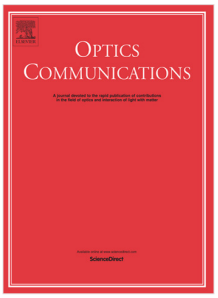
Accepted Manuscript



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PII: S0030-4018(18)30710-7
DOI: https://doi.org/10.1016/j.optcom.2018.08.020
Reference: OPTICS 23377

To appear in: *Optics Communications*

Received date : 3 May 2018
Revised date : 28 June 2018
Accepted date : 9 August 2018

Please cite this article as: N. Nair, E. Bochove, Y. Braiman, Almost perfect in-phase and anti-phase chaotic and periodic phase synchronization in large arrays of diode lasers, *Optics Communications* (2018), https://doi.org/10.1016/j.optcom.2018.08.020

Almost Perfect In-Phase and Anti-Phase Chaotic and Periodic Phase Synchronization in Large Arrays of Diode Lasers

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Abstract

In this paper we study phase synchronization in large arrays of weakly coupled single mode semiconductor laser diodes. We show that if the coupling topology is chosen appropriately, the laser array exhibits robust phase synchrony (including chaotic and non-chaotic phase synchrony). Furthermore, one can define coupling topologies that lead to chaotic anti-phase synchronization. To the best of our knowledge, chaotic anti-phase synchronization has not been observed in large arrays of coupled nonlinear oscillators. When diodes are coupled via a decayed non-local coupling scheme, the leading spatial mode can be stable. This leads to an almost-perfect phase synchronous state where the phases are synchronized, but the system is not set exactly on the synchronization manifold. This almost-perfect phase synchronous state is robust to noise and frequency disorder and can be realized under periodic (fixed-intensity limit cycle) continuous-wave and chaotic behavior. The presented result is an example of the broader phenomenon of linear transverse mode selection taking place in a coupled oscillator system with nonlinear dynamics.

Introduction

Synchronization in networks of nonlinear elements has been studied for years, revealing a variety of interesting and exciting phenomena[1]–[12]. Examples of network synchronization feature wide variety of spatial and temporal behaviors such as perfect in-phase synchrony (all the elements in array behave in identical manner), intensity synchronization (all the have the same time-dependence of intensities but vary in phases), time-delayed synchronization [7], cluster synchronization (some clusters of the array are synchronized by other elements in the array are not) [5], [8], and other types of synchronized behavior. Time series of synchronized arrays may show periodic or fixed-point behaviors, chaotic behavior (chaotic synchronization[9]), and chimera states where some clusters are periodically synchronized and others are chaotically synchronized [6], [10], [13], [14].