Demystifying Manhattan

Bruce Cameron Reed: The Physics of the Manhattan Project, 4th ed. Cham: Springer, 2021, xxi +256 pp, $79.99 HB

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Few scientific undertakings have tugged so sharply at the popular imagination as the Manhattan Project. The psychological power of nuclear weapons, their dramatic appearance on the world stage at the close of World War II, and the secretive nature of the crash project to develop them have fueled a potent cultural myth. In that myth, heroic physicists deployed their prodigious intellects in a race against their Nazi counterparts to build the bomb just in time to win the war, and their success is a model for how science can be used to respond to other urgent problems.

Every myth about science invites historians and philosophers of science to shout their opprobrium from the rooftops, and the myth of Manhattan is no exception. Historical scholarship has shown that Germany (which surrendered two months before the Trinity test) was nowhere close to achieving success in its own bomb project (Walker 1995). It has cast doubt on the necessity of the bomb for ending the war in the Pacific, and questioned its morality (Alperovitz 1995). It has recovered the engineers, chemists, and metallurgists who were much more essential to the project than the physicists (Johnson 2012). And it has argued that the peculiarities of nuclear science and geopolitics in the 1930s make the Manhattan Project a poor model with which to approach other scientific problems (Wellerstein 2012).

Bruce Cameron Reed is not shouting from any rooftops, but his *The Physics of the Manhattan Project* is no less of a contribution to scholarly efforts to demystify and demythologize. The fourth edition of Reed's definitive account of the technical ins and outs of the Manhattan Project is intended to be the last. It corrects a few minor errors in previous edition, clarifies several points, and includes a few additions—including a helpful preface describing the basic features of the Little Man and Fat Boy bombs, and, charmingly, a short debunking of the claim that a single fissioning atom can cause a grain of sand to make a jump visible to the naked eye. The volume is targeted at readers with an advanced undergraduate physics background, with the goals of explicating the principles behind the fission bombs completed in 1945, and of using these principles to illuminate more general areas of physics, such as electromagnetism and statistical mechanics.

It pursues these goals through five substantive chapters. The first wends its way through the conceptual headwaters of the Manhattan Project. Reed builds up the nuclear physics notation the book relies upon while explaining discoveries in early radioactivity studies, the discovery of the neutron, and the understanding of fission as it evolved through the 1930s. Here, as in other chapters, Reed drops in the occasional historical aperçu. The present text, however, introduces historical detail sparingly, and principally to provide a context for physical understanding. A fuller historical treatment is available in a companion volume (Reed 2019).

The second chapter, the book's longest and most detailed, addresses the physics of bomb design. Given a basic understanding of nuclear physics and the behavior of uranium and plutonium, how can we calculate critical mass? How do bomb-design choices, such as the nature of the dense tamper surrounding the core or the combination of different fissile materials, change critical mass? How can one estimate the yield of a particular bomb without conducting a costly and destructive test? Careful readers of this chapter will come away with the tools to answer these questions. Those tools are presented in modern notation and make use of modern understanding, but Reed is careful to flag when he is injecting knowledge that was not available to the historical actors.

We meet the problems of isotope separation in chapter 3. The Manhattan Project was phenomenally expensive, racking up a bill of $2 billion in the 1940s (somewhere north of $30 billion in 2021 dollars). Most of that money was not for clarifying physical principles or working out bomb designs—it was plowed into the gargantuan industrial operation required to generate fissile material in the first place. This chapter is the simplest to follow, technically speaking. It covers the essentials of the nuclear reactors used to generate plutonium for the Fat Man bomb, as well as the electromagnetic and thermal diffusion techniques used to separate the more fissionable, but rarer, uranium-235 from its stabler and more abundant sibling, uranium-238.

A reader who has made it this far will have gained a meticulously detailed physical understanding of how fission weapons work, and how they are made. The final two chapters do some mop up work, treating issues such as impurity and contamination of nuclear material and reactor moderators (chapter 4) and offering miscellaneous calculations for objects of curiosity, such as the warmth of plutonium to the touch and the brightness of the Trinity test (chapter 5)—it is here where we encounter the one myth Reed sets out explicitly to slay, namely the myth of the hopping grain of sand. The book finishes with a series of technical appendices, including a set of exercises that can be set for students, or tackled by more ambitious readers. In service of this interactive function, Reed has made available on his website a number of spreadsheets that support the calculations modeled throughout the book.

The Physics of the Manhattan Project, taken as a whole, defies genre classification. It is part textbook—based as it is on a course Reed has taught at Alma College for a number of years—but it is unlikely to be adopted wholesale by physics instructors working within their own programs' requirements. It is part technical history, but its goal remains to clarify the physics behind fission weapons as we now understand them, rather than to reveal how that understanding actually took shape in context.

As a result, both physicists and historians might find it most useful as a reference work. Readers with sufficient interest, ready to brave a book bristling with equations, can still use it to develop a comprehensive understanding of how exactly the fission bombs came into being, and why they worked. But the care and thoroughness Reed has brought to the task of making this possible also means that both the physicist who is inspired to jazz up a course on electromagnetism with a unit on isotope separation and the historian who needs to interpret an otherwise opaque discussion of tamper materials within a primary source can dip into this volume with the confidence of coming away with the illumination they need.

References

Alperovitz, Gar. 1995. The Decision to Use the Atomic Bomb. New York: Alfred A. Knopf.

Johnson, Sean F. 2012. The Neutron's Children: Nuclear Engineers and the Shaping of Identity. Oxford: Oxford University Press.

Reed, Bruce Cameron. 2019. The History and Science of the Manhattan Project. Cham: Springer.

Walker, Mark. 1995. Nazi Science: Myth, Truth, and the German Atomic Bomb. New York: Plenum Press.

Wellerstein, Alex. 2012. "Do We Want Another Manhattan Project?" Restricted Data: The Nuclear Secrecy Blog, April 2, 2012, accessed August 17, 2021, http://blog.nuclearsecrecy.com/2012/04/02/do-we-want-another-manhattan-project/.