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Theory of dielectric relaxation in non-crystalline solids: from a set of micromotions to the averaged collective motion in the mesoscale region

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Abstract

Based on the rather general decoupling procedure that reduces a set of micromotions to the averaged collective motion in the mesoscale region, a consistent and general theory of dielectric relaxation describing a wide set of dielectric spectroscopy (DS) data measured in a certain frequency/temperature range can be developed. The new theory explains and generalizes the Vogel–Fulcher–Tamman (VFT) equation and leads to the new type of kinetic equation, containing non-integer operators of differentiation and integration combined in the specific triads. Each triad combines three operators: the first non-integer operator has a real exponent, the other two form a pair of non-integer operators having the complex conjugate power-law exponents. This approach explains naturally the 'universal response' (UR) phenomenon discovered by Jonscher in a wide class of heterogeneous materials and confirms the justified data-curve fitting approach developed previously as a phenomenological tool for the analysis of raw complex permittivity data. It explains and generalizes some well-established experimental facts and contains also new predictions that can be verified in the experiment. This general approach helps to find the proper place for the DS as a science studying the different types of the 'reduced' collective motions and their various interactions with each other in the mesoscale region. This new theory explains also the fact *why* kinetic equations containing non-integer operators are realized in reality. They are necessary for description of slow collective motions which are probably realized in the intermediate range of scales not only in DS. Reology and mechanical relaxation represent also interesting and not well-understood phenomena, where the 'fractional' kinetics will find its proper place.

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