Nonlinear coupled systems: effects of gain, loss and nonlocality

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Abstract

Nonlinear phenomena exist in almost every type of physical systems. Arguably the most prevalent type of interaction is third-order nonlinearity, which is usually described by Gross-Pitaevskii Equations or Nonlinear Schrodinger Equations (NLSE). In certain cases nonlinear medium allows for coexistence of multiple components interacting with each other. In this case, Coupled Nonlinear Schrodinger Equations are used to describe complete physical system. Coupled NLSE are used in multiple fields of study, including optical waveguides, liquid crystals, cold atoms and polariton condensates. The main goal of this thesis is to explore influence of nonlocality, saturable gain and other effects on coupled nonlinear systems. Additional goal is to present different analytical and numerical methods for exploration of nonlinear effects in concise manner.

Research presented in my thesis is divided into two distinct areas. In first part we focus on two linearly coupled rings with saturable gain. This system is based on rings traps for polariton condensates. We discovered rich family of solutions, exhibiting several interesting phenomena, including modulational instability, inhomogeneous stable states, chaotic behavior and spontaneous symmetry breaking. We also observed spontaneous vortex generation in system with localized coupling between rings. This processes are explained by observing current flow both inside and between rings.

In second part we explore beam propagation in system with nonlocal nonlinear coupling. This system models two-colour vector solitons in nematic liquid crystals. We focused our research on supermodes - multi-peak fundamental solitons, emerging due to counteraction of focusing and defocusing nonlinearity. We observed spontaneous trajectory bending due to breaking of action-reaction symmetry. We've shown that dynamics of trajectory bending can be predicted by looking at relative shift between two components of vector soliton.

Conclusions, acknowledgements, list of publications, list of figures etc.