The History and Science of the Manhattan Project.

Alex Wellerstein

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BOOK REVIEWS

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The History and Science of the Manhattan Project. Bruce Cameron Reed. 467 pp. Springer, Heidelberg, 2014. Price: $59.99 (hardcover). ISBN 978-3-642-40297-5. (Alex Wellerstein, Reviewer.)

The Manhattan Project has been a subject of near-constant interest since the first atomic bombs were dropped on Hiroshima and Nagasaki in 1945. These events provide an example of military, industrial, civilian, and academic collaboration that is still regularly invoked today as a symbol of how extraordinary technological feats can be accomplished in a short amount of time. The cost and size of the project—around two billion (1945) dollars and 600,000 personnel at more than 30 separate sites—give some indication of its staggering impact. The scientific and technological problems to be solved are still difficult even with modern technology, much less with 1940s understandings, and the historical issues are deep and thorny. It is no surprise, then, that many books on the topic are still being written.

Bruce Cameron Reed's *The History and Science of the Manhattan Project* is a new addition to the large body of work on the Manhattan Project. It is hard to know exactly how to categorize it. It is an excellent, detail-oriented work of history that has been written by a physicist for the purpose of illuminating some of the basic scientific work that went into making the bomb. The book seems to be aimed at two somewhat different audiences. One is for college-level physics students who will be perhaps surprised to learn that much of the science that goes into the making of nuclear weapons and reactors is entirely comprehensible to them. The other is for dedicated consumers of nuclear weapons history who are interested in more technical detail than can be found in books like Richard Rhodes' *The Making of the Atomic Bomb* (Simon and Schuster, 1986) but do not want quite as much technicality and specificity as can be found in Lillian Hoddeson *et al.*, *Critical Assembly: A Technical History of Los Alamos during the Oppenheimer Years, 1943–1945* (Cambridge University Press, 1998).

Reed's book goes through the history with a great amount of attention to detail. He has clearly done the archival research necessary to tell a deep, mostly technical story about the work that went into making the bomb. Reed writes in a straightforward, matter-of-fact manner that does not embellish or overgeneralize. As a historian myself, I found Reed's historical coverage quite refreshing in this regard. Throughout the historical narrative, he takes time to explain the technical points under discussion. This is not a book for the phobic of equations, but Reed's patience in explaining how they work, and showing how to derive results from them (which he then compares against the results of the historical actors), makes this a thoroughly rewarding approach for someone who is not especially quantitative but eager to learn (like myself). But it is probably too quantitative for a general audience, who, in my experience, find even Rhodes' book too technical at times. Reed's treatments, however, are easy to follow, even by someone who comes at this from a primarily nontechnical background (like myself).

I cannot testify as to how useful it would be for teaching a seminar of undergraduates in physics, as this is beyond my experience, but it is designed to be usable in a sophomore-level course on modern physics. It is far more detailed than any other treatment I have seen along these lines and provides reasonable quantitative questions at the end of each chapter for a student (or interested layman) to tackle. It does not strike me as the sort of book that could be easily shoehorned into a pre-existing course—it would really need to be the centerpiece of a course on the same topic. As such, though, I think it would be extremely successful.

For myself, as a historian who teaches history courses on this subject to undergraduates, it has vastly supplemented my own understanding of these matters and provided me a wealth of interesting technical details and a better understanding of the technical problems involved with nuclear fission weapons, nuclear fission reactors, plutonium reprocessing, uranium enrichment, and many other key aspects of bomb-making then and now. It truly deepened my technical understanding of the history in question. I could see using sample chapters, or problems, from this book to help nonscientist students understand that most of the "secret" behind early atomic weapons is not theoretical in nature and that indeed many of the key theoretical problems can be solved with only a basic understanding of algebra. (The actual application of this theory is, of course, where the real difficulty comes in.)

Reed also has recently written a slimmer volume on *The Physics of the Manhattan Project* (Springer, 2011). There is some overlap between the two volumes in terms of technical detail but the use of history as a narrative framework and a guide to the equations makes the more recent book more usable and comprehensible in my view, and the earlier volume is somewhat more technically dense than the newer one.

Reed's book is an excellent and unique contribution to a crowded field. It should be an important resource for those involved in the teaching of topics related to nuclear weapons or who are themselves interested in a significantly deeper technical understanding of the history of the Manhattan Project.

Alex Wellerstein is an Associate Historian at the Center for History of Physics at the American Institute of Physics, College Park, Maryland. He is a historian of science who works on the history of nuclear weapons. He is the author of Restricted Data: The Nuclear Secrecy Blog (http://blog.nuclearsecrecy.com) and is finishing a book on the history of nuclear secrecy in the United States.

Starlight Detectives: How Astronomers, Inventors, and Eccentrics Discovered the Modern Universe. Alan Hirshfeld. 383 pp. Bellevue Literary Press, New York. 2014. Price $19.95 (paper). ISBN 978-1-934137-78-9. (Neil F. Comins, Reviewer.)

In 1826, French inventor Nicéphore Niépce aimed his rudimentary camera out a window in his home near Chalon-sur-Saône, France and exposed his primitive film plate, which he called a heliograph. Eight hours later, he ended the exposure, developed the first image taken of the outdoors, and the world entered the photographic age. Eight-hour exposures have some drawbacks; they don't show people, for example, whose images are washed out because they don't remain still for the requisite number of hours. In 1837, French artist Louis Daguerre developed a faster film technology that he named daguerreotype, which became the film of choice around the world for a decade. Eventually, daguerreotype was eclipsed in the mid-1850s by the wet collodion plate process pioneered by sculptor Frederick Scott Archer. While a chemical nightmare, this technology allowed for even faster exposures and, therefore, more photographic flexibility than daguerreotypes.

Film technology continued to improve right through the twentieth century. An early precursor to the rolls of film that were common until CCD cameras took their place was developed by British physician (not a typo) Richard Leach Maddox, who made it available in 1871. Using a light-sensitive silver-salt compound embedded in gelatin on a solid plate, these negatives did not require immediate development, as did the wet collodion plates. In less than 50 years after the first daguerreotype was taken, photographic plates were transformed into relatively high-speed, high-resolution technology that has helped create a permanent record of life on Earth.

Driven in large measure by the development of photography in the nineteenth century, telescope technology underwent a renaissance during the same period. Tracking of objects in space to allow for sufficiently long exposures of the primitive photographic plates was a major problem back then. For example, NYU chemistry professor John Draper took a 20-min daguerreotype exposure of the Moon in 1840. During those 20 min, the Moon moved and Draper was unable to track it well enough to get a detailed image.

The desire to track stars, planets, and the Moon while taking photographs drove the development of ever more sophisticated telescope drive mechanisms. In 1859, British chemist Warren de la Rue refined his telescope in Cranford, England with a drive mechanism that followed the stars sufficiently well for him to produce high quality photographs. He even modified the drive so that he could take images of the Moon, which moves at a different speed across the sky than do the stars.

As the photographic abilities of telescopes improved, the demand for telescopes that did not distort the photographic images also grew. This led to the modification of refracting telescopes and the dramatic improvement of reflecting telescopes, which have fewer optical distortion problems than do refractors. It was during this period that reflecting telescopes transitioned from the relatively low-reflectance speculum metal mirrors to the much higher-reflectance silver-coated glass mirrors, such as the pioneering 1856 telescope built by Léon Foucault. As film sensitivity improved, new objects in space were discovered; this helped drive the demand for ever-larger telescopes to discover ever-dimmer objects.

Determining the chemical properties of the Sun and other astronomical objects also became possible in the 19th century. Beginning in the 18th century, chemists discovered that when heated, different elements and molecules emit signature wavelengths. In 1802, William Hyde Wollaston placed a prism in the path of a narrow beam of sunlight and observed that the resulting spectrum contained dark lines. Joseph Fraunhofer rediscovered these lines in 1814 and they are now called Fraunhofer lines (Fraunhofer did much pioneering work in what we now call spectroscopy). The discovery that some of the Fraunhofer lines in the Sun's spectrum correspond to bright lines seen in the spectra of gases emitted on Earth led to the correct belief that elements and molecules emit certain wavelengths of electromagnetic radiation and somehow they also absorb the same wavelengths.

Although the explanation of spectral emission and absorption came in the twentieth century with the Bohr model of the atom and the subsequent development of quantum mechanics, nineteenth century scientists were able to create photographic spectra of objects in space on the primitive film they had available. These spectra allowed them to determine, for example, the chemistry of the Sun's outer layers. Henry Draper, son of John Draper, mentioned above, and Antonia Maury, John's granddaughter by his daughter Virginia, both became spectral astronomers. Henry's observatory in Hasting on Hudson, I learned from Alan Hirshfeld's *Starlight Detectives,* was just a few miles from where I grew up in Ardsley, NY.

It was the merger of sufficiently sophisticated photography, sufficiently sophisticated telescopes, and sufficiently sophisticated spectrographs starting in the second half of the nineteenth century that laid the foundation for our present understanding of the chemistry of the cosmos, the motion of objects in it, and the evolution of stars, among other things.

Alan Hirshfeld's wonderful *Starlight Detectives* is a tour-de-force synthesis of the historic and scientific factors relating nineteenth century photography, astronomy, and spectroscopy. The book also gives us a satisfying glimpse at the early development of one of the great observatories of the twentieth century. Hirshfeld's narrative brings to life some of the major players in the early development of observational astronomy including many of those I have cited. Indeed, he does this latter work so well that one often feels transported back to that nineteenth century era of steam engines, photographic dark rooms, coal-fired stoves, and primitive telephones. The book has numerous black and white images of early photographs, including images of early photographers and astronomers, which are ideal for visualizing the black and white (photographic) era from which they came. Hirshfeld also does a great job of adding depth to the stories of several women astronomers of the era whom, we are all too often told, just sat around and analyzed photographs and spectra.

Starlight Detectives is divided into three sections. The first focuses on the development of photography and the adaptation of telescopes to this technology. The second section brings astronomical spectroscopy into play and explores some of the insights that it revealed, including the fact that the universe is expanding. The third section takes the story of astronomical observations from the end of the 19th century into the 20th century. This section focuses on the development of one of the major 20th-century research observatories, Mt. Wilson, near Pasadena, California.

Eminently well written, the story lines immerse the reader in situations and events that provide real insight into the roles of numerous amateur (here meaning not formally trained) astronomers in moving the field forward, as well as how professional astronomers have worked with amateurs to the advantage of both. Hirshfeld's writing style brings the 19th century back to life and provides a rich tapestry of astronomical history.

Neil F. Comins teaches astronomy, astrophysics, and physics at the University of Maine. He has had 18 trade and text books published. His research focuses on general relativity, galactic dynamics, and correcting misconceptions about astronomy.

BOOKS RECEIVED

Modern Electrodynamics. Andrew Zangwill. 994 pp. Cambridge University Press, New York, 2013. Price: $85 (hardcover) ISBN 978-1-521-89697-9.

Light: The Physics of Photons. Ole Keller. 482 pp. CRC Press, Boca Raton, FL, 2014. Price: $79.96 (hardcover) ISBN 978-1-4398-4043-6.

Statistical Thermodynamics: With Applications to the Life Sciences. Arieh Ben-Naim. 435 pp. World Scientific, Singapore, 2014. Price: $45 (paper) ISBN 978-9814578202.

The Asteroid Threat: Defending our Planet from Deadly Near-Earth Objects. Willam E. Burrows. 282 pp. Prometheus, Amherst, NY, 2014. Price: $19.95 (paper) ISBN 978-1-61614-913-0.

Path Integrals and Hamiltonians: Principles and Methods. Belal A. Baaquie. 435 pp. Cambridge University Press, New York, 2014. Price: $120 (hardcover) ISBN 978-1-107-00979-0.

Curiosity: An Inside Look at the Mars Rover Mission and the People Who Made it Happen. Rod Pyle. 300 pp. Prometheus, Amherst, NY, 2014. Price: $19.95 (paper) ISBN 978-1-61614-934-5.

The Chemistry of Alchemy: From Dragon's Blood to Donkey Dung, How Chemistry was Forged. Cathy Cobb, Monty Fetterwolf, and Harold Goldwhite. 364 pp. Prometheus, Amherst, NY, 2014. Price: $24.95 (hardcover) ISBN 978-1-61614-915-4.

Discrete or Continuous? The Quest for Fundamental Length in Modern Physics. Amit Hagar. 278 pp. Cambridge University Press, New York, 2014. Price: $90 (hardcover) ISBN 978-1-107-06280-1.

An Introduction to Mechanics, 2nd ed. Daniel Kleppner and Robert Kolenkow. 562 pp. Cambridge University Press, New York, 2014. Price: $80 (hardcover) ISBN 978-0-521-19811-0.

Time in Powers of Ten: Natural Phenomena and Their Timescales. Gerard't Hooft and Stefan Vandoren. 240 pp. World Scientific, Singapore, 2014. Price: $24 (paper) ISBN 978-981-4489-81-2.

Dynamics of the Standard Model, 2nd ed. John F. Donoghue, Eugene Golowich, and Barry R. Holstein. 592 pp. Cambridge University Press, New York, 2014. Price: $80 (hardcover) ISBN 978-0-521-76867-2.

Lectures on Quantum Mechanics. Steven Weinberg. 377 pp. Cambridge University Press, New York, 2013. Price: $75 (hardcover) ISBN 978-1-107-02872-2.

Principles of Discrete Time Mechanics. George Jaroszkiewicz. 379 pp. Cambridge University Press, New York, 2014. Price: $130 (hardcover) ISBN 978-1-107-03429-7.