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Abstract

Non-Debye vs. Debye Dielectric Relaxation: How Does Memory Effect Arise? †

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The Debye model presents an essential and elegant description for the relaxation phenomena based on statistical mechanics. However, this model describes systems characterized by a single relaxation time as perfect liquids and crystals, quite far for the complexity which affects almost all amorphous and glassy materials.

The Debye model has been used as a starting point for other dielectric relaxation theories, named non-Debye (or anomalous) relaxation models, as for example the Havriliak-Negami relaxation model.

All these models show a power law decay behaviour for the response function as experimentally proved. A useful and powerful mathematical tool for investigating this behaviour is the fractional calculus.

The present study deals with a novel approach involving a fractional generalization for the time and frequency variables.

This approach allows us to generalize the Debye's idea to more complex systems addressing the problem from another point of view complementary to the well-known one ruled by fractional calculus.

In particular this method examines the time-domain response function defined in terms of a Gamma distribution. The complete monotonicity of the pulse response function follows directly from our investigations.

Moreover, this method encourages the emergence of the fading memory effects as an intrinsic feature of these complex systems due to the presence of the Gamma distribution.

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