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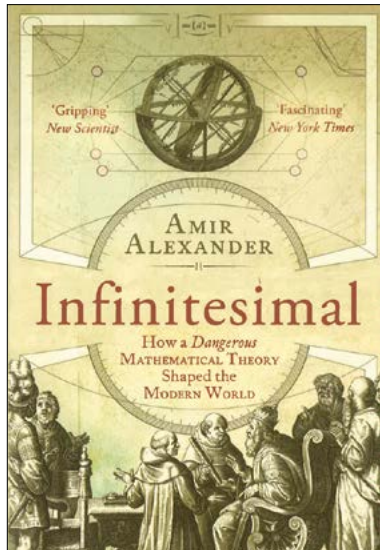
Infinitesimal: How a Dangerous Mathematical Theory Shaped the Modern World

By Amir Alexander
One World

Lying midway between the history and the philosophy of science, this book illuminates a fascinating period in European history during which mathematics clashed with common thought and religion. Set in the late 16th and early 17th centuries, it describes how the concept of infinitesimals – a quantity that is explicitly nonzero and yet smaller than any measurable quantity – took a central role in the debate between ancient medieval ideas and the new ideas arising from the Renaissance. The former were represented by immutable divine order and the principle of authority, the latter by social change and experimentation.

The idea of indivisible quantities and their use in geometry and arithmetic, which had already been developed by ancient Greek mathematicians, underwent its own renaissance 500 years ago, at the same time as Martin Luther launched the Reformation. The consequences for mathematics and physics were enormous, giving rise to unprecedented scientific progress that continued for the following decades and centuries. But even more striking is that the new way of thinking built around the concept of infinitesimals crossed the borders of science and strongly influenced society, up to the point that mathematics became the main focus of the struggle between the old and new orders.

This book is divided into two parts, each devoted to a particular geographical area and period in which this battle took place. The first part leads the reader to late 16th century Italy, where the flourishing and creative ideas of the Renaissance had given birth to a prolific number of mathematicians and scientists. Here, the prominent figure of Galileo Galilei – together with Evangelista Torricelli, Bonaventura Cavalieri and others – was at the forefront of the new mathematical approach involving the concept of infinitesimals. This established the basis of inductive reasoning, which makes broad generalisations from specific observations, and led to a new science founded on experience. On the opposite side, the religious congregation of the Jesuits used these same mathematical developments in its fight against heresy and the Reformation. To them, the traditional mathematical approach was a solid basis for the absolute truth represented by the Catholic faith and the authority of the Pope. The fierce



opposition of the Jesuit mathematicians led Galileo and the “infinitesimalists” to damnation, with irreparable consequences for the ancient tradition of Italian mathematicians.

The second part of the book moves the reader to 17th century England, just after the English Civil War in the years of Cromwell’s republic and the Restoration. In that context, the new ideas represented by infinitesimals were not only condemned by the Anglican Church but also opposed by political powers. Here, the leading figure of Thomas Hobbes took the stage in the fight against the indivisibles and the inductive method. For him, traditional Euclidean geometry – which, contrary to induction, used deduction to achieve any result from a few basic statements – was the highest expression of an ordered philosophical system and a model for a perfect state. Hobbes was also concerned about the threat to the principle of authority that emanated from traditional mathematical thought. In his struggle against infinitesimals, he was confronted by the members of the newly founded Royal Society, eager for scientific progress. Among them was John Wallis, who considered mathematical knowledge as a “down-up” inductive system in which calculus played the role of experiments in physics. Solving many of the toughest mathematical problems of his times by infinitesimal procedures, Wallis defeated traditional geometry – and Thomas Hobbes with it. The triumph of Wallis made way

for scientific progress and the advance of thought that opened the door to the Enlightenment.

This book is excellently written and its mathematical concepts are clearly explained, making it fully accessible to a general audience. With his fascinating narrative, the author intrigues the reader, depicting the historical background and, in particular, recounting the plots of the Holy See, the Jesuits’ fight for power, the Reformation, the absolutist power of the kings, and the early steps of Europeans towards democracy and freedom of thought. The book includes extensive notes at the end, a useful index of concepts, a timeline and a “*dramatis personae*” section, which is divided between “infinitesimalists” and “non-infinitesimalists”. Finally, the images and portraits included in the book enhance the enjoyment for the reader.

● Pablo Fernández Martínez, CERN.

The Many Faces of Maxwell, Dirac and Einstein Equations: A Clifford Bundle Approach (2nd edition)

By Waldyr A Rodrigues Jr and Edmundo Capelas de Oliveira
Springer

In theoretical physics, hardly anything is better known than the Einstein, Maxwell and Dirac equations. The Dirac and Maxwell equations (as well as the analogous Yang–Mills equations) form the basis of the modern description of matter via the electrodynamic, weak and strong interactions, while Einstein’s equations of special and general relativity are the foundations of the theory of gravity. Taken together, these three equations cover scales from the subatomic to the large-scale universe, and are the pillars on which the standard models of cosmology and particle physics are built. Although they constitute core information for theoretical physicists, they are rarely, if ever, presented together.

This book aims to remedy the situation by providing a full description of the Dirac, Maxwell and Einstein equations. The authors go further, however, by presenting the equations in several different forms. Their aim is twofold. On one hand, different expressions of these famous formulae may help readers to view a given equation from new and possibly more fruitful perspectives (when the Maxwell equations are written in the form of the Navier–Stokes equations, for instance, they allow a hydrodynamic interpretation of the electrodynamic field). On the other hand, casting different

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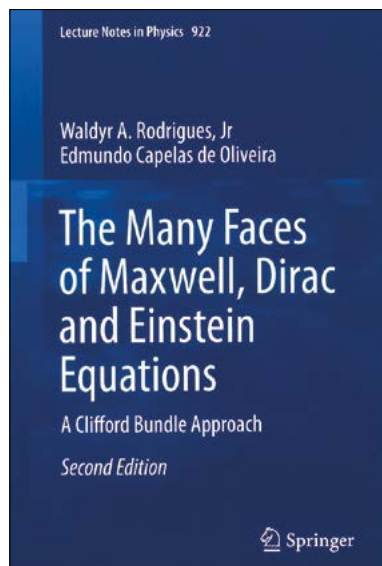
equations in similar forms may shed light on the quest for unification – as happens, for example, when the authors rewrite Maxwell's equations in Dirac-like form and use this to launch a digression on supersymmetry.

Another feature of the book concerns concepts in differential geometry that are widely used in mathematics but about which there is little knowledge in theoretical physics. An example is the torsion of space–time: general differential manifolds are naturally equipped with a torsion in addition to the well-known curvature, and torsion also enters into the description of Lie algebras, yet the torsional completion of Einstein gravity, for instance, has been investigated very little. In the book, the authors take care of this issue by presenting the most general differential geometry of space–time with curvature and torsion. They then use this to understand conservation laws, more specifically to better grasp the conditions under which these conservation laws may or may not fail. Trivially, a genuine conservation law expresses the fact that a certain quantity is constant over time, but in differential geometry there is no clear and unambiguous way to define an absolute time.

As an additional important point, the book contains a thorough discussion about the role of active transformations for physical fields (to be distinguished from passive transformations, which are simply a change in co-ordinates). Active transformations are fundamental, both to define the transformation properties of specific fields and also to investigate their properties from a purely kinematic point of view without involving field equations. A section is also devoted to exotic or new physical fields, such as the recently introduced “ELKO” field.

Aside from purely mathematical treatments, the book contains useful comments about fundamental principles (such as the equivalence principle) and physical effects (such as the Sagnac effect). The authors also pay attention to clarifying certain erroneous concepts that are widespread in physics, such as assigning a nonzero rest mass to the photon.

In summary, the book is well suited for anyone who has an interest in the differential geometry of twisted–curved space–time manifolds, and who is willing to work on generalisations of gravity, electrodynamics and spinor field theories (including supersymmetry and exotic physics) from a mathematical perspective. Perhaps the only feature that might discourage a potential reader, which the authors themselves acknowledge in the introduction, is the considerable amount of sophisticated



formalism and mathematical notation. But this is the price one has to pay for such a vast and comprehensive discussion about the most fundamental tools in theoretical physics.

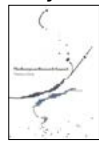
● Luca Fabbri, INFN Bologna, Italy.

Books received

The European Research Council

By Thomas König

Polity Press



Established in 2007 to fund frontier-research projects, the European Research Council (ERC) has quickly become a fundamental instrument of science policy at European level, as well as a quality standard for academic research. This book traces the history of the creation and development of the ERC, drawing on the first-hand knowledge of the author, who was scientific adviser to the president of the ERC for four years. It covers the period between the early 2000s – when a group of strong-minded scientists pushed the idea of allocating (more) money to research projects selected for the quality of the proposals, judged by independent, competent and impartial reviewers – and when the first ERC programme cycle was concluded in 2013.

The author is particularly interested in the politics behind those events and shows how the ERC could translate into reality thanks to the fact that the European Commission decided to support it, using a much more strategic, planned and technical approach.

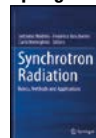
He also describes the way that the ERC was implemented and the creation of its scientific council, discusses the “hybrid” nature of the ERC – being somewhere between a programme and an institution – and the consequent frictions in its early days, as well as the process to establish a procedure for selecting applications for funding.

While telling the story of the ERC from a critical perspective and examining its challenges and achievements, the book also offers a view of the relationship between science and policy in the 21st century.

Synchrotron Radiation: Basics, Methods and Applications

By S Mobilio, F Boscherini and C Meneghini (eds)

Springer



Observed for the first time in 1947 – and long considered as a problem for particle physics as it can cause particle beams to lose energy – synchrotron radiation is today a fundamental tool for characterising nanostructures and advanced materials. Thanks to its characteristics in terms of brilliance, spectral range, time structure and coherence, it is extensively applied in many scientific fields, spanning material science, chemistry, nanotechnology, earth and environmental sciences, biology, medical applications, and even archaeology and cultural heritage.

The book reports the lecture notes of lessons held at the 12th edition of the School on Synchrotron Radiation, held in Trieste, Italy, in 2013 and organised by the Italian Synchrotron Radiation Society in collaboration with Elettra-Sincrotrone Trieste. The book is organised in four parts. The first describes the emission of synchrotron and free-electron laser sources, as well as the basic aspects of beamline instrumentation. In the second part, the fundamental interactions between electromagnetic radiation and matter are illustrated. The third part discusses the most important experimental methods, including different types of spectroscopy, diffraction and scattering, microscopy and imaging techniques. An overview of the numerous applications of these techniques to various research fields is then given in the fourth section. In this, a chapter is also dedicated to the new generation of synchrotron radiation sources, based on free-electron lasers, which are opening the way to new applications and more precise measurements.

This comprehensive book is aimed at both PhD students and more experienced researchers, since it not only provides an introduction to the field but also discusses relevant topics of interest in depth.