

Optical Fiber Communications by means of Chaos Generation

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Abstract:

The Chaos in the single-mode semiconductor lasers is generated by means of an optoelectronic feedback.

Chaotic been generation under selected experimental initial condition of semiconductor laser model with optoelectronics feedback under appropriate conditions.

MATLAB packages using to simulate the model behavior of semiconductor laser diodes with optoelectronics feedback.

The Chaos in the single-mode semiconductor lasers is generated by means of an optoelectronic feedback. And result generated due to the simulated models.

The existence of slow chaotic spiking sequences in the dynamics of a semiconductor laser with an optoelectronic feedback demonstrated experimentally and theoretically.

Key words: Chaos, Optoelectronics, Feedback

1. Introduction:

Secure communication now is the most popular application that uses chaotic waveforms as "carriers" of information promise possible advantages over traditional communications strategies in the achievement of power efficiency gains and better use of broadband capability.

Optical communication utilizing synchronized chaotic lasers with optoelectronic feedback has been demonstrated for quite slow data rates by using chaotic wavelength fluctuations [1].

In particular, semiconductor lasers (SLs) subject to optical feedback[3], opto-electronic feedback, or optical injection can conveniently generate chaotic signal for its potential applications such as a feedback

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interferometer[2], secured communications, all-optical frequency conversion[4], laser chaos-based LiDAR[5], and radar and sensors[6].

High-frequency chaos generated due to the semiconductor laser with optoelectronic feedback in comparison to optical feedback the advantage of being phase insensitive.

Optical semiconductor devices are widely used, in fields ranging from optical fiber communication systems to consumer electronics, and have become indispensable devices in the equipment and systems making up the infrastructure of our society. Most optical semiconductor devices are optoelectronic pn-junction devices, such as laser diodes, light-emitting diodes, and photodiodes [5].

The main interest in the field of optoelectronic devices has shifted from device physics and operation principles to device applications. That is why we require a wide range of knowledge related to optoelectronic semiconductor devices [8].

2. Theoretical Concepts:

Semiconductor laser with optoelectronic feedback is schematically shown in (Fig.1)[7]and (Fig.2)[11] In this configuration, a combination of photo detector and amplifier is used to convert the optical output of the laser into an electrical signal that is fed back to the laser by adding it to the injection current[7]. Because the photo detector responds only to the intensity of the laser output, the phase of the laser field is not part of the dynamics of this system.

In optoelectronic feedback, chaotic pulses may be generating by positive or negative feedback,[9] Positive optoelectronic feedback is different from negative optoelectronic feedback in the mechanism that drives the nonlinear dynamics of a semiconductor laser. In the case of negative optoelectronic feedback, the feedback current is deducted from the bias current,[10].

3. Experimental setup:

i. Chaos in Optoelectronic Feedback Lasers

The schematic experimental setup for the investigation of semiconductor lasers with optoelectronic feedback symmetrical to general schematic diagram as seen in Fig [1].

The simulated model work due to this configuration so the laser diode is driven by a DC bias current and lases in a single mode, the output light is received and converted to a current by a photo detector to model a feedback.

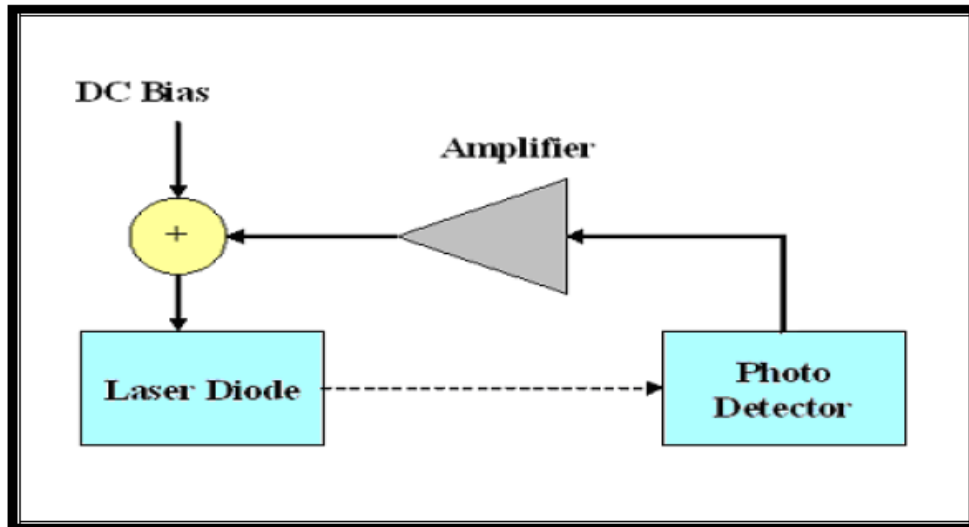


Fig (1): Schematic diagram of laser diode with delayed optoelectronic Feedback [7].

ii. Mathematical Model:

Laser diode with optoelectronic feedback model mathematically describes by three models differential equations as follow:

1. Model equation:

$$\dot{x} = x(y-1) \quad (1)$$

$$\dot{y} = \gamma(\delta_0 - y + f(w + x) - xy) \quad (2)$$

$$\dot{w} = -\varepsilon (w + x) \quad (3)$$

System model been implemented and designed by using different software packages and environments

System been simulated alsomodel behaviorsand characteristics describe according to the following parameters:

System parameters setting.

Initial condition value.

Time interval responds.

The setup and initiating values that use in programming models to produced system results are as follow:

$\text{gama} = 0.001$;

$\text{eps} = 2e-5$;

$s=11$;

$\text{delta1}=8.727$;

$f=0$;

These simulated parameters symmetrical and accepted to the mathematical model parameters in model equation (1), equation (2) and equation (3) as mention in Table-1.

Table (1): Mathematical and Simulation Parameters

Mathematical model variables	Simulation model variables
γ	gama
ϵ	eps
$s = \gamma_c s' k / g$	s
δ_0	delta1

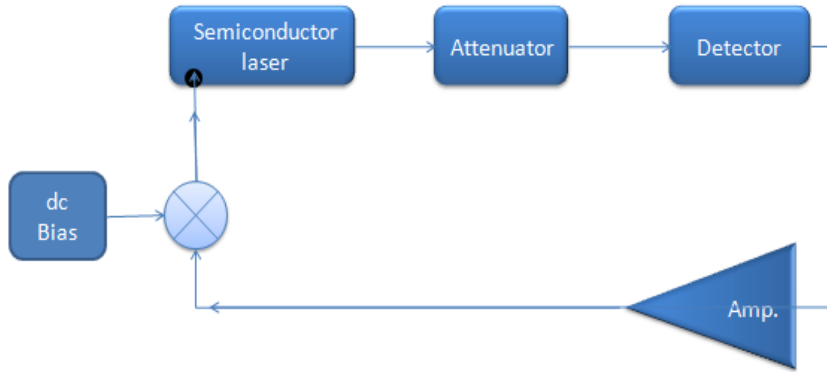


Fig (2):Chaotic spiking scenarios in semiconductor lasers with optoelectronic Feedback [11].

4. Result and Discussion:

Parameters used in the simulation are demonstrated due to the simulated model that make the system generates chaotic signals as following result forms. (Form-1 to form-5).

The result forms display chaotic behavior.

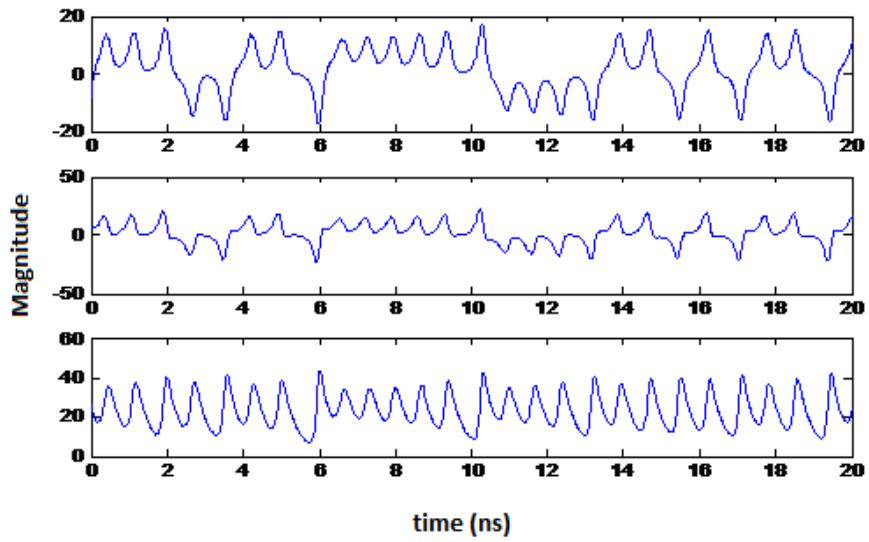
Different time interval selected to describe the magnitude of chaotic signal and spiking sequences during time interval selected as mention in (Table-2) with respectively result forms.

The plotting results form also demonstrates sensitive dependence on initial conditions within the region of phase space occupied by the system attractor. (Figure (3)).

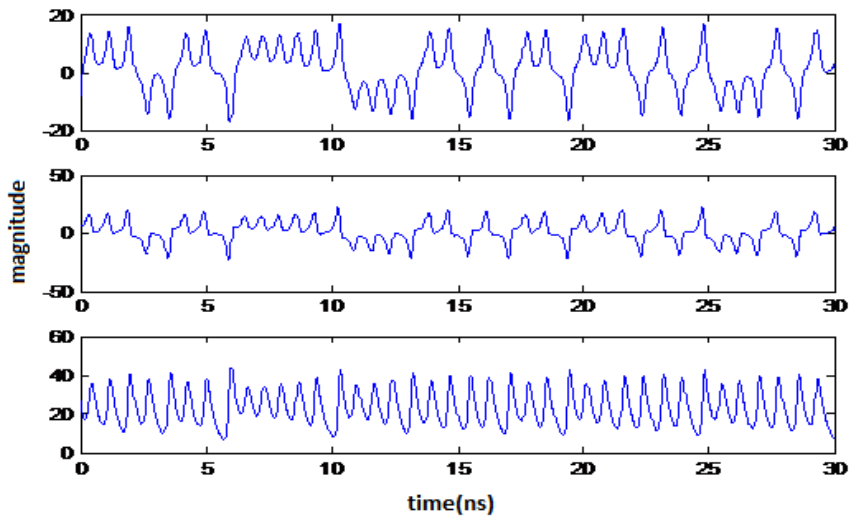
Time interval for simulation varies to get different form of result as follow:

Table (2): Simulation Results forms

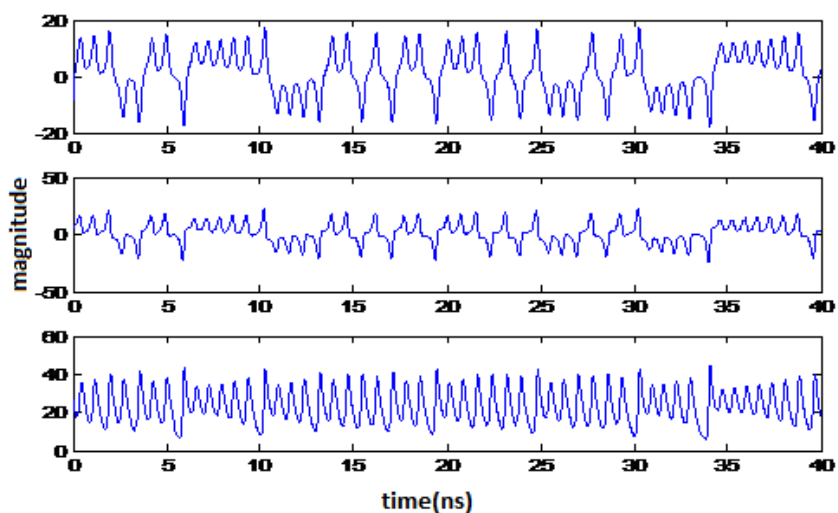
Symbol forms results	Time interval selected
Result form-1	0 to 20 ns
Result form-2	0 to 30 ns
Result form-3	0 to 40 ns
Result form-4	0 to 50 ns
Result form-5	0 to 60 ns



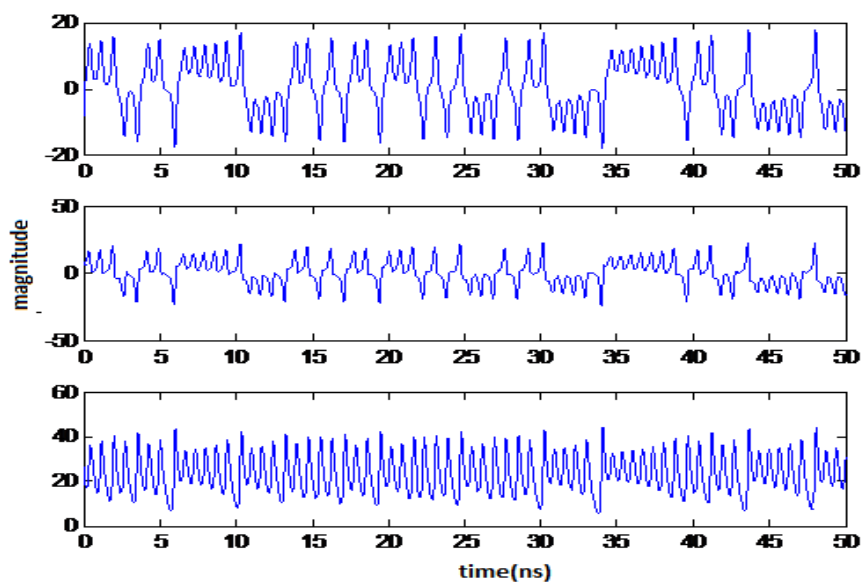
Result form-1 (t=0:20):



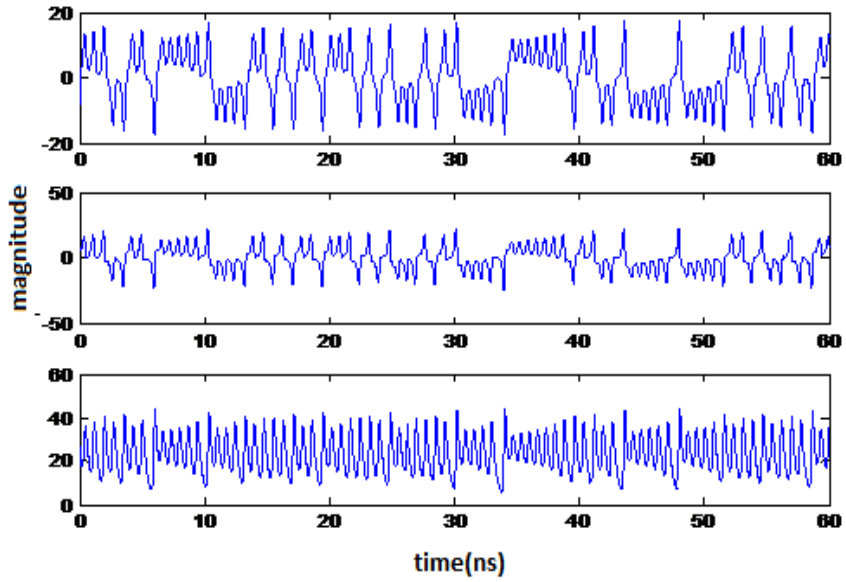
Result form-2 (t =0:30):



Result form-3(t =0:40):



Result form-4(t =0:50):



Result form-5(t = 0:60):

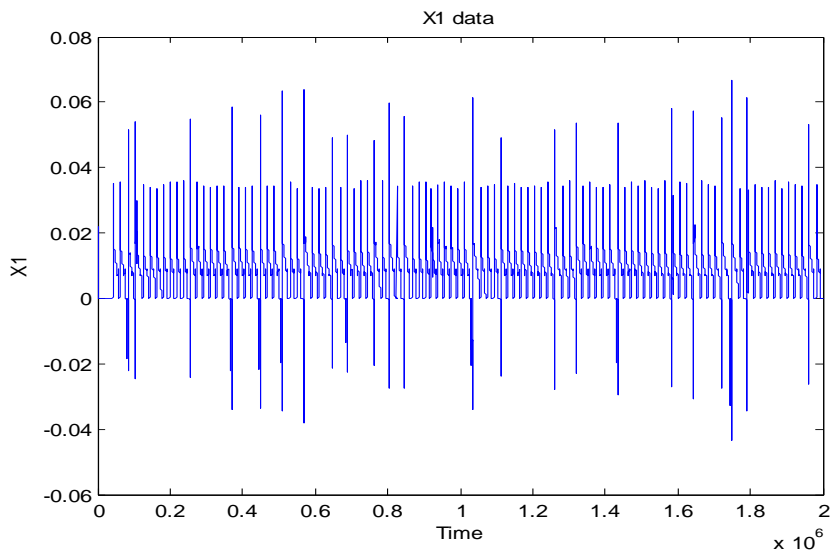
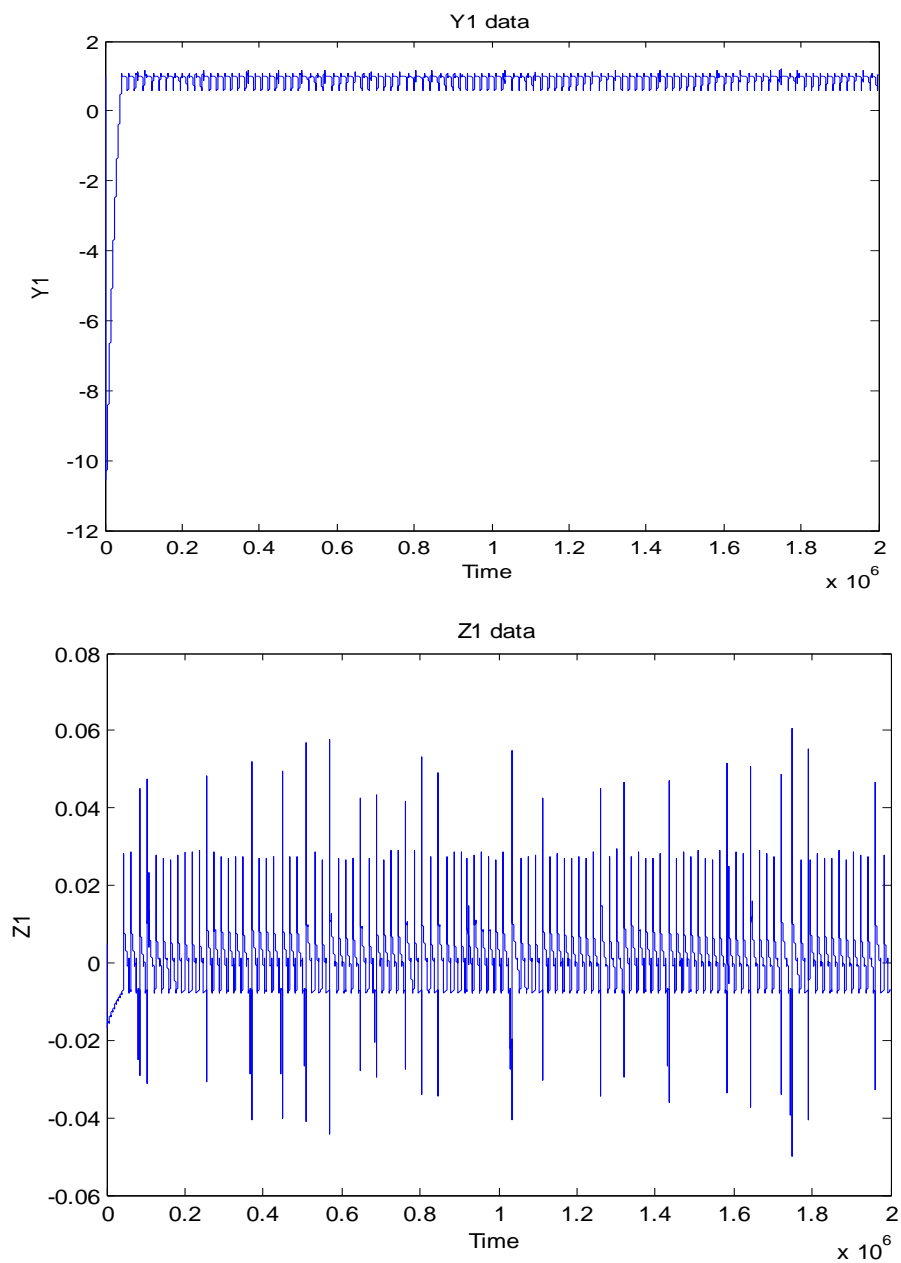
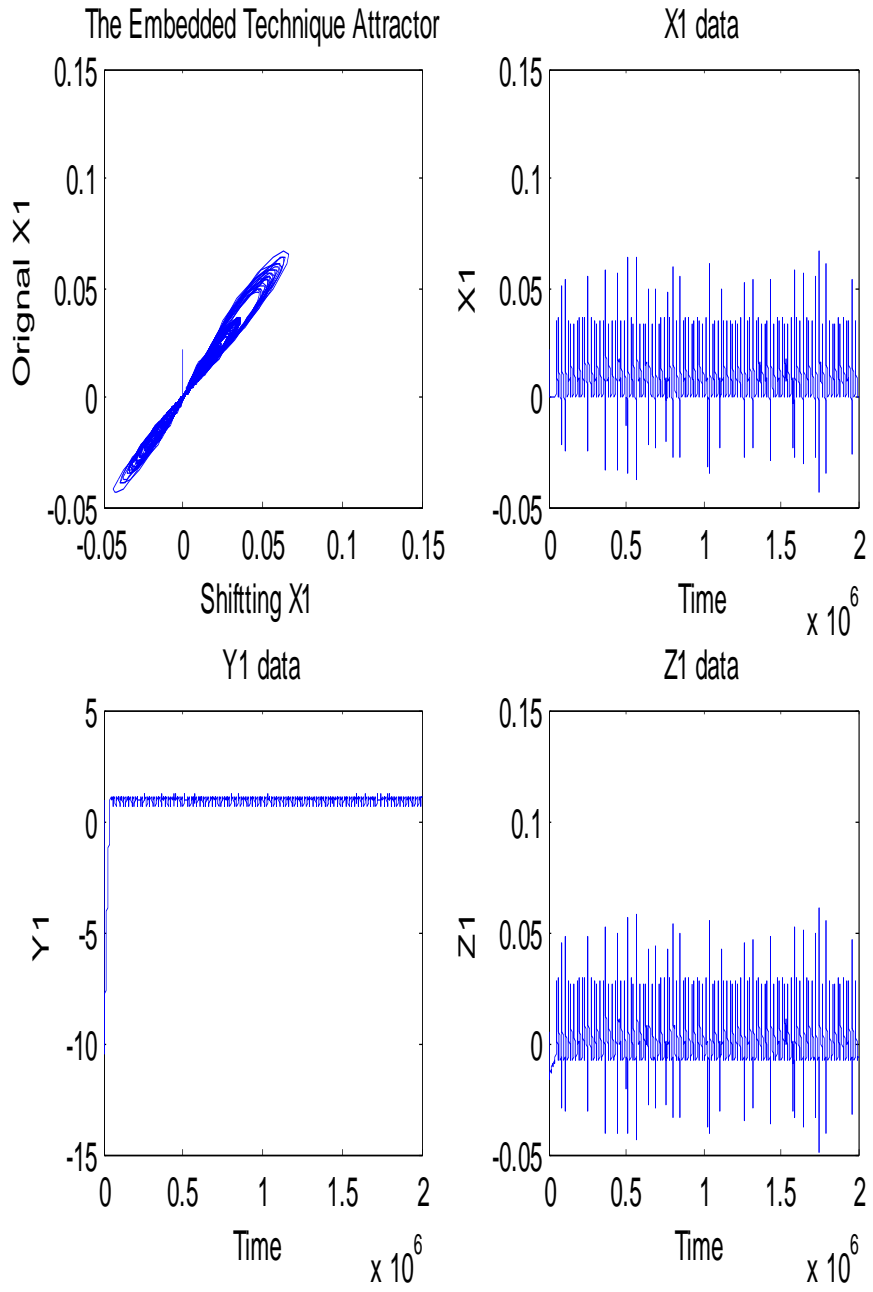


Figure (3): The embedded attractor





5. Conclusions

In this work we propose the efficient computer Simulation model scheme for the Chaos generation in the single-mode semiconductor laser with optoelectronic feedback.

Experimental results on the route to chaos presented.

Experimentally the existence of slow chaotic spiking sequences in the dynamics of a semiconductor laser with optoelectronic feedback been demonstrated.

Due to the simulation model the results show that chaos been generated and also can be controlled.

Bias and optical current play an important role in the process of chaos and its controlling.

We hope this work will offer useful insight to the nonlinear dynamics of chaotic laser systems.

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