Spontaneous Pulse Formation in Bistable Systems

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Abstract

This dissertation considers localized spontaneous pulse formation in non-linear, dissipative systems that are far from equilibrium and which exhibit bistability. It is shown that such pulses can form in systems that are dominated by the combined effects of: 1) a saturable amplifying or gain region; 2) a saturable absorbing or loss region; and 3) cavity effects. Analysis is based upon novel models for both an inertia-less material in which the absorber responds instantaneously and inertial material in which there is temporal delay in the response. Additionally, we include the situation where the material does not fully relax between pulses; i.e., memory effects. The results are shown to be generic but direct application is made to pulse formation and stability as observed and exploited in a colliding pulse mode-locked (CPM) dye laser in which the saturable gain and absorber are spatially localized. Bifurcation from a steady, pulsing state to one of several possible other states (laser dropout phenomena) is observed to occur in these systems and will also be addressed. Key results arising from the inclusion of memory effects are as follows: the existence of highly degenerate bifurcation scenarios, implying hysteresis-like behavior in drop-out/drop-in transitions; damped period-two oscillations; and much lower frequency damped oscillations – reminiscent of breathing modes.