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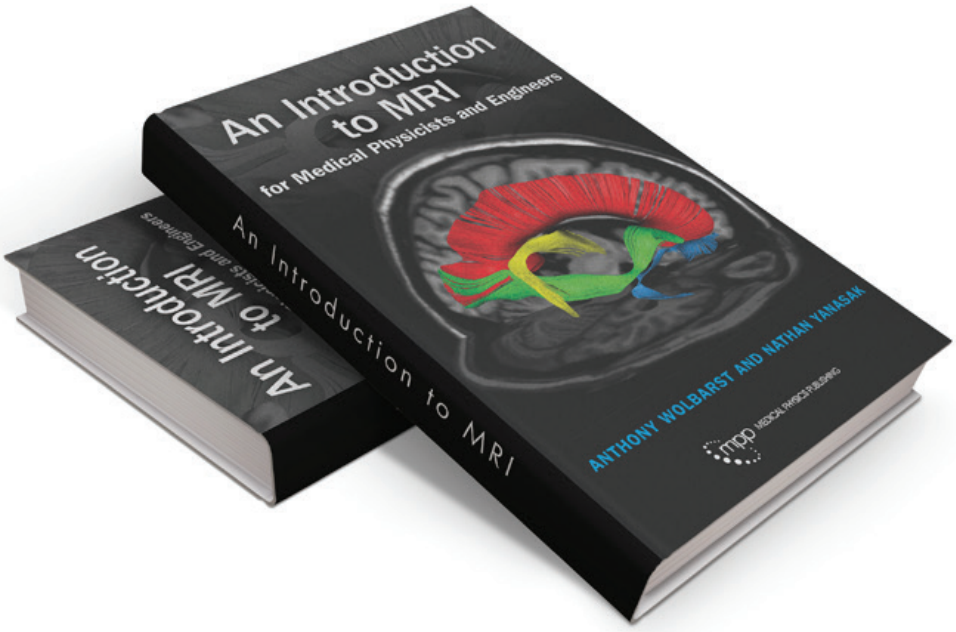
BOOK REVIEW

Book Review: "An Introduction to MRI for Medical Physicists and Engineers" by Anthony Wolbarst and Nathan Yanasak

Medical Physics Publishing (2019), 318 pages. Hardcover: ISBN 9781930524200; eBook: ISBN 978-1-930524-58-3, $120 (both versions). Link to book on publisher's web site.



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If you already know the book "Physics of Radiology" or one of the others by Anthony Wolbarst, you won't be surprised about the quality of this one on the topic of MRI. For this book he teamed up with Nathan Yanasak, an expert in MRI, adding up 40 years of teaching experience in total. Before I go into details about the 16 chapters of this book, let me tell you what I like the most about it. As the subtitle indicates, this book is not only written as an introduction to MRI for Medical Physicists from undergraduate level on but also for engineers. This can be noticed by the technical facts that are mentioned in various places throughout the book, e.g. when it comes to the "real" implementation of MRI when the authors include the residual readout time (RRT) of MR pulse sequences in extension to the pure physical facts. Besides instructive and well-coloured illustrations, there are numerous well placed exercise questions in the text to guide the reader to work out the essential ideas and concepts of MRI, ideally discussed with course mates.

The introductory chapter 1 (available in part as a free PDF on the publisher's website) gives a good overview of what is to come in the following chapters to make you keen to read on. Chapter 2 on electromagnetism and the quasi-quantum magnetic moment of the proton in a single voxel provides the necessary background and formulae, where most other MRI books would only refer to dedicated books on electromagnetism. The authors are not afraid to provide the full set of formulae to be physically correct, but never forget to catch the reader's interest by down to life comparisons. One example: I like very much the authors' comparison of scanning the NMR-frequency through the proton resonance to slowly tuning the radio frequency during a January blizzard in the Dakotas and suddenly hearing Pink Floyd music from a soft-rock station coming out of the speakers instead of the static noise before!

Chapter 3 deals not only with the MR frequency encoding of a 1D-patient by the use of gradient fields, but also on the basic concepts of image quality parameters reaching beyond the pure MR topic. This might well be because one of the authors has already written about this in one of his famous books, but it adds nicely a broader scope to this introductory book. Chapter 4 extends MR to a more detailed look at the local magnetization of a voxel taking into account the spin dynamics, intro-

ducing the first relaxation time T_1. Like the section on image quality parameters before, chapter 5 is another one providing basic background knowledge to the reader about the mathematical machinations like the Fourier transformation and k-space that are needed for a full understanding of MRI by detailed examples and figures. This and others that "look beyond" the pure topic of MRI render this book so valuable to the reader who is new to the field. On top and important to beginners, the authors provide explicit warnings of common misconceptions. Chapter 6 is on the classical approach to proton NMR in a single voxel by the 90°-pulse and the Bloch equations, including the concept of the rotating frame of reference.

Chapter 7 takes the reader stepwise to the MR pulse sequence to read out the MR-signal to get an image of a 1D-patient. The authors provide here not only the full mathematical equations again, but also the technical aspects of sampling the MR-signal in time steps of Δt_{dwel} to get the data in k-space before the Fourier transformation of it. The more technical interested reader will like chapter 8 on the MRI instrumentation that extends from the main magnet to phased array receiver coils. The RF part is explained by the basic electronic circuit of an AM radio receiver. (Maybe one of the authors is a ham radio fan?!)

The next two chapters 9 and 10 are on the relaxation times T_1 and T_2 and their molecular background, explained by the classic Bloembergen theory. Starting with chapter 11 the reader is first introduced to the spin echo pulse sequence for a simple 1D-patient again, before the authors extend the image reconstruction to 2D in chapter 12 by means of spin warp. Here, from the start on, the true effects of partial saturation depending on the choice of the parameters TR and TE with respect to the relaxation times are taken into account in the formulae. The T_1-, T_2- and PD-weighting is explained in good didactic manner by the help of magnetization-time diagrams as well as the corresponding signal formulae. In this chapter, the need for the refocussing gradient fields in the pulse sequences is not only stated as often found in other books, but explicitly explained by the phase changes introduced by the readout gradient field itself.

The reader is introduced to different concepts of data sampling paths in k-space that are explained in more detail in the following chapter 13 on fast imaging techniques, dealing with echo trains and the gradient echo techniques, multiplexing the slices in time and space as well as undersampling tricks that make use of the inherent symmetries of k-space.

The final three chapters are on MR sequences for fluid motion (MR angiography, perfusion and diffusion tensor imaging and the fMRI BOLD technique), QA and safety advices of an MRI system and a broad look into the horizon of MRI developments for the future by briefly touching the topics of quantitative imaging, compressed sensing, low and high field MRI, CEST for other nuclei, helium free MRI systems, quiet imaging, hybrid PET-MRI and the application of artificial intelligence or quantum computers.

If you wonder now, how Wolbarst and Yanasak manage to get all this information that include besides an extensive index of the book also an appendix with a long list of symbols, their meanings/definitions and their occurrences in the text, tables of MR-relevant units, constants, relationships / principles and the periodic table into only 318 pages, please realize that this book is printed on a page format of 8½ x 11 inches, larger than most other textbooks. Finally, I enjoyed reading this book very much and recommend it to you, too, if you are looking for an excellent introduction to MRI!

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Markus Buchgeister entered the field of medical physics in radiation therapy at the university clinic of Tübingen in 1995. In 2010, he received a call for a position as professor for medical radiation physics at the Berliner Hochschule für Technik (university of applied sciences and technology) at Berlin. Since 2003, he is engaged as co-opted DGMP board member for public relations and communications of the German Society for Medical Physics. Parallel, he served as chairman of the EFOMP Communication and Publications Committee 2003-2009 and from 2009-2015 as German EFOMP delegate. In 2017-2018 he was chairman of the EFOMP Education and Training Committee and is now German EFOMP delegate for a second round.