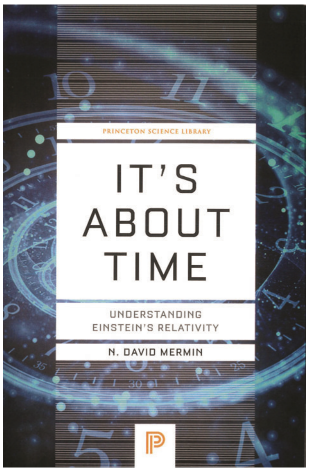

It's About Time: Understanding Einstein's Relativity. N. David Mermin. Princeton University Press, 41 William Street, Princeton, New Jersey 08540, USA. 2021. xv + 192 pages. Price: US$ 16.95.

A book to expose Einstein's special theory of relativity to high-school students, from an exceptionally skilled pedagogue like David Mermin (Cornell University), will no doubt attract attention beyond its intended readership. Among the few books on relativity that I came across as a student, I would like to mention the delightful introduction by Einstein himself (*Relativity: The Special General Theory*), H. Bondi's *Relativity and Common Sense*, and also the pedagogical classic by E. Taylor and J. A. Wheeler, *SpaceTime Physics*, requiring slightly more effort. The little delight by L. Landau and Yu. Rumer (*What is the Theory of Relativity?*) was widely available through the Mir Publishers outlets in India, for a price less than that of a masala dosa then (still the relative choice of most students was the dosa). Later I came across *Relativity Visualized* by Lewis Carrol Epstein, which has a 'wonderland' quality.

In the Preface, Mermin writes about the seed of such a book, which was eventually written and published in the centenary year of relativity (2005), as follows: 'in the 60th anniversary year, as a new young assistant professor of physics at Cornell, I decided that it was about time to make relativity a standard part of the high school curriculum'.

One will more than agree on this. The theory of relativity is our most fundamental physical theory. It has reached even a lay person due to applications like the GPS. When one hopes to introduce such an intellectual heritage to a young student, it is unfair to expose the subject without its historical and intellectual context. But, Mermin's text falters by its surprising indifference to the factual development of the theory of relativity. I quote from the book, 'Relativity is about time. What could be more familiar? What makes the subject so fascinating is that relativity reveals the nature of time to be shockingly different from what had been taken completely for granted, up until 1905'. Mermin repeats such assertions, 'The fact that the laws of a theory are so designed is often summarized in the assertion that the theory is "Lorentz invariant" or "Lorentz covariant." The terminology honours H. A. Lorentz, who published in 1904 the Lorentz covariant form for the laws of electromagnetism, without, however, understanding the meaning of his achievement, which only emerged with the insight into the nature of time enunciated in 1905 by Einstein'. For anybody who is familiar with the earlier writings of Poincaré on relativity, time and simultaneity, such repeated feeding of 'fake physics news' to the reader is unfortunate.

Mermin emphasizes the pedagogical device used by Einstein in the exposition of his theory, 'Anybody… must be able to visualize how certain events taking place, say, in a railroad station, are described from the point of view of a passenger… on a uniformly moving train and, conversely, … Without the ability to translate from one such description to another, one cannot begin to understand relativity'. This is both good and bad for teaching relativity. It is good for the concrete visualization of two reference frames. However, it is bad because of the danger of treating the platform as the 'really' stationary frame and the train as the 'really' moving frame, instead of two equal frames that are 'relatively moving', due to the common empirical prejudice. Then, one makes fatal mistakes regarding the deductions about 'simultaneity' in the theory, as Einstein himself succumbed to.

In the first chapter, Mermin repeatedly mentions that subtle and deep issues are involved, all of which he decides to ignore. Just raising them as deep questions and then dismissing them as practically irrelevant gives a bad taste about the conceptual integrity of the book. One fundamental concept in relativity is that of the inertial frames. He poses, 'How do you know that a frame of reference is inertial?'. Then, 'Fortunately, there is a simple physical test for whether a frame is inertial. In an inertial frame, stationary objects on which no forces act remain stationary'. But this is misleading. Is the motion of the Earth inertial or not? Scholars were tortured for asserting a moving Earth. It is a noninertial frame, yet practically undetectable. So, the tests of inertial state are not at all simple or conclusive.

While reading the book I was often puzzled about Mermin's reluctance to check sources when he discusses certain events in history. While discussing the velocity of light, he mentions Galileo's attempt for its measurement. Galileo's method involved human 'detectors' of lantern light, and thus the human response time was a hurdle. Mermin writes, 'I don't know if Galileo worried about it, but there is a problem here'. Well, a cursory reading of Galileo's *Discourses* (chapter 'First day'), would have answered his query. Galileo was well aware of this and the experimenters had to practice to minimize the response time when the separation was small, and the same response was assumed when the observers were separated by a large distance.

Mermin writes on the central postulate of special relativity, 'This fact – known as the constancy of the speed of light – is highly counterintuitive. Indeed, "counterintuitive" is too weak a word. It seems downright impossible. One of the central aims of this book is to remove this sense of impossibility and to see how it can, in fact, make perfect sense'. Does he succeed in this mission? Not at all. Compare this with what Charles Nordmann wrote in 1922, '... there is still something infinitely troubling in the Einsteinian system. This system is admirably coherent, but it rests on a particular conception of the propagation of light… no matter how hard we try, we cannot make the mechanism and nature of that propagation intelligible… The whole Einsteinian synthesis, as coherent as it is, rests on a mystery, exactly like the revealed religions'.

The twin paradox is discussed in detail, meant to put the student at ease about a satisfactory solution within the theory of special relativity. However, the chapter on the theory of general relativity shatters this peace by noting that 'This is only a tiny piece of the puzzle solved by the general theory of relativity'. Of course, this was exactly Einstein's stand in his paper on the twin paradox in 1918, that it did not have a solution within special relativity. Finally, confusion prevails for the reader.

The algebraic features of the Lorentz transformations and the underlying space–time physics are introduced and discussed in some detail, at a level that is useful to the high-school student. However, the treatment here is not as systematic as in *Space-Time Physics*, for example. The problem seems to be the verbose digressions that disturb the attention of the student, at the cost of systematic unfolding of the physics of relativity. Since the book was written at a time when many applications of relativistic physics became common in particle accelerators, atomic clocks and satellite-based navigational systems like the GPS, there were ample examples to present the subject attractively to the eager student. Mermin was not alert to such a pedagogic opportunity.

Apart from the topic of time, another central quantity in relativistic physics is 'mass'. Every student is familiar with the Einstein relation $E = mc^2$ and its manifestations. Mermin asserts that the 'correct' definition of mass is as 'inertia'. 'Here, finally, is a qualitative formulation of the correct definition: The mass of an object is a measure of how hard it resists attempts to change its velocity'. This assertion on the 'correct' definition would be misleading for a student, because Mermin does not discuss the 'mass' as the source of gravity. In fact, this concerns the central point that allowed Einstein to take his next step in relativity, to the general theory, leaping from the empirically supported equivalence of the mass as the inertia and also as the source of gravity. In the chapter that mentions the general theory of relativity, the presentation of the equivalence principle is haphazard and historically deficient.

Finally, I may mention a sociological issue. Many students come into science both for its thrill and its lofty ideals. In actual practice, however, there are large and unfair imbalances. Mermin writes, 'This process of discovering that one's former beliefs are wrong, and the painstaking search to identify the old errors, enabling one to construct better founded beliefs to replace them, is what makes the pursuit of science so engrossing. *The world would be a far better place for all of us if this joy in exposing one's own misconceptions were more common in other areas of human endeavor*' (emphasis is mine). Mermin assumes that the scientist follows this dictum of self-correction, while it is absent in other human endeavours. His recipe for universal joy is not based on what is factual in the practice of science, with all its biases and some hardened beliefs. Sure, on a long term, science is self-correcting, but that duration could be longer than a lifetime, which is not a fair situation.

Reading this book to learn Einstein's relativity needs more stamina and patience than what a high-school student can source. And for an advanced student, more effective and engrossing texts are available in plenty. I think in the days of excellent lectures with graphics and animations available on the internet, the weak pedagogic elements in Mermin's book are unlikely to elicit a keen interest from its intended readers.

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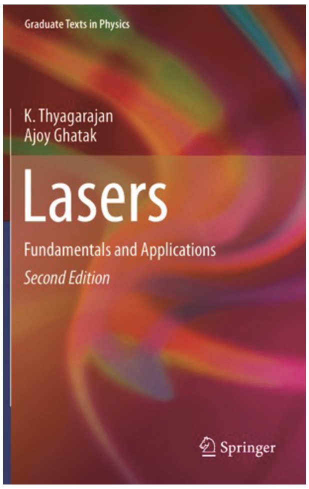

Lasers: Fundamentals and Applications (Second edition). K. Thyagarajan and Ajoy Ghatak. Springer Science + Business Media, LLC, 233 Spring Street, New York, NY 10013, USA. 2011, 659 pages. Price: € 79.42. ISBN: 978-1-4419-6441-0.

The book under review is an up-to-date textbook that surveys applied or engineering optics, including lasers and certain other areas that might be called modern optics. This book also is a useful handbook for the practising physicist or engineer who works from time to time with optics. The book gives an intuitive understanding of the fundamental concepts of optics, in detail with the important experimental advances and discusses various applications including semiconductor lasers. It is therefore an essential purchase for any graduate student entering the research area. Indeed, the book begins with an introduction to the laws of optics and optical interactions with matter using both classical physics and quantum mechanics.

The main topics of the book discuss the working principle of a laser; the parts of a laser-like the laser resonator and the active medium; beams of radiation generated by a laser; femtosecond laser pulses; different types of lasers and their advanced applications. Additional topics deepen our understanding of more specific questions concerning, in particular, origin of semi-classical and quantum mechanical theory to gain pumping process to elaborately explain the applications of radiation in doped lasers and fibres.

The authors emphasize this subject and provided enough mathematics for easy understanding. They use an elementary quantum mechanical basis, of the Einstein coefficients of absorption, spontaneous and stimulated emission of radiation to characterize the interaction of radiation with an atomic system. After covering the basic optics and basic quantum mechanics, the authors discuss the basic physics behind laser operation, some important laser types and the special properties of laser beams. The formulation of the working principle of a laser is done by using rate equations, yielding the condition of laser oscillation and other properties of a laser (chapters 5–9).

Chapters 1 and 2 discuss the basic concepts of optics including wave equations, interference, diffraction and linearly, circularly and elliptically polarized waves. Chapter 4 consists of Einstein coefficients derived from elements of quantum mechanics which is discussed in chapter 3 using Schrödinger equations. Chapters 10–14 deal with physical properties of lasers, some solid, liquid and gaseous, semiconductor laser systems, doped fibre amplifiers and lasers optical parametric oscillators including their construction working principle and lasing actions.

The second part (chapters 15–19) of the book discusses some of the most important applications of lasers in spatial frequency filtering, holography, laser-induced fusion, light wave communications, and in science and industry.

The book also covers basic wave propagation theories for beginners, but can be useful for the readers with little knowledge in ray and physical optics. The subject matter is useful for graduates. Although