Book Review: Gbur's *Mathematical Methods for Optical Physics and Engineering*

Blake Stacey

Science After Sunclipse

(Dated: October 12, 2011)

I review Gregory J. Gbur's textbook *Mathematical Methods for Optical Physics and Engineering* (2011, Cambridge University Press).

By golly, I wish I'd had this book [1] as an undergrad.

As it was, I had to wait until this past January, at the ScienceOnline 2011 conference [2]. These annual meetings in Durham, North Carolina feature scientists, journalists, teachers and students, all blurring the lines between one specialization and another, trying to figure out how the Internet can help us do and talk science. Lots of the attendees had books recently published or soon forthcoming, and the organizers arranged a drawing. We could each pick a book from the table, with all the books anonymized in brown paper wrapping. Greg "Dr. Skyskull" Gbur had brought fresh review copies of his textbook. Talking it over, we realized that if somebody who wasn't a physics person got a mathematical methods textbook, they'd probably be sad. So, we went to the table and hefted the offerings until we found one which weighed enough to be full of equations, and everyone walked away happy.

MMfOPE is, as the kids say, exactly what it says on the tin. It begins with vector calculus and concludes with asymptotic analysis, passing through matrices, infinite series, complex analysis, Fourierology and ordinary and partial differential equations along the way. Each subject is treated in a way which physicists will appreciate: mathematical rigour mortis is not stressed, but when more careful or Philadelphia-lawyerly treatments are possible, they are indicated, and the ways in which their subtleties can become relevant are pointed out. In addition, issues like the running time and convergence of numerical algorithms are, where appropriate, addressed.

The sticker put on by the intellectual toy store would read, I think, "Ages: sophomore and up". The prerequisites which the text effectively expects would be covered by the first year or so of university mathematics. If you've made it through Silvanus P. Thompson's *Calculus Made Easy,* you'd be pretty well set, though some experience with vectors, in the way which first-year physics courses grapple with them, would also be helpful. The physics content one ought to know before diving in is, likewise, pretty well encapsulated by first-year mechanics and electromagnetism (what I still think of as 8.01 and 8.02).

I wish I'd had this book when we got to 8.03, because it covers just about everything I should have learned then but ended up having to teach myself later. Rather than plodding through a stupefying number of simple examples to "make sure we get the point", it builds at a reasonable pace so we can reach interesting things and learn material we can actually use to do stuff. (The sophomore-level classes were easily the worst of MIT's physics curriculum. I don't know why, but the sentiment was widely shared, and I appreciate an antidote like Gbur's book, which makes the subject matter not just clear but also interesting.)

The content was chosen with optics in mind. This does not rule out the usefulness of the book for general physics majors, though an instructor would likely benefit by drawing problems from a supplemental source. Students aiming for statistical physics would enjoy applications of Fourier transforms and convolution to probability theory. Those whose interests lean to mechanical or electrical engineering might appreciate the poles-in-the-complex-plane technology being applied to control theory and the study of stability. This is just to say that a book written with a different goal in mind would have turned out different, and that I myself would like to see those topics explained with the same verve.

The level and style of the presentation befits a text written for students who are seeing most of the material for the first time. Fine books have been written which have the feel of a walk through a forest with a worldy-wise teacher, far from any blackboard. They can achieve a conceptual clarity, but the novice reader often wishes there were a few more stepping stones along the path between equations 17 and 18. *MMfOPE* generally assumes its readers do not need to be reminded "the derivative of the sine is the cosine", but its paths are well furnished with intermediate steps.

The historical notes, which indicate who discovered what and where theorems came from, are much appreciated. Without making the book a history-of-science monograph, they correct some common misconceptions and convey the impression that history is richer than we often let on, which is a good thing to be aware of. (The author's experience as a science blogger with an interest in historical quirks [3] shines through here.) Many exercises also point into the literature. Homework problems which begin, "Read the paper by…" will help students learn what facing into The Literature requires (and that sometimes, it stares back into you).

When our paths have intersected, Prof. Gbur and I have got along in a singularly fabulous way. It is therefore with genuine regret that I note the presence of aberrations in the text which may interfere with its reading. Missing factors of π are the bane of the working physicist; Zee advises us that the difference between a good theorist and a bad one is that the good one makes an *even* number of sign errors. None of the glitches I have found in *MMfOPE* seriously impede understanding. They are of the kind which can only get squeezed out when a text is used in a classroom a few times over, so its odd byways get explored by people who don't already know what should be on the page. For example, on p. 147, Eq. (5.32) is missing an equals sign after the $\mathbf{A}^\dagger\mathbf{A}$. On p. 530, α^2 is on the wrong side of Eq. (15.165), and this goof propagates for a few equations after that, though without affecting the conclusions of the section. In Figure 14.7 on p. 490, the two panels make sense on their own, but work oddly in juxtaposition; they would be more clear if the curve in part (b) were the derivative of that in part (a).

COI DISCLAIMER: As indicated, I got a copy of *Mathematical Methods for Optical Physics and Engineering* for free. That said, I have no financial stake in its success.

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[1] Gregory J. Gbur (2011), *Mathematical Methods for Optical Physics and Engineering.* Cambridge University Press. ISBN 978-0-521-51610-5. Solution manual available to instructors via `http://www.cambridge.org/knowledge/isbn/item5634813`.

[2] See `http://scienceonline2011.com`.

[3] See `http://skullsinthestars.com/category/history-of-science/` for examples.