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The Exotic Thermodynamic States and Negative Absolute Temperatures

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Abstract
Heat, entropy and temperature are the key fundamental concepts of thermodynamics. The present work gives a concise overview of the fundamentals and applications of these basic notions of physics, including the new developments on this issue. These include the finite-size systems and the negative absolute temperatures. We suggest to discuss these issues under a new angle, namely by considering such systems as certain exotic thermodynamic states. For the ordinary thermodynamic states temperature increases with increasing energy. It changes from zero, asymptotically approaching positive values (up to infinity) when the energy increases. For exotic thermodynamic states the entropy may not increase when the energy increases, i.e., when energy is added to the system. This concise review discusses and critically examines various opinions and both the applications and foundations of the negative absolute temperature concept. We are focusing on the analysis of physical clarity of the various approaches to the problem as well as on their consistency with the basic notions of statistical thermodynamics such as the thermodynamic limit.

Keywords Thermodynamics · The exotic thermodynamic states · The concept of temperature · The ultra high and very low temperatures · Spin temperature · Negative absolute temperatures · The Gibbs and Boltzmann entropy

1 Introduction

> Classical thermodynamics is the only physical theory of universal content concerning which I am convinced that, within the framework of the applicability of its basic concepts, it will never be overthrown. A. Einstein

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