

## BOOK REVIEW

### The Foundations of Physical Law

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**The Foundations of Physical Law** by Peter Rowlands, World Scientific, Singapore, 2015, pp. xiv + 247. Scope: monograph, £71 (or ebook £56), ISBN 978-981-4618-37-3 (Hardcover). Level: professional physicists and mathematicians, senior undergraduates, postgraduates.

Many physicists enter the profession because, often as children, they felt a burning curiosity about the world. They wanted to know why material objects behave as they do, what they are made of, and where everything came from. So they were drawn inexorably towards physics, the most basic science, as the the best place to seek answers. They will have found, however, that the answers only go just so far. Physics has constructed a world picture, a model of reality, that is based on well-established fundamental scientific laws. If one takes the latter as given then, at least in a broad-brush kind of way, one has an explanation of everything. But where do the laws themselves come from? This is the question that Peter Rowlands confronts directly in his interesting new book.

It is true that, without at least some intuition about the origin of the fundamental laws, our whole (extraordinarily successful) scientific edifice is floating and without firm foundation. In trying to remedy this uncomfortable situation, Peter Rowlands' aim is to focus on concepts like simplicity, minimalism, abstraction, symmetry, and recurring patterns, in the hope that thinking along these lines will lead towards the creation of a conceptual basis for physical law. Obviously, new ideas that contradict existing theories are to be eschewed. Rather, we should be looking for the simpler ideas and patterns that underpin existing theories and lead automatically to them. It is, as he puts it, "...a search for the common origins of all physical theories, and their common origin with mathematics, in effect the explanation of the 'unreasonable effectiveness' of mathematics in physics and of physics in mathematics". It is a challenging and ambitious agenda.

The initial context-setting chapter points out that the subject is "risky" due to its lack of status, career structure, funding, impact and so on: it is not yet an accepted part of the physics discipline. It is also unusual, and peculiarly difficult, in that the final goal of the enterprise is to find the starting point. The reader is thoughtfully introduced not only to the problems and challenges, but also to the nature, fascination, and extraordinary importance of the topic. Peter Rowlands reminds the reader that nearly all properties that we are familiar with are emergent properties arising from the complexity of simpler underlying systems. For example, notions like solidity or of extended objects have no meaning at a fundamental level, because the reality is just arrays of points in otherwise empty space. He also discusses the approaches and principles to be used – basically favouring simplicity, avoiding the arbitrary, looking for patterns and symmetry, and indulging in inductive thinking.

Mathematics is the key to Peter Rowlands' approach, and he provides a whole chapter about the particular kinds of slightly-off-mainstream mathematics that are going to be needed later.

One example is quaternions (and octonions), which to most physicists these days, are musty relics from a bygone Victorian era that have long since been replaced by our now conventional vector algebra. They are totally misguided in this view, however, as is convincingly demonstrated. The book goes on to develop different ways of looking at measurement, conservation laws, symmetry, quantum mechanics, quantum field theory, gravity, and particles – in fact, the whole of physics at a fundamental level.

The author has effectively created Foundations of Physics as a new subdiscipline within physics, quite different to anything that went before, even though names may have been similar. Although I cannot pretend to have understood every aspect, I found the the book fascinating and would commend it warmly to all physicists interested in the fundamentals of our subject. It originated in a series of 10 well-attended lectures given by Peter Rowlands at Liverpool University, of which at least two are publicly available: <https://www.youtube.com/watch?v=W2XdhzCORbo>. The lectures, and the speaker's answers to questions from members of the audience, convey effectively the scholarship and spirit of enquiry that characterise the book.

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