Identification of multiple folding mechanisms of chaos generation by topological analysis applied to a highly dissipative system

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The chaotic emission of an erbium-doped fiber laser with sine-wave pump modulation has been analyzed for different modulation frequencies and modulation indexes. For each working condition considered, the template which summarizes the corresponding chaotic attractor has been determined by means of topological analysis techniques. The interest of the work is double: on the one hand, because of the procedure employed for the analysis, which is not the conventional one; and on the other hand, because of the diversity of templates obtained, much wider than in any other experimental systems previously studied, and particularly because of the novelty of some of these templates.

As the system is highly dissipative, it is possible to complement the usual topological analysis procedure (1) with a different technique (2): the high dissipation causes that the Poincare sections obtained are thin enough to be considered as a line. A continuous parameterization along this one-dimensional object can be defined so that the first-return map with regard to the parameter chosen is an application. Maxima and minima of the first-return map obtained determine a generating partition and, therefore, the number of branches of the template, the parity of each branch and the symbolic names of the unstable periodic orbits identified are easily obtained. This way, the procedure of analysis is considerably simplified. Concerning the templates found, apart from horseshoes, reverse horseshoes or jellyroll structures with different global torsions, two more kinds of structures have been observed. One of them presents three branches folded the same way than a staple. The other one, also with three branches, presents the folding mechanism of an S, which is especially notable as it does not fit the rolling scheme valid for all templates found in former experimental studies.

The variety of topological structures obtained strengthens the usefulness of templates as significant objects for characterization of chaotic attractors of three-dimensional dynamical systems.

1 R. Gilmore, M. Lefranc, The Topology of Chaos (Wiley, New York, 2002).

2 J. Used, J.C. Martin, Phys. Rev. E 79, 046213 (2009).