Experimental investigation of chaotic oscillations in DFB and FP semiconductor lasers with strong incoherent optical feedback

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Chaotic secure communications are the subject of many experimental and theoretical investigations, since the idea of synchronization between two chaotic oscillators was proposed by Pecora and Carroll in 1990 [1]. In particular, chaotic oscillations of laser diodes have drawn considerable attention due to their potential applications in fiber-optical secure communication systems [2]. In general, the chaotic carriers can be generated by semiconductor lasers through relatively weak optical injection, or optical feedback. There are many parameters to characterize instabilities and chaos in semiconductor lasers however one important and most useful parameter to figure out the characteristics is the reflectivity of the external mirror [2]. The optical feedback phenomena from a distant reflector longer than the laser coherence are usually attributed to the incoherent effect.

In this work, we focus on an experimental characterization and comparison of chaotic oscillations in semiconductor distributed feedback (DFB) and Fabry-Perot (FP) lasers without in-built optical isolators subjected by a strong incoherent optical feedback. Both DFB and FP standard telecommunication lasers routed to chaos exhibits a widened RF spectrum accompanied by clear optical spectrum changes. As we found the linewidth of DFB laser drastically increases up to 0.5 nm for 40 Emission in the time domain is amplitude-modulated, showing a non periodic and very complex behavior with positive maximum Lyapunov exponents for all investigated regimes. However we did not record understandable dependence of maximum Lyapunov exponent on intensity reflectivity despite the fact that standard intensity deviation strongly depends on feedback strength.

Altogether FP laser subjected by strong incoherent feedback strength demonstrates more chaotic behavior compare with DFB one for frequencies up to 1 GHz, very likely due to additional variations attributed to power switching between longitudinal FP laser modes. The obtained experimental results of chaotification in lasers are of fundamental importance for practical applications, in particular for chaos synchronization and chaotic communication in networks; see for example [3].

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3. Posadas-Castillo C., López-Gutiérrez R.M., and Cruz-Hernández C. (2008) Synchronization of chaotic solid-state Nd:YAG lasers: Application to secure communication, Commun. Nonlinear Sci. Numer. Simul., Vol. 13, No. 8, 1655-1667. López-Gutiérrez R.M., Posadas-Castillo C., López-Mancilla D., and Cruz-Hernández C. (2009). Communicating via robust synchronization of chaotic lasers. Chaos Solitons Fractals, Vol. 41, No. 1, 277-285.