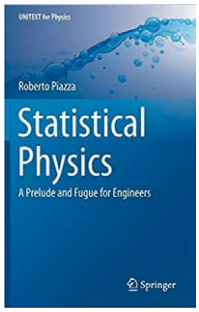

Roberto Piazza

Statistical Physics
A Prelude and Fugue for Engineers

UNITEXT for Physics. Springer Nature, 2017

hardcover: pp. XV + 453, € 72,79
ISBN: 978-3-319-44536-6

e-book: € 59,49
ISBN: 978-3-319-44537-3

Gradus ad Parnassum in Statistical Physics

The first lesson of this textbook is the dedication at page iv "to all my students, who taught me the difficult art of teaching". I'm grateful to Roberto for adding in pencil my name below that line of my book copy, as I consider myself one of those students after learning so much from this book. I fully share the concept expressed in the dedication, which actually reflects the substance and the style of the book. Gaining new knowledge is a rewarding joint endeavour, and the logical clarification process which makes knowledge understandable to newcomers is an essential step of its transmission. Such clarification rests on the historical sequence of notions and the links, either instrumental or analogical, among different disciplines. In this way an interactive teaching may become an effective part of research.

The parallel with musical forms, providing the appropriate tune to the book and its chapters, recalls another basic aspect of science, the fundamental role of creativity and intuition on one side, and the essential need to be expressed in a rigorous language on the other side. It is implicit that the beauty of music and that of science have comparable aesthetic values: *Scientia reddit opus pulchrum,* wrote Bonaventure. Considering the original destination of the book to engineers, one may think of this statement as addressing to applied science, but the Preface admonishes the readers with Pasteur's words that there is no applied science, but only science applications. Far-reaching applications always start(ed) from a solid background in basic science and a curiosity-driven crossdisciplinary attitude. Due to present rapid increase of knowledge and technology, no student can hope today to learn in the class exactly what will be requested at the end of his studies. That's why high schools and university should first of all stimulate curiosity and open the mind of their students, more than just teaching a profession.

Another concept inspiring the author is that a valuable textbook should remain a good companion all along the professional career. This is here achieved with three levels of learning aids: the *basic requirements*, including also notions currently not included in engineer curricula such as the elementary concepts of quantum mechanics, etc.; the *focus on applications*, in harmony with the author's statement that *scientists aim to understand the world, engineers to change it*. The third level is *graded learning*: the book is organized in closely connected sections, which according to their marks (stars and playing-card suits) are suitable to the undergraduate, as well as to the graduate, and doc/post-doc levels: something worth being kept in the bookshelf for ever, and possibly integrated by the numerous additional readings suggested at the end of each chapter.

As we rapidly go through this symphony, we are first requested in Chapter 1 to play by ear the basic notions of classical thermodynamics: time and temperature, work, energy, entropy, thermodynamic potentials, up to the Brownian motion, casting our eyes into the microworld. This in introduced in Chapter 2 with the ouverture in B(oltzmann) major, *i.e.*, the statistical approach, from the thermodynamics of ideal gases to the Gibbs paradox and Maxwell-Boltzmann approximation. By comparing the worlds of Newton's apples and Schrödinger's cats and that of distinguishable and undistinguishable particles, quantum mechanics knocks on the door. It is opened at Chapter 3, accompanied by "easy rhytms and melodies": after a thorough discussion of *canonical* distributions, the specific heat of solids and the low-temperature enigma come about, solved by his majesty *h*-bar. The work by Petit et Dulong and the corresponding law, dating back to as early as 1819, offers the occasion for a masterful *intermezzo*, a pièce of history of physics illustrating "the bright and dark sides of experimental science". Together with the elementary, clear introduction to the dynamics of solids, the frequent reference to magnetic systems and models is quite appropriate on both the tutorial and applicative levels.

Chapter 4 *on fluid chords* moves to the statistical physics of real gases and charged fluids, "from plasmas to DNA", and to a precious (starred) section on the microscopic structure of liquids. It is indeed a *crescendo* the one which takes us to Chapter 5 on ferromagnetism, spontaneous symmetry breaking and the role of fluctuations, up to scaling and renormalization (the latter with their obvious stars). With the stat-physics of open systems and grand-canonical distributions we enter the vast world of inhomogeneous systems and gas-surface interactions (Chapter 6), but the growing importance in condensed matter of electrons and related optical properties, where energies largely exceed the experimental temperature, imposes low-temperature physics, *i.e.*, quantum mechanics and quantum statistics. Chapter 7 on "fuzzy and cool melodies" introduces the reader to fermions and bosons, overviewing the basic facts on which rests quantum statistical physics, say Planck's theory of the black-body spectrum, the theory of free electrons in metals, Bose-Einstein condensation and superfluidity, and, for refined listeners in search of stars, superfluid helium-3. All these extraordinary variations on the theme are closed by the canonical fugue.

The book is enriched by five appendices, A to E. A presents the mathematical tools necessary to a deeper understanding of statistical physics. B, quoting "the rest is noise" –a famous book by Axel Ross on XX century music– actually speaks of entropy and information, which in nonlinear thermodynamics could even lead to music (order) out of noise (chaos). C offers a substantial historical section illustrating the roots of fundamental concepts in statistical mechanics. Random walks, diffusion and the Langevin equation, the scattering of identical particles and the rules of detailed balance are summarized in D and E, the last notes of this excellent score. The colloquial style of the entire book, full of wit and humour, shows how one of the most exciting and important parts of physics can be conveyed (played) in the form of a *divertimento*, without being less rigorous and thorough than needed: a lesson for smart students and young professors training in the difficult art of teaching.

Giorgio Benedek
Università Milano-Bicocca