Soliton excitations in a polariton condensate with defects

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We consider a polariton Bose-Einstein condensate with defects. We describe it by Gross-Pitaevskii equation with an additional term which takes into account the finite lifetime of the polaritons. We want to study soliton excitations in this system. We use the Madelung transformation to obtain .hydrodynamic equations from the Gross-Pitaevskii equation.. The reductive perturbation method reduces these hydrodynamic equations into a modifed Korteweg-de-Vries equation in the long wavelength limit.. The resulting equation can have solitons as solutions when the damping and the external potential equal zero. We have chosen a set where the damping and the defects are non-zero but small enough to be treated as perturbations; we have written the solution of the system as a sum of a soliton function and a response function. In the case of traveling excitations, a full analytical solution is given using the variation of constants method. The results are valid for any external perturbation . We calculated the solution for a constant perturbation and noticed that it deforms the soliton in an asymetrical way., we have noticed that the response function always oscillates. So the external perturbations (damping and defects) disturb the solitons: they make dark solitons oscillate. We have found that the response function is more sensitive to the damping than to the external potential intensity.

In a more general form of excitations we have solved the Gross-Pitaevskii numerically. We notice that the response function always oscillates around an equilibrium value. These oscillations exist even if there are no defects. We have also noticed that the oscillation period and intensity depend on the velocity of the flow (the period is shorter and the intensity is lower for higher velocity). We notice also that the density variation induced by the modification of the damping is more important than the one caused by the external potential intensity; this is more obvious when the velocity of the flow is The oscillation of the dark soliton response functions suggests that these waves are stable. These oscillations exist even if there are no defects,i.e, they are caused by the continuous gain and loss of polaritons. The polariton self-interaction nature is now responsible for their stability. The repulsion between the polaritons promotes the creation of dark solitons in nonlinear systems and consequently helps also their stability. This results are consistent with those obtained by the soliton perturbation theory where it was found that dark solitons oscillate after interaction with an obstacle and maintain their shape and velocity. It was also demonstrated that dark solitons are stable in the case of a saturated gain.

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