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A Short Journey from Quarks to the Universe

Selected Solutions

Springer

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There is, of course, an immense liberating role of Science at the central existential level. It is what Aristotle was saying about "θαυμάζειν". Science humanizes us, liberates us from our animal instincts, just because it makes us wondering and at the same time desiring to explain… Yet it shows us our limits and our mortality… Thus Science is something immeasurably precious…. Science can help us approach anew the real poetic and mythical dimension of human existence.

C. Castoriadis

To Christos, Eleni, Zinovia, Yiannis, and Evropi with wishes "για καλή στράτα" in life's pathway.

Suggested by A., of course

Preface

This short book grew out of lectures presented to different audiences (physics students, physicists, material scientists, engineers) and on various occasions (colloquia and seminars in physics and other departments, conferences, special events). The main purpose of these lectures and, obviously, of the present book is to show that basic formulae concerning the various structures of the *physical world* pop out quickly, if some *basic ideas*, the *universal physical constants, and dimensional considerations* are exploited. Of course, as R. Feynman pointed out, "a little thinking has to be applied too".

The basic ideas include the three cornerstones of science, namely the atomic idea, the wave-particle duality, and the minimization of free energy as the necessary and sufficient condition for equilibrium (these are presented in Chaps. 2, 3, and 4 respectively). These fundamental ideas exhibit their worth when accompanied by the values of the physical constants: the universal ones, $\hbar$, c, the coupling constants of the four interactions, G, e, g_w, g_s and the masses of the elementary particles, m_p, m_n, m_e, m_w,... An important consequence of the atomic idea is that the relevant (for each case) physical constants will appear in the quantities characterizing the various structures of the world (microscopic or *macroscopic*). Combining this last observation—often overlooked—with dimensional analysis, presented in Chap. 5, and "a little thinking", one can obtain, in several cases, an amazing short-cut derivation of formulae concerning the various structures of nature from the smallest (baryons and mesons) to the whole Universe, as shown in Chaps. 6–13. In each one of these 8 chapters, in parallel with a demonstration of the method just outlined, a *condensed* (sometimes too condensed) introduction to the relevant subject matter together with a few physical remarks are presented.

I must admit that the main fronts on which our horizons are widened, namely the *small*, the *large*, and the *complex* could not be treated even remotely adequately in this short book. Actually the *complex*, as represented by the living matter, was too complex for our simple method; so it was left out completely (however, see the epilogue). The *large* (cosmology) and the *small* (elementary particles) tend to converge to a unified subject (the snake in Fig. 1.1, p. 2, is biting

its tail) fed with novel observational data from special instruments mounted usually on satellites, and boosted by high experimental expectations from the Large Hadron Collider. Nevertheless, in these fields there are several open fundamental questions concerning conditions well beyond our present or near future experimental capabilities. This vacuum of confirmed knowledge is filled with new, intriguing, imaginative ideas and novel proposed theories (such as supersymmetry, string theory, M-theory, see reference [P1]) which, if established, will radically change our world view. In spite of the wider interest in these ideas and theories and their high intellectual value, I decided for several reasons to restrict myself in the present book to experimentally or observationally tested ideas and theories.

The intended readers of this book are senior undergraduate or graduate students in Physics, Engineering, Applied Mathematics, Chemistry, and Material Science. They may find the book a useful supplement to their courses as a concise overall picture of the physical world. Research physicists, physics teachers, and other scientists may also find this short book intellectually stimulating and entertaining. The required background is no more than a *working* familiarity with the first year Science or Engineering material.

I am deeply indebted to my colleague, Prof. V. Charmandaris, for his encouragement during the writing of this book and for reading my entire manuscript and making many useful suggestions. Of course, whatever misprints or misrepresentations remained are my own responsibility only. I am also grateful to Ms Maria Dimitriadi for her invaluable help in bringing my manuscript to its final form.

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