Time-delayed PT-symmetric systems: theory and experiments

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Open classical or quantum systems with balanced gain and loss have attracted a lot of attention in recent years. Such systems are described by an effective, non-Hermitian Hamiltonian that is invariant under combined parity and time reversal operations. A key feature of such systems is the PT-symmetry breaking transition, which occurs when then the strength of the non-Hermiticity is larger than the energy scale set by the Hermitian part of the Hamiltonian. Physically, this transition leads to a state that is far removed from equilibrium because the local excesses or deficits, created by the gain and the loss potentials respectively, are not rapidly neutralized. All of these models are governed by first or second order time-differential equations, and thus local in time.

Here I will introduce PT-symmetric systems with a time delay, which physically encodes the finite speed of communication between the gain and the loss, and show how they can be realized in coupled semiconductor lasers. I will show that the simplest model of time-delayed PT-symmetric system - a two-site model with balanced gain and loss - shows a rich phase diagram with multiple PT-symmetric and broken regions. I will discuss the similarities and differences between PT-symmetric systems with time delay and the PT-symmetric Rabi problem. I will then present experimental results for the time-delayed PT-symmetric system.

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