1].

We show theoretically that such a behavior can be modeled numerically by a system of Maxwell and nonlinear Schrödinger equations for cavity polaritons [2] and explained via the competition between the bistability of a driven nonlinear MC polariton and the instabilities of parametric polariton-polariton scattering [3,4].

Numerical solutions demonstrate a sharp transition from a regular behavior at lower pump intensities to a strongly fluctuating behavior above an abrupt threshold. Below the threshold the signal and idler are peaked around the intersections of the renormalized signal and idler LP dispersion branches. If the pump detuning is positive (pump energy above the lower polariton branch), the signal and idler peak around in-plane momenta $k_s<0$ and $k_i>2k_p$, correspondingly in agreement with the simple picture (k_p is pump momentum).

Above the threshold a qualitatively different behavior is seen. The scattered signal undergoes an abrupt jump from the resonant momentum $k_s<0$ towards the normal direction $k_s \sim 0$ and its intensity in normal direction becomes significantly stronger than just before the threshold. The averaged intensity of the scattered noise above the transition increases by several orders of magnitude.

This unusual behavior is a result of the sharp increase of the internal polarization induced by pump in the microcavity. For the positive detuning the internal polarization is a very steep function of the external pump field amplitude. After the drastic 'blow-up' of the internal polarization the polariton scattering in the microcavity changes abruptly its angular distribution and appears to be far from the one expected form a naive extrapolation of the stationary models.

[1] V. D. Kulakovskii et al., Nanotechnology 12, 475 (2001).
[2] N. A. Gippius, V. D. Kulakovskii, A. I. Tartakovskii, D. N. Krizhanovskii, M. N. Makhonin, S. G. Tikhodeev, and L V Keldysh, Proceedings of the 26th Int. Conf. on the Physics of Semiconductors, Edinburgh, UK (2002).
[3] N.A.Gippius, S.G.Tikhodeev, V.D.Kulakovskii, D.N.Krizhanovskii, and A.I.Tartakovskii, cond-mat/0312214, 2003
[4] V. D. Kulakovskii, D. N. Krizhanovskii, A. I. Tartakovskii, N. A. Gippius and S. G. Tikhodeev 2003 *Uspekhi Fiz. Nauk* **173**, 995 [2003 *Physics - Uspekhi* 46 n.9].