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Crossing Times For A Passive Scalar In A Turbulent Boundary Layer

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The transport of a passive substance by a turbulent flow is important in many natural and engineering settings. In atmospheric flows, the hazard related to toxic or flammable substances directly depends on the substance concentration, which exhibits a complex stochastic dynamics. Experimental evidences have shown that, in the case of a point source, the one-time, one-point probability density function (PDF) of the concentration is very well approximated by a Gamma distribution. Two parameters -mean and variance- define the Gamma distribution, which is though unable to furnish information on the temporal dynamics of the concentration. For example, the PDF does not provide the crossing times -the mean period that the concentration is above a certain threshold-, which are crucial to determine the exposure to toxic substances and their effect on human health. By comparing with experimental results, we here show that the White Shot Noise (WSN) provides a good stochastic model for the concentration dynamics. The main advantage is that the WSN yields, beside the Gamma distribution for the concentration, a closed form for the crossing times. In this framework, the only additional parameter needed is the integral time scale, for which we provide an analytical esteem. The results presented in this work may serve as a rapid and practical way to estimate the dynamics of a pollutant diffused in the atmosphere and its consequent effect on the environment.