Nonlinear networks and the formation of dissipative solitons in problems of dynamic holography

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Dynamic holographic systems can be considered as a nonlinear network that describes the effects arising due to the coupling of laser beams in a nonlinear medium. A feature of this network is the presence of a coupling function, for which an additional equation can be written. The physical meaning of this function is to describe the evolution of the amplitude of the dynamic grating excited by interacting laser beams, and it obviously includes a temporal relaxation term.

Multiscale analysis has proven to be a powerful technique for considering nonlinear phenomena in various fields including nonlinear mechanics, fluid dynamics, nonlinear optics. It is well known that such a technique has been successfully applied to transform the nonlinear evolutionary sine-Gordon equation into the nonlinear Schrodinger equation (NLS) [1]. We report on the application of the multiscale perturbation method to an entire nonlinear system describing a network. This approach makes it possible to obtain a unified evolutionary equation of the complex Ginzburg-Landau type (CGLE) [2], [3]. It is known that equations of NLS and CGLE types are considered as an universal mathematical approach that giving rise a multiplicity of dissipative soliton (DS) solutions. In this respect, for our system, each DS solution can predict a new effect, which can be achieved by means of dynamic holographic set-ups. A single DS solution describes the formation of a spatially localized profile for the envelope of the amplitude of the dynamic grating. The whole evolutionary process is considered as a nonlinear interaction of two lattices: a light lattice (an interference intensity pattern) and a dynamic grating (a periodic pattern of matter changes photoinduced in a nonlinear medium).

The proposed approach seems to be very promising for practical applications of dynamic holographic systems, which are now experiencing a new leap in development [4]. Their applications occupy manipulations of laser pulses for optical communication technologies, image processing, holographic optical memory, both dynamic and permanent, and even solar energy conversion. Especially it reveals a new look at the development of a holographic artificial intelligence machine (AIM).

References

1. T. Dauxois & M. Peyrard, *Physics of solitons*, Cambridge University Press (2006).
2. S. Bugaychuk & R. Conte, Ginzburg-Landau equation for dynamical four-wave mixing in gain nonlinear media with relaxation, *Phys. Rev. E*, **80**, 066603–1–7 (2009).
3. S. Bugaychuk & R. Conte, Nonlinear amplification of coherent waves in media with soliton-type refractive index pattern, *Phys. Rev. E*, **86**, 026603–1–8 (2012).
4. J.T. Sheridan, et.al., Roadmap on holography, *J. Opt.*, **22**, 123002 (2020).