Preface

Yet another book about thermodynamics? Wherefore? This almost 200-year-old physics subject is being discussed in depth and presented in a plethora of textbooks extensively. It is not my intention to add one to this number. It is the experience in modern research problems dealing with matter under extreme conditions which challenges me to write a book about this topic. Physical matter at high energy, velocity and momenta, under extreme acceleration or deceleration, or by another particular circumstance, such as unusual complexity, does behave strangely. Talking about extremely high or low, by the familiar thermometer not measurable temperatures, leads us not only to the question, what is the temperature of such matter, but also to the question, whether the very concept of absolute temperature is applicable: Is there a temperature at all?

The more important this question becomes since the "social" disciplines of physics, like biological physics, econophysics, sociological models started to apply mathematical models and concepts originally devised for the study of "ordinary," i.e. atomic matter. These generalized statistical and stochastic models apply quantities analogous to the physical energy, to the entropic measure of order and disorder, and to the associated concept of absolute temperature. By such applications of physics, however, the exception seems to be the rule: most studied distribution properties are peculiar from the classical thermodynamics viewpoint. To give an example, the Black–Sholes model, describing pricing strategies for derivative financial transactions,[1] is mathematically a classical diffusion model, like the Fokker–Planck equation. Meanwhile, it turned out that more realistic models describing the price fluctuations do show a fat tail, namely a non-Gaussian distribution. Such tails, frequently occurring as power-law tails, can be described as a result of anomalous diffusion. The general theory dealing with such distributions, as classical thermodynamics does with the canonical exponential energy distribution, is in its making currently. One of her tentative names is *non-extensive thermodynamics*.

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[1] The Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel was awarded to Robert C. Merton and Myron S. Sholes in 1997, who worked out this model in close collaboration with Fisher Black.

However, this book is not another introduction into non-extensive thermodynamics either. There are good books devoted to this task. The intention here is to present basic concepts at the very heart of statistical physics as they are challenged in high energy nuclear and particle physics by phenomena like energy distribution of particles irradiated from a fireball mimicking the Big Bang in little, like a quite formal use of absolute temperature as a parameter of higher than four-dimensional objects or like the particular behavior of colored noise in the dynamics of elementary fields. By doing so we particularly concentrate to the recurring question whether all the "anomalous" thermodynamics behavior is just a finite-size finite-time effect, or it survives the (in several cases only theoretical) limit of a large number of degree of freedom, commonly called the "thermodynamical limit." This question can presently be answered in the mathematical framework; the answers in physical experiments seem to be delegated to the future. Notably, also the question: Is there a temperature? in these exotic, highly energetic physical phenomena.

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