Reinjection Probability Density Function for Type-II and Type-III Intermittencies with Lower Boundary of Reinjection and Noise

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ABSTRACT

Chaotic intermittency is a route to chaos where dynamical systems have transitions between regular (or laminar) phases and chaotic bursts (or non regular phases). Intermittency has been observed in several fluid dynamics phenomena, such as Lorenz system, Rayleigh–Bénard convection, turbulent flows, Derivative Non-Linear Schrodinger equation (DNLS equation), etc. In this paper a recent methodology [1-3] is used to analyze type-II and type-III intermittencies considering different values of the lower boundary of reinjection (LBR) and the noise intensity. With this approach, new analytical expressions for the reinjection probability density function (RPD) are obtained. The noise effects on the RPD are introduced by convolution integrals [4,5]. The reinjection mechanism for type-III intermittency, generally, is more complex than type-II intermittency because trajectories around a singular point (point with zero or infinite derivative) need more than one iteration to reinject in the laminar zone. Therefore, to evaluate the noise effects on the RPD, two o more convolution integrals must be considered. Also, the adjacent reinjection concept is introduced (theoretical and numerically), and its effects on the RPD are analyzed. This mechanism produces a high reinjection concentration near the upper limit of the laminar interval. The resulting RPD functions have a piecewise structure addressing the different reinjection mechanisms appearing in the nonlinear system depending on the LBR value and the noise intensity. To validate the theoretical expressions several numerical test have carried out. In all test, analytical results and numerical data present high accuracy.

REFERENCES

[1] E. del Rio and S. Elaskar, “New characteristic relation in type-II intermittency”, *Int. J. Bifurcat. Chaos* **20**, 1185–1191 (2010)

[2] S. Elaskar, E. del Rio and J. Donoso, “Reinjection probability density in type-III intermittency”, *Physica A* **390**, 2759–2768 (2011).

[3] E. del Rio, S. Elaskar and J. Donoso, “Laminar length and characteristic relation in type-I intermittency”, *Commun. Nonlinear Sci. Numer. Simul.* **19**, 967–976 (2014)

[4] E. del Rio, M. Sanjuan and S. Elaskar, “Effect of noise on the reinjection probability density in intermittency”, *Commun. Nonlinear Sci. Numer. Simul.* **17**, 3587–3596 (2012).

[5] S. Elaskar, E. del Rio, G. Krause and A. Costa, “Effect of the lower boundary of reinjection and noise in Type-II intermittency”, *Nonlinear Dyn.* **78**, DOI 10.1007/s11071-014-1750-1 (2014).