

Effect of Modulation Instability on Bright Solitons Propagating in Spatially Nonlinear Media



PHYSICS

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ABSTRACT

A soliton is a localised wave that propagates without change through a nonlinear medium. A two-dimensional bright spatial solitons propagation through a nonlinear medium is possible when the dispersion associated with the wave is balanced by the non-linear change of the properties of the medium which is induced by the wave itself and due to transverse modulation instability break-up of two-dimensional bright spatial solitons is possible.

1.1.1: INTRODUCTION:

Solitary wave solutions of nonlinear propagation equations are quite important with regard to nonlinear dynamics. Solitons are found in nature and have been considered as building blocks in future especially in the field of optical devices[1].

Temporal solitons are classified in to two types

- 1) Bright temporal solitons
- 2) Dark temporal solitons.

Pulses of light which represent a local increase in wave amplitude is called bright soliton and dark solitons[7] represent a decrease in wave amplitude and the amplitude dropping to zero which is experimentally observed in number of system but not in water.

Considering fig below we see group velocity dispersion effect and kerr effect mechanisms[4] acts in positive direction (or) one cancels the effects of other and vice versa and thus maintains the pulse shape and size while propagation and such pulses which are propagating and maintain the size and shape are called temporal soliton pulses[5].

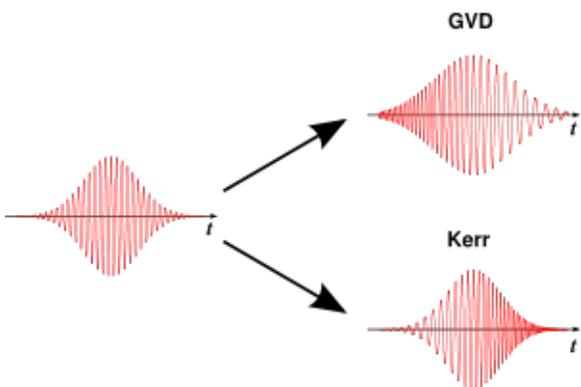


Fig. 1: Effects of SPM and GVD parameters on Gaussian pulses.
Source: Wikipedia.

1.1.2: Results and Discussion:

In the experiments a laser ($\lambda = 0.6328 \text{ mm}$) was passed through a variable beam splitter and a system of two cylindrical lenses. The beam was directed into a photorefractive crystal. The beam was placed about 0.2 mm in front of the crystal so that the input beam in the crystal was diverging. A variable dc voltage was applied and images of the intensity distribution were recorded.

Figure 2 shows the near-field distributions of the input (a) and the output (b), (c), d), (e), (f) beam for different values of the applied voltage (different values of the nonlinearity).

Under transient conditions the transverse modulation instability was clearly seen breaking up of two-dimensional bright spatial solitons[2] propagating in nonlinear medium due to transverse modulation instability[3].

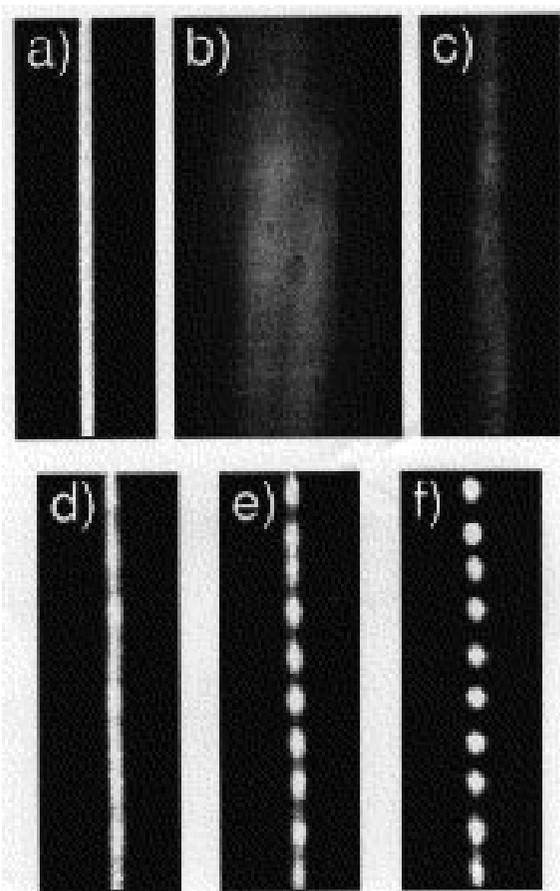
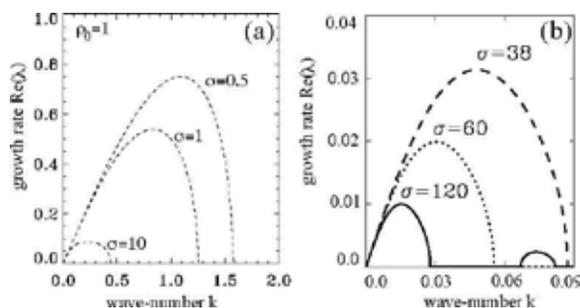


Figure.2: Break-up of two-dimensional bright spatial solitons propagating in nonlinear medium due to transverse modulation instability.

Also, wave propagation in nonlinear media constitutes one of the most fundamental effects associated with Modulation instability (MI). It signifies the exponential growth of a weak perturbation of the wave as it propagates[6]. Modulation instability growth rate as a function of the transverse wave number k for the bright solitary wave is shown below.



re.3: Modulation instability growth rate as a function of the transverse wave number k for the bright solitary wave soliton.

CONCLUSIONS:

Optical solitons pulses which can preserve their shape by balancing the mechanism called self phase modulation (SPM) resulting from the Kerr non-linearity and pulse broadening effect of GVD (Group velocity dispersion). This is important, because to any pulse travelling through a nonlinear media is affected by both the Kerr nonlinearity effect and group velocity dispersion effect. Also, under transient conditions the transverse modulation instability was clearly seen which gives break-up of two-dimensional bright spatial solitons propagating in nonlinear medium due to transverse modulation instability.

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