Preface

This book is a developed version of lecture notes that were prepared for graduate students at the University of Gothenburg and Chalmers University of Technology. It has the aim to fulfill two needs. First of all, it should summarize some of the relevant literature and provide a collection of results for anybody who works with statistical aspects of nanoparticles. Thermal processes are ubiquitous and a proper understanding of the field is necessary for a complete description of the physics of nanoparticles. It is therefore important to have collected a number of results that refer specifically to small particles and the special features they exhibit.

But a mere collection of literature results would limit the usefulness of the book. A textbook which only reviewed literature results would run a serious risk of degenerating into a supermarket for shopping for the equation which seemed to fit some particular data set. The other purpose is therefore to derive results from scratch in a manner that allows the reader to follow the important steps in the derivation and to gain an understanding of the applicability and the limitations of the equations, both from the literature and of the homegrown variety. The term 'homegrown' does not carry any derogatory meaning. As with food, homemade may be worse or better than dishes sold ready-made. And as with food, one usually wants to know the ingredients before the dish is consumed. One important *leitmotif* of the derivations presentated here is to make it clear to the reader what are physical assumptions and what are mathematical approximations. A calculation of some physical quantity may at the same time be extremely precise, less accurate and completely unreliable. One should not confuse precision in the numerical estimate of the consequences of a model with the accuracy with which the model has been derived. And one should under no circumstances confuse the accuracy of a model calculation with its reliability.

With these two purposes in mind, the material in this book is often presented in more than one way and some of it is redundant from a strictly logical point of view. Occasionally models are elaborated beyond the applicability to a real physical system. The purpose of this is mainly to explore the limits of the approximations and demonstrate the power of the methods. On the other hand, some problems are presented and solved with a degree of simplification which is not on par with the

best available experimental data of specific systems. The reader should be equipped with the necessary tools to improve on the text and to provide their own solutions for specific systems. The text also contains subjects and subsections that are intended to provide examples and illustrations. I trust that the reader will be able to distinguish between fundamental results, applications and illustrative examples.

The book has a strong emphasis on microcanonical physics. Supported particles are very relevant for applications of nanotechnology but fundamental properties of nanosystems are best studied free of the disturbing and frequently uncontrolled influence of a substrate. A large number of experiments have been and more will be performed in molecular beams, ion traps and storage rings, for which the microcanonical description is the appropriate one. But since microcanonical properties can be converted to canonical by a simple integration, also workers who equilibrate their particles to a external heat bath should find useful results here.

Books on statistical physics are full of equations. Remarkably, one can get away with very little advanced mathematics and yet describe a very wide range of observable phenomena. The number of equations is therefore not a measure of the level of mathematical sophistication the student is required to master. They are simply there to show how one gets from point a to point b, and to show how point b looks like. After all, equations are economically expressed figures.

This book contains material which is covered in most basic courses on statistical physics. Experience has shown that these skills often need to be brushed up and that some recapitulation of subjects is necessary in practice. When the present text falls short of this target, the reader can consult the additional reading list in Appendix A.

I have received a number of suggestions for the contents and corrections to the text that have helped immensely, from O. Echt (Chaps. 1, 3, 6), V.V. Kresin (Chap. 10), and from students who have taken my course. But as the sole author of this manuscript I have no other to blame for its shortcomings.

Perfectionism is only the desire to spend time admiring your (almost) completed work, and it is time to publish this volume. Readers will hopefully report suggestions, misprints, miscalculations and plain errors to me at klavs.hansen@physics.gu.se.

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