Optical solitons

Instructor: Boris Melamed (Malomed)

Light propagation in optical fibers, bulk and planar waveguides, and Bragg gratings; dispersion and diffraction. Fundamental nonlinearities in optical media, of the Kerr (cubic) and second-harmonic generating (quadratic) types. Fundamental mathematical models: nonlinear Schroedinger equations and systems of coupled equations. Continuous-wave (uniform) states, modulational instability, and the collapse in multidimensional nonlinear media. Temporal and spatial solitons; solitons in optical fibers; polarization and bimodal propagation. Solitons in dual-core couplers and waveguiding arrays; discrete solitons. Introduction to the method of the inverse scattering transform and integrability. Solitons in nonintegrable systems and variational approximation; dispersion management; interactions between solitons and bound states. The potential use of solitons in telecommunications and data-processing schemes. Parametric solitons in media with the quadratic nonlinearity. Gap solitons in gratings structures. Multidimensional, spatiotemporal, and vortical solitons. Solitons in dissipative media and laser cavities; Ginzburg-Landau equations as fundamental models of dissipative optical media.

Remark: Some topics may be reduced or skipped if the teaching time will not be sufficient.

Preliminary requirements: the students should have taken introductory courses of
(1) electromagnetic fields;
(2) partial differential equations.

Recommended books:

Y. S. Kivshar and G.P. Agrawal, Optical Solitons: from Fibers to Photonic Crystals (Academic Press, 2003)

T. Dauxois and M. Peyrard, Physics of Solitons (Cambridge University Press, 2006)

B. A. Malomed, Soliton Management in Periodic Systems (Springer: New York, 2006)

J. Yang, Nonlinear Waves in Integrable and Nonintegrable Systems (SIAM: Philadelphia, 2010)