Interdisciplinary applications of a periodically modulated Poisson noise process with regulated periodicity

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Random pulse processes with regulated periodicity, such as dead-time-distorted Poisson pulse noise and pulse process with fixed time intervals, are widely used for modeling noise-induced effects. These processes are used in different fields ranging from stochastic thermodynamics, nanotechnology, and electronics to population dynamics and epidemiology. Experimental and computational studies presented in literature have explored the similarities in the behavior of these systems. For population dynamics and epidemiology this model helps to take into account the influence of seasonal changing of environment on some unpredictable events, such as huge increases of a population, epidemics, and other environmental modifications. In the case of quantum optics, the parameter of periodicity can be used as criterion to distinguish between quantum and classical optics. If the quasi-period of the pulses is the average time between photons registration and the period is the inverse frequency of the light, then the condition of small parameter of periodicity is equivalent to the condition that light intensity is much less than Planck constant. In billiard theory, this noise can be used to describe the acceleration of a billiard particle by periodically moving scatterers. The correlation time of this process is estimated to verify, for Markovian behavior, the applicability of the Fokker-Planck equation to obtain the probability distribution of the velocity and to calculate the Fermi acceleration.

We present a new stochastic process, consisting of delta pulses modulated by a periodical function, which is suitable to be treated both by analytical and numerical approach. This modulated Poisson process is characterized by a random time interval between two successive pulses. The mean value of these random time intervals is called quasi-period of the Poisson process. The ratio between the period of the amplitude modulating function and the quasi-period of the pulses is called parameter of periodicity. The larger the parameter of periodicity the larger the correlation of the process. This process can be used as noise source, with a different degree of randomness ranging from white noise to quasi-periodical process, in stochastic differential equations describing fluctuating parameters in physics and biology. We analyze the spectral density, the correlation function and the moments and their dependence on the parameters characterizing this new stochastic process.

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