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THEORY OF TRANSPORT PROCESSES AND THE METHOD OF THE NONEQUILIBRIUM STATISTICAL OPERATOR

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The aim of this paper is to provide better understanding of a few approaches that have been proposed for treating nonequilibrium (time-dependent) processes in statistical mechanics with the emphasis on the interrelation between theories. The ensemble method, as it was formulated by Gibbs, has great generality and broad applicability to equilibrium statistical mechanics. Different macroscopic environmental constraints lead to different types of ensembles, with particular statistical characteristics. In the present work, the statistical theory of nonequilibrium processes which is based on nonequilibrium ensemble formalism is discussed. We also outline the reasoning leading to some other useful approaches to the description of the irreversible processes. The kinetic approach to dynamic many-body problems, which is important from the point of view of the fundamental theory of irreversibility, is alluded to. Appropriate references are made to papers dealing with similar problems arising in other fields. The emphasis is on the method of the nonequilibrium statistical operator (NSO) developed by Zubarev. The NSO method permits one to generalize the Gibbs ensemble method to the nonequilibrium case and to construct a nonequilibrium statistical operator which enables one to obtain the transport equations and calculate the transport coefficients in terms of correlation functions, and which, in the case of equilibrium, goes over to the Gibbs distribution. Although some space is devoted to the formal structure of the NSO method, the emphasis is on its utility. Applications to specific problems such as the generalized transport and kinetic equations, and a few examples of the relaxation and dissipative processes, which manifest the operational ability of the method, are considered.

Keywords: Statistical mechanics; irreversible thermodynamics; ensembles; nonequilibrium processes; transport phenomena; nonequilibrium statistical operator; generalized kinetic and evolution equations; dissipation.

1. Introduction

We may say that equilibrium statistical mechanics is mainly statistical, whereas the nonequilibrium statistical mechanics is mainly mechanical.

Radu Balescu

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