Dissipative Solitons and their Technological Applications

Soumendu Jana*
School of Physics and Materials Science,
Thapar Institute of Engineering and Technology, Patiala,PIN-147004,Punjab, India.
* soumendujana@yahoo.com

Abstract: Dissipative solitons (DS) are a family of localized structures, like, waves or pulses in lossy systems. Any real time system is dissipative by nature; therefore, no 'conservative' soliton can be excited. Instead an appropriated dose of 'gain' or continuous external energy supply may lead to formation of DS. Such DS has been excited in form of bright spot on dark background in a vertical cavity surface emitting laser (VCSEL) based models in conjugation of frequency selective feedback and saturable absorber (SA). Since generated inside a dissipative cavity these DS are popularly referred as cavity soliton (CS). DSs in cavity or cavity solitonsare unique amidst a large variety of DSs due to their plasticity, bistability and self-localization. CSs are excited at planes transverse to the propagation direction. Those CSs and their clusters play the role of memory "bit". By tuning the orientation of the CS-excitation plane the gross memory-capacity can be multiplied. Moreover, 'reallocation' and 'rectification' of memory have been shown possible.Like any sustained localized structure a CS or CS cluster requires a stable background. We found two species of CSs (of distinct height and width) on a stable background. This may lead to realization of three-level logic.

Generally 'stationary', but CSs canexhibit intriguing dynamics, visualization of what is facilitated by the large area of the VCSEL. The parametric space for stabilization and control of CS has been determined, which will eventually ease experimental excitation and control of CSs. The CS movement is too sensitive to the any inhomogeneity present in the system. This feature has been used to explore the possibility to design a'soliton force microscope'; an alternate all-optical microscope. Going one step forward the present investigation can easily assess the impact of system-randomness (almost of any kind), an unavoidable feature of an experimental environment. However, the size of the CS, which is pivotal to decide the resolution of the microscope, is yet to be reduced. Technique has been suggestedboth to reduce the CS spot size as well as how scanning can be done even with the existing size of CS. The result may lead to design anon-chip 'soliton force microscope' for biomedical applicationsfor mass.

Bistability is an essential aspect of CS that can be better realized by introducing a SA material in the cavity. Generally, semiconductorsaturable absorber mirrors are used. We explored the potential of Graphene and other 2D materials as SA-layer within the VCSEL. Principally, Graphene eases the CS generationconsiderablyand more importantly, upgrades the CS-system to an efficient biomedical sensor. The relevanst research and technological challenges as well as future line of investigation are highlighted.

References:

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