Pleating tori, a way to bifurcate toward chaos in a spatio-temporal laser

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Homogeneously broadened single-mode lasers are known to produce quite complicated spatio-temporal dynamics [1,2]. Most of the time, they are investigated either by using a temporal approach with phase portraits and first-return maps, or by using spatio-temporal diagrams. But, to the best of our knowledge, there is no investigation trying to combine both to provide a better understanding of the bifurcations that may be observed when a parameter is varied. In our case, the observed dynamics is interpreted in terms of non-trivial (pleated and/or folded) toroïdal structures. For instance, in a certain domain of the parameter space, the chaotic behavior occurs after three Hopf bifurcations, followed by "pleating" requiring an additional dimension. The chaotic behavior is observed once the torus is sufficiently pleated, then inducing a folding as invoked in the Curry-Yorke scenario (foldings on the torus) [3]. The road to chaos is thus a combination between the Ruelle-Takens scenario [4] and the Curry-Yorke scenario. An unexpected "pleating" making a link between them. The corresponding spatio-temporal diagrams show changes that may be linked with each of the bifurcations identified in the temporal approach. In particular, the defects are observed only when a pleated torus or a toroïdal chaos is identified in the phase portrait. The advantage of combining the temporal and the spatio-temporal approaches is therefore demonstrated.

Bibliography

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