Nonlinear physics in a nutshell

Place and time: … .
First lecture:
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Language: English

Nonlinear phenomena are encountered in all branches of science, including physics, chemistry and biology. In this course we will introduce some of the most fundamental theoretical concepts and demonstrate the universality of models that are commonly used to describe nonlinear processes across disciplines. There will be some emphasis on wave equations, including the ones related to quantum physics, however other aspects will be discussed as well. Topics covered in this course will include:

- How do nonlinearities appear in nature? Why do we observe nonlinear phenomena even though the fundamental theory (quantum mechanics) is entirely linear?
- Nonlinear waves in hydrodynamics, optics, cold atom physics.
- Common nonlinear wave models (Korteweg-de Vries equation, Nonlinear Schrödinger equation, Complex Ginzburg-Landau equation) and their derivation.
- Solitons and other self-localized states (vortices, skyrmions, etc.), quantum solitons.
- Exactly solvable problems and analytical methods.
- Approximate methods: linearization of nonlinear equations, variational method.
- Fixed points, stability and bifurcations, conservative and dissipative systems, attractors.
- Symmetry breaking and pattern formation.
- Deterministic and quantum chaos, spatio-temporal chaos.

Prerequisites: Basics of quantum physics (Schrödinger equation), differential and integral calculus, linear algebra.