Quasi-Linear Evolution and Saturation of the Modulational Instability of Partially Coherent Optical Waves

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Abstract:

Modulational instability (MI) is a generic feature in nonlinear wave propagation governed by the Nonlinear Schrödinger equation. MI has recently in theoretical as well as experimental works been found to take place also for partially coherent optical waves. The partial coherence has been shown to provide a stabilizing effect that tends to suppress the MI [1]. However as the developing MI grows it will ultimately begin affecting the background wave, a problem which has already been investigated for the coherent case [2].

In this work we extend the previous coherent analysis by considering the development of the MI of a partially coherent wave in a dispersive nonlinear Kerr medium beyond its initial linear stage. The analysis is based on the Wigner formalism of partial coherence. It is found that the self-consistent interaction between the unstable perturbation and the background wave may be described by a quasi-linear diffusion equation for the Wigner distribution, which characterizes the coherence properties of the background. In fact, in this formalism the problem is mathematically similar to the phenomena of Landau damping/growth of electron plasma waves and the concomitant quasi-linear diffusion of the electron velocity distribution [3].

It is found that the quasi-linear evolution of the Wigner distribution tends to counteract the MI by further degrading the coherence of the background wave until the growth rate of the MI is made to vanish. In the case when the MI is originally stabilized by the damping due to the partial coherence, the redistribution may increase the coherence of the background until either the perturbation is completely quenched or the growth rate of the MI is made to vanish.

References:

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