Aging in Blinking Quantum Dots: Renewal or Slow Modulation ?

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In the context of complexity science, in the last few years there has been an increasing interest in the fluorescence intermittency of new nanomaterials, which for this reason have been called [1] Blinking *Quantum Dots* (BQD). The theoretical interest for these new materials is due, to a great extent, to the properties of their power spectrum. Macroscopic samples of BQD have been studied and have been proved to generate *1/f* noise [2,3]. Thus, understanding these new materials is a problem directly connected with the origin of the *1/f* noise. BQD is a prototype of complex systems exhibiting Non-Poissonian statistics. The search for the dynamical origin of complexity, meant to be a statistical condition departing from the Poisson prescription, is a hot topic, and recently a proposal, called *superstatistics*, was made by Beck and Cohen [4]. Furthemore, Beck [5] showed that superstatistics can be obtained as a *slow modulation* process, *i.e.*, a process with slowly changing parameters.

On the other hand, there is an increasing conviction [6] that anomalous diffusion, and especially sub-diffusion, might find a satisfactory theoretical framework in the *subordination* perspective. This can be thought as a generalization of the Continuous Time Random Walk (CTRW) model, developed by Montroll and co-workers (see, for example, Montroll and Weiss [7]). In the CTRW model, the Waiting Time (WT) between two consecutive jump events, generating the walker diffusion, is not fixed but is randomly drawn from a given distribution. Being WTs independent from each other, the CTRW model is based on concepts and ideas of *renewal theory* [8] and in agreement with the existence of renewal (unpredictable) events, which have the main property of erasing memory of the past in the trajectories of the system. Also the subordination perspective is based on renewal theory and extends this procedure to the case of fluctuation-dissipation, thereby applying also to cases where diffusion is balanced by friction.

In this contribution we shall illustrate, with physical arguments, that renewal-subordination perspective seems to be the best approach for the description of BQD behaviour. Firstly, we shall show that these two different perspectives (slow modulation and renewal-subordination), yielding the same non-Poisson distribution of waiting times, actually produce less evident effects, *aging* and *lack of aging*, and that a difference on these less evident properties makes it possible for us to experimentally assess which theoretical perspective is closer to the real physics of blinking quantum dots. More precisely, we show that a renewal process, with power-law distribution of the WTs, yields aging, while a slow modulation process does not, even if producing the same power-law distribution of WTs. Performing a novel time series analysis based on renewal-subordination perspective we find, in agreement with Brokman et al. [9], that experimental BQD data show aging .

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