Chaos and noise control by current modulation in semiconductor lasers subject to optical feedback

By: Ahmed, M (Ahmed, M.)[1,2] ; El-Sayed, NZ (El-Sayed, N. Z.)[2] ; Ibrahim, H (Ibrahim, H.)[2]
View ResearcherID and ORCID

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Abstract

This paper introduces comprehensive large-signal analyses of modulation dynamics and noise of a chaotic semiconductor laser. The chaos is induced by operating the laser under optical feedback (OFB). Control of the chaotic dynamics and possibility of suppressing the associated noise by sinusoidal modulation are investigated. The studies are based on numerical solutions of a time-delay rate equation model. The deterministic modulation dynamics of the laser are classified into seven regular and irregular dynamic types. Variations of chaotic dynamics and noise with sinusoidal modulation are examined in both time and frequency domains over wide ranges of the modulation depth and frequency. The results showed that chaotic dynamics can be converted into five distinct dynamic types; namely, continuous periodic signal (CPS), continuous periodic signal with relaxation oscillations (CPSRO), periodic pulse (PP), periodic pulse with relaxation oscillations (PPRO) and periodic pulse with period doubling (PPPD). The relative intensity noise (RIN) of these types is characterized when the modulation frequencies are much lower, comparable to, and higher than the resonance frequency. Suppression of RIN to a level 8 dB/Hz higher than the quantum limit was predicted under the CPS type when the modulation frequency is 0.9 times the resonance frequency and the modulation depth is 0.14.

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Author Information

Reprint Address: Ahmed, M (reprint author)

+ King Abdulaziz Univ, Fac Sci, Dept Phys, Jeddah 80203, Saudi Arabia.

Addresses:

+ [1] King Abdulaziz Univ, Fac Sci, Dept Phys, Jeddah 80203, Saudi Arabia

+ [2] Menia Univ, Dept Phys, Fac Sci, Al Minya, Egypt

E-mail Addresses: mostafa.hafez@science.miniauniv.edu.eg

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