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L. Leuzzi and T.M. Nieuwenhuizen: Thermodynamics of the Glassy State

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The monograph by L. Leuzzi and T.M. Nieuwenhuizen is a general overview of the modern theory of glasses. Starting from basic thermodynamic principles, the authors explore recent theoretical advances such as the emergence of effective temperatures in the relaxation processes that characterize glassy systems. A number of solvable models are studied and allowing a general thermodynamic picture of these systems to emerge from the analysis.

An important aspect of glassy systems that has received considerable attention for an extended period is the idea about the existence of an effective temperature describing nonequilibrium properties of the glassy state. In the last decade many advances have been made to understand the physical effects of these effective temperatures. These have generally been presented in journals and specialized conferences. The book by L. Leuzzi and T.M. Nieuwenhuizen presents a new two-temperature thermodynamics for the glassy state which may serve as a new approach to the subject for condensed matter physicists.

The book consists of seven chapters. The first is a short review of the basic properties of glasses and glass-forming liquids and serves to introduce the main aspects discussed throughout the book. The second introduces the basic notion of two-temperature thermodynamics and defines the concept of *effective temperature* through a generalization of the fluctuation-dissipation theorem extended to the nonequilibrium regime.

In Chaps. 3, 4 and 5 these concepts are analysed in the framework of exactly solvable models. These simplified models allow for a deep understanding of the possibilities and limitations of two-temperature thermodynamics. Chapter 3 is devoted to models of Monte Carlo oscillators where the asymptotic decoupling of timescales is the basis for a generalization of equilibrium thermodynamics to systems out of equilibrium. Particularly interesting is the discussion of the Kovacs effect in the HOSS (harmonic oscillators-spherical spins) pointing out one of the limitations of the aforementioned two-temperature thermodynamics. In Chap. 4 the authors introduce aging urn models which historically have played a very important role in the formulation of fundamental concepts of statistical mechanics (such as

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fluctuations out of equilibrium). In particular, a detailed study of the Backgammon Model (BG) and its nonequilibrium relaxation is presented. In this chapter the reader will find a very enlightening discussion of the collective modes which appear in the disordered version of the BG. Chapter 5 is devoted to the directed polymer model putting forward the picture of a hierarchical structure of phase space.

Chapter 6 discusses the concept of effective temperature within the potential energy landscape approach analysing different models such as the random energy model, the random orthogonal model, and many-body glassy models. This chapter is very useful for those researchers interested in computer models with applications in condensed matter physics.

Finally, the last chapter reviews some well established theories of the glassy state such as the mode-coupling theory for undercooled liquids or the replica theory for mean-field glasses. This chapter also provides an updated bibliography of recent theories of the glassy state.

Thermodynamics of the glassy state is a very useful introductory reference to researchers interested in glassy systems; it provides a very well written introduction to the phenomenology of glasses and a deep review of different models and theories. However, the nonspecialist reader may find difficulties to follow the exhaustive mathematical calculations carried out throughout the book.

This book is also useful to the researchers with experience in glasses and glassy systems who will find a systematic analysis of the recent theoretical advances in the field together with deep reflections on the new concepts. It must be said that the expert reader could miss some attention paid to kinetically constrained models.

The monograph by L. Leuzzi and T.M. Nieuwenhuizen will almost certainly be an essential item in the library of any researcher working in the field in the foreseeable future.