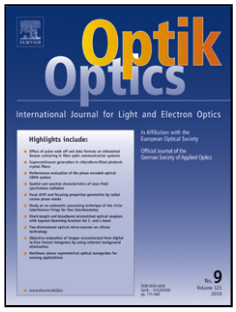

Title: Synchronization and secure communication in time delayed semiconductor laser systems

Author: Thang Manh Hoang Sanjay K. Palit Sayan Mukherjee Santo Banerjee

PII: S0030-4026(16)30983-4
DOI: http://dx.doi.org/doi:10.1016/j.ijleo.2016.08.105
Reference: IJLEO 58122

To appear in:

Received date: 11-6-2016
Revised date: 22-8-2016
Accepted date: 29-8-2016

Please cite this article as: Thang Manh Hoang, Sanjay K. Palit, Sayan Mukherjee, Santo Banerjee, Synchronization and secure communication in time delayed semiconductor laser systems, *<![CDATA[Optik - International Journal for Light and Electron Optics]]>* (2016), http://dx.doi.org/10.1016/j.ijleo.2016.08.105

Synchronization and secure communication in time delayed semiconductor laser systems

Thang Manh Hoang[a], Sanjay K. Palit[b], Sayan Mukherjee[c], Santo Banerjee[d,*]

[a]*School of Electronics and Telecommunications, Hanoi University of Science and Technology, 01 Dai Co Viet, Hanoi, Vietnam*
[b]*Basic Sciences and Humanities Department, Calcutta Institute of Engineering and Management, Kolkata, India*
[c]*Department of Mathematics, Sivanath Sastri College, Kolkata, India*
[d]*Institute for Mathematical Research, Universiti Putra Malaysia, Selangor, Malaysia*

Abstract

We investigate the synchronization in coupled time delayed semiconductor laser models without and under the influence of external noise sources. The synchronization and its robustness is observed by mean synchronization error and the effect of parameter mismatch respectively. A communication scheme is introduced based on symmetrical encryption and decryption method in the frame of coupled synchronized lasers with optical feedback. The scheme is effective irrespective of the nature and dynamics of the transmitted signal.The security of the scheme is verified by the effect of relative parameter mismatch, key sensitivity frequency and cross correlation analysis. Numerical results support the proposed analysis.

Keywords: Time delayed semiconductor laser system, Additive random noise, Symmetrically secured optical communication, Complete synchronization, Parameter mismatch, Communication security.

1. Introduction

The last three decades have witnessed the study of dynamics of semiconductor lasers [1–9] with external optical feedback. The dynamics of semiconductor laser especially with delayed feedback exhibits a large variety of interesting properties ranging from bifurcations, thresholds of instability (or stability) to deterministic chaos. Several theoretical approaches with numerous experimental investigations in parallel have been proposed for a better understanding of the nonlinear dynamics of compound laser system. However, most of them were developed on the basis of the rate equations proposed by Lang and Kobayashi(LK)[10, 11]. The LK rate equations are used to explain the physical mechanisms of the steady-state, transient low frequency fluctuations (LFF), and also the chaotic itinerancy in case of relatively strong feedback. The LK rate equations were originally introduced to model a single-mode laser with weak feedback and large delays. The LK system was further generalized in [12] by adding another external cavity which results in another feedback rate and delay. The study of semiconductor lasers has got tremendous response to the research communities due to its rich chaotic phenomenon and optical communications [11–18]. In any communication networks, enhancement of security and privacy are must and Chaotic optical communication [19] stands as a promising technique in this context. It employs synchronized chaotic nodes [20] to encode and decode information at the hardware level.The generated chaotic carrier at the sender end is used to encode information which can be extracted properly only at the appropriate receiver end.
Synchronization of two identical autonomous chaotic systems was first introduced by Pecora and Carroll [21]. Later on synchronization has been widely investigated in diverse domain ranging from physical [22], chemical and ecological science [23, 24], to secure communications [25]. In synchronization of coupled dynamical system, the drive system (master) sends the driving signal to drive the response or driven system (slave) and some functional relation must exist in their trajectories during interaction. Various synchronization schemes are available. Among those complete synchronization (PC) [21], generalized synchronization [26], projective and complex projective synchronization [27], lag synchronization [28], phase synchronization [29] have been studied widely in various applications. However, complete synchronization either with unidirectional coupling or with bidirectional coupling scheme is more often used in secure communication. The basic idea behind chaos synchronization based secure communication is that the signal to be transmitted (referred to as message signal) over the communication channel is hidden by modulating it with a complex signal produced by a chaotic system, and the same is recovered by synchronizing the master at the transmitter side with the slave at the receiver side. Since the signals produced by the master is chaotic, broadband and noise like, it is successfully used as a carrier for secure transmission. Thus, the security of chaos based communication not only depends on the

*Corresponding author
Email address: santoban@gmail.com (Santo Banerjee)