

The background of the cover is a vibrant cosmic scene featuring a large, dark, filamentary nebula structure, possibly the Carina Nebula, set against a deep blue and purple starry sky. Numerous bright stars are scattered throughout, some with prominent diffraction spikes. The overall color palette is dominated by blues, purples, and oranges, creating a sense of depth and wonder in space.

Ross Barrett
Pier Paolo Delsanto

DON'T BE

Quantum Mechanics, Relativity

AFRAID OF

and Cosmology for Everyone

PHYSICS

 Springer

Don't Be Afraid of Physics

Ross Barrett · Pier Paolo Delsanto

Don't Be Afraid of Physics

Quantum Mechanics, Relativity and
Cosmology for Everyone



Springer

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ISBN 978-3-030-63408-7 ISBN 978-3-030-63409-4 (eBook)
<https://doi.org/10.1007/978-3-030-63409-4>

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The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

Getting to the top of a high mountain without any effort, e.g. with a cable car or a helicopter, may perhaps seem to make no sense, since all the feelings of adventure and achievement are lost. Likewise, wanting to learn physics without bearing the effort of fathoming the intricacies of its equations and having to face the quagmire of its daunting theories could also be considered questionable or even futile. Yet, trying to allow non-scientists to understand the foundations and beauty of physical theories has been a goal of many pioneers of the field, and I have myself greatly benefited from their endeavours.

I remember with a vivid emotion my first reading of *The Evolution of Physics* by Albert Einstein and Leopold Infeld, which had precisely the purpose of introducing the non-initiated to the wonderful world of science in general and physics in particular. Their book led me to a gratifying level of satisfaction for the qualitative understanding of the basic concepts which I had reached, accompanied later on by an inevitable dissatisfaction, due to the lack of a more quantitative understanding, which I (partially) achieved only after a university degree in physics (following a first one in engineering). In other words, if I became a scientist, it is partly thanks to such a book.

The present book is framed in this context, taking advantage of a modern approach and of the extraordinary advances, achieved in the field of physics and related applications in the last century or so. Should anybody have any doubt about the flourishing progress (or rather explosion) of the field,

it is enough to recall the *Quantum Technologies Flagship* (a major initiative by the European Commission to support quantum technology research) and, of course, similar initiatives worldwide. We are already fully immersed in a second quantum revolution, with untold scientific and technological consequences for everyone.

The book of Barrett and Delsanto is ideally suited in this context, since it covers all major fields of current research in physics, with a language which is simplified as much as possible, but not *oversimplified* (to quote one more time Einstein), and devoid of any mathematical formula. Well, to be honest, there is one formula, and I will let everyone try to figure out for themselves, *which one*. In short, the book should represent an entertaining reading for curious minds, since it also offers nice *short stories*, to illustrate the contents of each chapter, plus a myriad of anecdotes and asides.

The main purpose of the book should be, in my opinion, as a textbook for courses of science for college students majoring in a non-scientific field, since it teaches a great amount of modern physics without being a burden for them. But it also can be very useful for students majoring in a scientific field, since very seldom are they offered courses covering all the topics discussed in the book. Equally important, the first part of the book analyses concepts, which are prerequisite to a solid formation in science, such as the meaning of understanding, reality and accuracy, both from a philosophical and a scientific point of view.

It is a sad fact of life that in an epoch in which most people enjoy the benefits of modern technologies, and new relevant discoveries are made on a daily basis in all disciplines from physics to chemistry to biology to medicine, in spite of all of that, superstition, prejudices against science and profound ignorance coexist and often prevail. Part I of the book should help to let people around us gain an understanding of why we need good science.

Finally, from a personal point of view, what I probably like most is Part III, which provides an anticipation of the future directions of the field and possible solutions of the current *open problems*. Here, everything seems to be non-dogmatic, well-motivated and very *reasonable*. Yet, at the end of a long discussion, we are left permeated by an almost unshakeable certainty that the future will reserve to us a quite different scenario, with wonderful unpredictable surprises. Science is all but boring!

To conclude, the book encompasses essentially all relevant modern physics and is described in a language comprehensible to the non-scientist. The authors, physicist Ross Barrett, former Research Leader at the Defence Science and Technology Organisation, Adelaide, Australia, and Pier Paolo

Delsanto, Senior Professor from the Politecnico of Turin, Italy, present difficult concepts, which would normally be accompanied by many pages of mathematics, in lucid logic with clear straightforward figures. Their book is for every curious person interested in better understanding the secrets of Nature.

And you, man, who considers in this work of mine the admirable works of Nature, if you judge it to be vile to destroy it, now think it the vilest thing to take away life from man; if this creation seems to you a wonderful artifice, think it as being nothing compared to the soul that lives in such architecture

Leonardo Da Vinci. See N. Pugno, [The commemoration of Leonardo da Vinci](#). MECCANICA (2019), 54, 15, 2317–2324.

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Acknowledgements

It is our pleasure to thank Prof. Angelo Tartaglia for his contribution to the present book by means of countless stimulating discussions and constructive advice. Professor Tartaglia co-authored an earlier book¹ with us on modern physics, and we would have been delighted to have him once again as a co-author. Unfortunately, this turned out to be impossible, due to a number of very pressing engagements on his side. In fact, he is currently serving as leader of one of the work packages of the Agenzia Spaziale Italiana (ASI) Agency *Galileo for Science* project. In addition, he is involved in several scientific programmes, such as measurements of dark matter effects and, in a completely unrelated context, energy sustainability and econometrics. We wish him success in these new endeavours.

¹R. F. Barrett, P.P. Delsanto and A. Tartaglia: *Physics: The Ultimate Adventure*, Springer 2016.

Introduction

One thing I have learned in a long life: that all our science, measured against reality, is primitive and childlike—and yet it is the most precious thing we have
—Albert Einstein [1].

In the modern world, science and technology are all around us. Almost every tool that we encounter on a daily basis is a product of modern technology. This trend¹ will continue, and even accelerate, in the foreseeable future. Adverse side effects from science, such as the creation of various means of mass destruction, climate change, pollution and overpopulation, attract and merit concern. The pros and cons of our *blind progress* are debated vigorously throughout the world on a daily basis, to the extent that science is seen by some to threaten the very existence of our species.

However, science, originally known as *natural philosophy*, was born because of the very human desire to understand the natural world. In undertaking this quest, we have let science lead us, as Ulysses led his sailors, into new and wonderful domains that stretch our imaginations and credulity. The journey is far from complete, and no end is in sight.

Unfortunately, to participate actively in this extraordinary adventure requires a thorough grounding in advanced mathematics, which is not available to all. With this book, we have attempted to guide the lay reader on

¹Called sarcastically *Le magnifiche sorti e progressive* (the magnificent and progressive fate) by the Italian poet, Giacomo Leopardi (1798–1837).

a journey of exploration to provide to everybody who is interested, at least a glimpse of the most challenging of nature's mysteries. We use no mathematics and include only one well-known formula. We begin our story with Neanderthal Man and end it with the foreseeable applications of quantum computing. In between, we will guide our readers not only along the well-established paths, but also to those regions where physics, which is our chosen discipline, is wavering in its choice of the path ahead. Along the way, we will often pause to lift our spirits with an occasional anecdote or short story, for, as with all voyages, our journey will be worth nothing unless we enjoy ourselves.

The book is divided into three parts. Part I deals with what we mean by science, its origins, methodologies and what differentiates it from other forms of human intellectual activity. Also, we note that there is such a thing as *good science* and *bad science* [2]; the latter can be worse than ignorance, and it is of primary importance to discriminate between the two.

Science began its existence as the deferential daughter of the noble discipline of philosophy. However, such has been the extraordinary progress of science and mathematics in the past 120 years that it now seems futile to us to speculate on how things should be (philosophy), without first having had a close look at how they are in reality. This leads, of course, to the question of what we mean by reality, which is by no means a trivial question, as we shall see in Chap. 1.

Part II of the book is an up-to-date² presentation of the state of the art in the most glamorous subfields of modern physics. We believe that a knowledge of these advances is an essential part of the cultural endowment of any educated human being. Too often, these fields are concealed behind the erudite mathematics and scientific jargon that is integral to science. Professional scientists sometimes forget that their work is funded almost entirely by the taxpayers, the general public of their respective countries. The knowledge that a privileged few unearth is a human right for everybody, akin to a UNESCO human heritage site. Quantum mechanics, general relativity and modern cosmology are the pyramids, Parthenon and cathedrals of our epoch, together, of course, with the most outstanding advances in other sciences.

By the time that readers arrive at Part III of the book, they will have concluded that although much has been discovered in the last century, there are still many gaps in our knowledge, and even contradictions between well-established theories. Newton once wrote: *I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore and diverting myself in now and then finding a smoother pebble or a prettier*

²Some areas of physics are advancing so quickly that even since the time of writing there will have been new developments, but we shall do our best.

shell than ordinary, whilst the great ocean of truth lay all undiscovered before me [3]. In the intervening three centuries, much progress has been made in the journey towards *truth*, but the boundaries of Newton's *great ocean* have not yet been charted.

In Part III, we indulge ourselves by exploring a few of the more speculative open questions of physics. We shall try to highlight some of the deficiencies in existing theories. In some cases, the finite limits of human resources may place the attainment of definitive answers beyond hope, in which case, if we wish to proceed further, we risk leaving physics and entering the domain of *metaphysics*.

Finally, before we begin our journey in earnest, let us remark that there is an alternative approach to the fundamental questions that underlie our book. This is, of course, religion. Religions (for there are many) are the antithesis of science, for they rely on faith, and not on observation. In Christianity, this difference is made explicit by the remark of Jesus to Thomas: *Because you have seen me, you have believed; blessed are those who have not seen and yet have believed* [4]. Our approach, which is entirely and solely based on reason and observations (or experiments), cannot be compared with religious beliefs, nor used to support, or to rebuff any of them. Its validity and usefulness are, however, underscored by the ever-growing number of tools, inventions and discoveries, which, in the modern world, are exploited on a daily basis.

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