# Delay induced multistability in parallel polarized Nd:YAG laser

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The effect of a delayed optoelectronic feedback on the dynamics of a two mode intra-cavity doubled Nd:YAG laser operating in the limit cycle region is investigated numerically. Both positive and negative delay feedbacks are studied separately. Bifurcation diagrams are drawn to show the variation of laser output intensity with delay time. Periodic, quasi-periodic and chaotic regions are identified in the laser output when a positive delay feedback is applied. Time series plots, phase portraits, power spectra and Poincare sections are used to verify the results. Existence of chaotic region is confirmed with a positive Lyapunov exponent and a fractional correlation dimension. It is also found that the laser exhibits hysteresis and multistability for two regions of delay. The first hysteresis occurs for a range of delay from 5500ns to 8000 ns. There is coexistence of periodic oscillations having different peak intensities in this region. The second hysteresis is found to occur for a delay range of 12000ns to 14500 ns. For a delay of 13000ns we can find the two coexisting states to be period one and period two oscillations. The most interesting behavior is observed corresponding to a delay of 14000ns where there is a coexistence of chaotic and quasi-periodic states. Time series plots and power spectra are used to identify various regions. The laser does not exhibit any interesting dynamics at higher feedback fractions. However a quasi-periodic state is observed at smaller delay time for all the feedback fractions. For laser with negative feedback a hysteresis is observed at a smaller feedback fraction. At higher feedback fractions the only noticeable dynamics is that the output laser intensity undergoes a sudden jump into the chaotic region for smaller delays.