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# Hierarchy of dielectric relaxation times in water

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## Abstract

This work presents a simple model, which allows us to obtain the relation between macroscopic and microscopic dielectric relaxation times in water on the basis of the Zwanzig–Mori formalism for the time correlation functions. In the model it is supposed that water consists of areas, so-called clusters, the size of which are defined by the dipoles spatial correlation radius. The macroscopic dielectric relaxation time of a sample is the relaxation time of the cluster polarization. The obtained relation between macroscopic and microscopic dielectric relaxation times contains the parameters depending on the cluster shape and structure. Such an approach is valid for the associated liquids having one macroscopic relaxation time only. As to systems with the wide distribution of relaxation times this approach demands generalization. © 2002 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

Water properties are the subject of investigations in physics, chemistry, biology and different applied fields of natural science. In spite of a great number of works devoted to liquid water there is no unified understanding of the experimental data being observed. The presence of several types of intermolecular interactions let the water show rather a complex associated structure due to which it has a number of its abnormal properties. Dielectric spectroscopy development led us to the fact that

the complex dielectric permittivity frequency spectrum including infrared and optical ranges became a parameter covering the frequency range from  $10^{-5}$  Hz up to  $10^{16}$  Hz. The dielectric spectrum embraces the microscopic water dynamics over the entire frequency range at once. The high frequency part of the water dielectric spectrum beginning from the infrared range has the clear and definite notion. As to the low-frequency part where the molecular and collective processes play an essential role there is no concordant understanding.

Until now the low-frequency dielectric spectrum of water does not have a complete interpretation despite the extensive experimental data accumulated lately. Even the well-investigated Debye-like relaxation range of the spectrum is still a subject of discussion [1]. The interesting fact is that the principal dielectric relaxation band in

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