The Physics of Radiation Dosimetry

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This book is dedicated to

my wife Mary

my children Jeffrey, Laura, and Maureen

my grandchildren Theresa, Cira, Samantha, Marie, Connor, and Daniel

and to the memory of my parents

Anthony Meli and Cira Meli

PREFACE

This book is the result of lecture notes written and revised over the years for a course on radiation dosimetry in a Master of Science Degree program in Medical Physics at Columbia University. While intended to be a graduate-level textbook, it may serve as a resource for those preparing for certification examinations and for anyone interested in the interactions of radiation with matter.

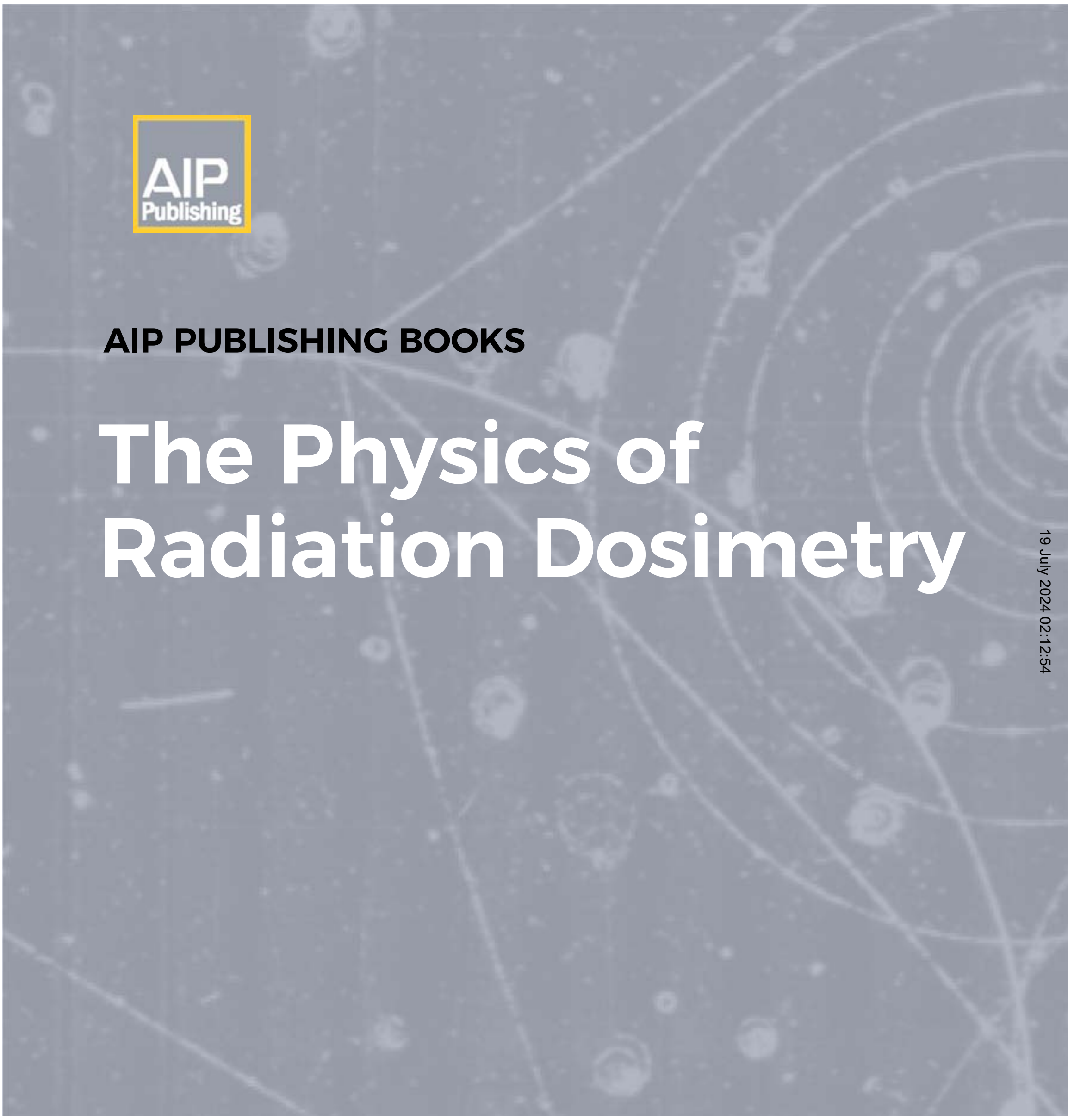
Radiation dosimetry has been a subject of interest since the late nineteenth century, with the discovery of x rays by Wilhelm Röentgen in 1895 and the discovery of radioactivity by Henri Becquerel in 1896. Many books cover various aspects of radiation dosimetry. Most of these are not designed to be textbooks but rather are detailed studies of one or more topics. Others, that could be used as textbooks for the topics covered, omit essential material for a complete course. A book widely used as a text is the excellent *Introduction to Radiological Physics and Radiation Dosimetry* by Frank H. Attix. However, I found several difficulties with this book as a text for a novice. It begins by defining quantities that are used in later chapters. This approach does not show the rationale for such quantities. While this is fine for those familiar with the field, it can be disconcerting to novices. Also, there is much detailed material that is covered in other courses. I found it necessary, as is common when teaching a course, to present topics in an order different from that of the book. This, combined with the elimination of very detailed material and the addition of more fundamental explanations, led me to begin writing my own notes.

In this book the interactions of radiation with matter and the basic methods used to measure radiation are discussed through a logical sequence of topics using interaction cross section as the underpinning explanation. This lays the foundation for the material covered in other specialty courses. Several topics are presented in ways not found in other books. For example, the work of Thomson is used to estimate the inelastic scattering cross section of charged particles with atomic electrons. This is expanded to show that the number of hard collisions far exceeds the number of soft collisions. The discussion of Bragg–Gray cavity theory is adapted from Gray's original paper, which I think is the clearest explanation of the theory.

Chapter 1 is a review of the basic concepts of physics that appear throughout the text. Chapters 2 and 3 introduce interaction cross section, its relation to interaction probability, and its application to elastic nuclear scattering. The material in these first three chapters is probably not new to students but the concepts are so central to understanding radiation interactions that they are worthy of review, especially since interaction cross section plays such a dominant role. The chapters on charged-particle interactions and dose in charged-particle beams are followed by chapters on photon interactions and dose in photon beams. This order was chosen because dose in photon beams is better understood through the interactions of electrons. Chapters on basic methods used to measure radiation emphasize the calibration and use of ionization chambers. The subject of radioactivity is relegated to an appendix mainly because, at Columbia, it is taught in a course concurrent with the radiation dosimetry course.

The book is designed so that its contents can be covered in a one semester graduate-level course. However, there is insufficient time to derive in class all the equations derived in the book. The derivations are not complex, and many are outlined in class and it is left to the student to follow the details in the text. Most of the illustrations in the book are not intended for the extraction of data but rather are meant to convey general behavior. The only data table provided is the Klein–Nishina cross section. For other data, such as stopping power, attenuation coefficients, etc. the student is referred to published tables such as on the NIST website. Finally, each chapter has a set of problems that have been used over the years as assignments or amplified for test questions.

I want to thank Dr. Robert J. Schulz of Yale University who was so receptive to my making a transition into the field of medical physics and for making clinical work and research so rewarding. I also thank Dr. Cheng-Shie Wuu of Columbia University for the opportunity to teach the radiation dosimetry course. I am grateful to students who commented on or questioned versions of my notes. Their input helped me see what needed better explanation and clarification.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