Multiscale phenomena in molecular matter



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Non-exponential relaxation: multiscale or nonlinear phenomenon?

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A distribution of relaxation times results in relaxation describable by formulae more complex than a single decreasing exponential function. A known example is the stretched exponential function

encountered in systems of very different nature starting from mechanical strain, electric and magnetic polarisation through electronic transitions to photoluminescence [1]. An official report of the National Academy of Sciences of USA calls it a "universal function for slow processes"[2]. The function possesses its inverse Laplace transform that allows one to treat it as a continuous linear combination of purely exponential decays [3]. This kind of behaviour would be, thus, a signature of a set of linear subsystems relaxing in all possible time scales. The corresponding impulse response function (Green's function), i.e. the response of the system to the Dirac's delta-like perturbation, can be obtained in the following way

 $<i>g(t)=-\partial u(t)\partial t=t^{\alpha-1}exp(-(t/\tau)^{\alpha})\tau^{\alpha}</i>. (2)$

Noteworthy is a singularity at t = 0 for 0 < &alpha < 1. An experiment providing both the relaxation function and the impulse response, and verifying their relation (eq. (2)), would be an evidence of a multiscale origin of the phenomenon. On the other hand, a non-exponential decay may be described as a relaxation of a single anharmonic element without any recourse to different time scales. An example is a power-law decay $<b<i>u(t)=u₀(1+(\delta-1)u₀<5-1</sub>(t-t₀)(sub>)(sub>)(\delta-1)</sub>(1+(\delta-1)u₀<5-1</sub>(1+(\delta-1)u₀<5-1</sub>(1+(\delta-1)u₀<5-1</sub>(1+(\delta-1)u₀<5-1</sub>(1+(\delta-1)u₀<5-1</sub>(1+(\delta-1)u₀<5-1</sub>(1+(\delta-1)u₀<5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><5-1</sub><t5-1</tb>1</sub><t5-1</td>1</sub><t5-1</td>1</sub><t5-1</td>1</sub><t5-1</td>1</sub><t5-1</td>11</td$

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