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Random Soliton Dynamics in Lambda Configuration Resonant Optical Media

In a resonant interaction, light of specific wavelengths excites electron transitions between atomic energy levels in an active optical medium such as gas or crystal. For instance, in the lambda- configuration, light interacts with a medium via a pair of electron transitions between an energetically higher and two energetically lower atomic levels, which involve light of opposite circular polarizations. My collaborators and I have identified a switching mechanism in this interaction: The polarization of the light will switch so that it will interact with the medium only through the transition between the higher level and the lower level less populated with electrons. If the initial occupation of the two lower levels varies randomly, an optical pulse passing through this material will switch randomly between the two polarizations. Mathematically, this phenomenon is described by exact solutions of a completely integrable random partial differential equation, thus combining the opposing concepts of integrability and disorder. Probability distribution functions of the parameters describing the light polarization will be presented and their properties discussed. The work was done in collaboration with Ethan Atkins, Ildar Gabitov, and Pete Kramer.