Einstein's relatively large contribution to quantum theory

Einstein and the Quantum
The Quest of the Valiant Swabian

A. Douglas Stone
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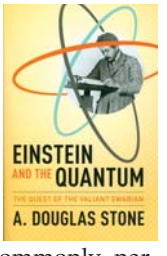
Reviewed by Daniel Kleppner

The pantheon of quantum mechanics includes Max Planck, Albert Einstein, Niels Bohr, Louis de Broglie, Werner Heisenberg, Erwin Schrödinger, Paul Dirac, and Max Born. All those personalities appear in *Einstein and the Quantum: The Quest of the Valiant Swabian*, Douglas Stone's audacious recounting of the subject's genesis. Stone, however, argues that the creation saga, as commonly narrated, seriously understates the immense breadth and depth of Einstein's contributions.



In the book, Stone shows how Einstein's ideas animated the development of quantum mechanics from its infancy through its first quarter century. He argues that the full extent of Einstein's impact is not appreciated because his iconic status in the world of physics, and also for the greater public, was due primarily to his creation of general relativity. Furthermore, Einstein himself sabotaged (my word, not Stone's) the history of his role: Rather than taking pride in the edifice he helped create, Einstein balked at quantum mechanics' "spooky action at a distance" and effectively disowned the theory. His scientific memoir is devoted to general relativity and makes only scant mention of quantum mechanics. Einstein is better known for denouncing quantum theory than for creating it.

Stone narrates the hectic circumstances that induced Planck to announce his quantum hypothesis in a speech on 14 December 1900. Planck viewed his proposal as a mathematical trick and a physical absurdity—an act of desperation, as he later called it. In contrast, the quantum hypothesis that Einstein presented in his paper on the photoelectric effect at the beginning of 1905, his annus mirabilis, was an act of deliberation and logical necessity.

Stone shows how Einstein recognized that the success of Maxwell's electromagnetic theory spelled the downfall of Newtonian physics. The error was deeper than the problem of the ether that Einstein had handily resolved with his special theory of relativity. The error lay in the statistical mechanics of radiation. Einstein was driven to conclude that radiation fields could exchange energy with matter only in discrete packages. Rather than accept Planck's hypothesis that the energy of matter is quantized, Einstein proved that for statistical mechanics to be consistent, the energy of radiation must be quantized. Unlike Planck's proposal, Einstein's paper had physical consequences with experimental ramifications.

Furthermore, Einstein recognized—again using statistical arguments—that if radiation fields are quantized, the energy content of matter must also be quantized. Lacking any theory for the structure of atoms, he turned to thermodynamics and focused on the specific heat of solids to show how vibrational quantization could explain the mysterious temperature variation of some materials. Stone describes a deep irony in the specific-heat paper: For the specific heat of diamond, Einstein used data taken by Zürich Polytechnic professor Heinrich Weber, who, irritated by Einstein's brashness, had blocked his academic career. That led to Einstein's employment in the Zürich patent office and the period of thinking and writing that culminated in the magical year.

As Stone points out, years before Bohr invoked the correspondence principle, Einstein had fully appreciated the significance of wave–particle duality; in 1909 he had discovered that the fluctuations of thermal radiation simultaneously display both wave-like and particle-like behavior. However, Einstein's attempts to build on that understanding and develop a full quantum theory of matter were unsuccessful, and so he turned to the problem of gravity. He later told Otto Stern that in his career he spent much more time thinking about quantum theory than about gravity. Einstein returned to quantum mechanics with his 1917 paper on radiation, in which he introduced the concept of spontaneous emission and laid the foundations for all future radiation theory. To his distress, probability played an essential role.

In the summer of 1924, Einstein unscrambled de Broglie's PhD thesis and recognized the significance of its seminal hypothesis. He explained it to Schrödinger, who thus was inspired to set out on the quest that led to the creation of wave mechanics as we know it today. That same year Einstein presented his theory of the quantum gas, which included the phenomenon that became known as Bose–Einstein condensation. In his 1935 paper with Boris Podolsky and Nathan Rosen, Einstein focused his attention on entanglement and its ensuing paradoxes. At that point he became estranged from the scientific community, much to the sadness of many of his colleagues.

Einstein and the Quantum is delightful to read, with numerous historical details that were new to me and charming vignettes of Einstein and his colleagues. By avoiding mathematics, Stone makes his book accessible to general readers, but even physicists who are well versed in Einstein and his physics are likely to find new insights into the most remarkable mind of the modern era. As for the book's enigmatic subtitle, "Valiant Swabian" was Einstein's signature to Mileva Marić in the early days of their courtship, before fate propelled his career upward and their marriage fell apart.

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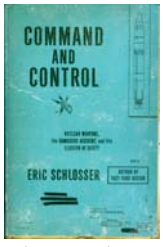
Command and Control
Nuclear Weapons, the Damascus Accident, and the Illusion of Safety

Eric Schlosser
Penguin Press, 2013. $36.00
(632 pp.). ISBN 978-1-59420-227-8

Because journalists often make poor historians, I had my suspicions when I

heard that investigative journalist Eric Schlosser was writing a book, aimed at a popular audience, about the history of nuclear weapons and their accidents. The ethos of journalism is about jumping into a topic, extracting information—usually from interviews—that is most relevant to the present day, publishing fast, and moving on. We historians try to understand historical issues according to what mattered at the time, and we generally believe that the written document trumps the spoken word. And we have never been accused of moving too fast.

Schlosser is justifiably famous for his exposés on fast food, marijuana regulation, and prisons. I enjoyed his book *Fast Food Nation: The Dark Side of the All-American Meal* (Houghton Mifflin, 2001). But I was uncertain when I heard he was wading into territory I knew a lot about, and whose history popular authors and journalists often get wrong.



I am pleased to report that Schlosser's *Command and Control: Nuclear Weapons, the Damascus Accident, and the Illusion of Safety* is an impressively researched, beautifully written, and carefully considered work of history. Though written for a popular audience, *Command and Control* is a serious piece of nonfiction and the best book on nuclear weapons to have been published in several years.

Nuclear weapons history can make for sensational reading, and accounts of the hundreds of nuclear weapons accidents that occurred over the course of the Cold War can be especially problematic to write about. Such accidents can vary dramatically, from the truly close calls that could result in substantial accidental nuclear yield, to the much more minor incidents that reveal possible flaws in the system but pose little risk to human life. Much that has been written on nuclear accidents is either dryly technical or hyperbolically alarmist. Schlosser finds a middle ground. He lets the documents and the experts do the talking; and he is careful not to overstate dangers. His sober, careful discussion of the technical matters is all the more alarming.

Command and Control is not the kind of history a historian would write. It tacks back and forth between two different threads. The first is a close, detailed, interview-based account of a 1980 accident at a Titan II missile base near Damascus, Arkansas, in which the dropping of one apparently innocuous socket set in motion a chaotic series of events that ended up destroying a silo and taking a life. The second is a broader history of nuclear weapons in the Cold War period, focused on the difficult problem of simultaneously trying to keep the weapons ready for use at any time while avoiding accidental or unauthorized nuclear war. The second narrative contextualizes the specifics of the first; the first shows the "low-level" consequences of the decisions made in the second.

The combination is brilliant. The Damascus accident allows Schlosser to be at his best as a journalist, and it is entirely gripping. The broader history proves that his background research was extensive and that he deeply understands the topic. He integrates complex scholarly interpretations of Cold War strategy, up-to-date knowledge about the differences between publicly stated policies and actual secret deployments, and a deeply humane appreciation for the broader implications of the vast systems created under the auspices of national security.

Schlosser's book is eye-opening and fresh even for those readers who feel they already have some idea about the history of nuclear weapons and have heard of several of the accidents that took place during the Cold War. It shows exactly how counterproductive some of the US Cold War policies were at creating security and how many of the choices about weapons deployments were driven by domestic politics and interservice rivalries, as opposed to any kind of master plan regarding nuclear strategy. Schlosser's book is a particularly damning portrait of the steady degradation of civilian control over nuclear weapons.

Schlosser relies on interviews with nuclear weapons engineers to summarize the dangers of the weapons themselves. And he persuasively argues that a culture of denial regarding nuclear safety hazards led to a level of negligence and ignorance about the weapons that extended deep into the organizations meant to handle them. The account of how that culture was created and maintained helps to explain some of the contradictions that one sometimes finds in the official histories of those nuclear accidents: Behind their bureaucratic silos and walls of secrecy, the US Air Force and the nuclear engineers were not always even looking at the same evidence. Schlosser manages to make his case without resorting to emotional appeals, without distorting subtleties of fact, and without accusing anyone of being a maniac. The only fault

anyone has in his book is being human.

As with all ambitious works of history, and especially technical history, there are some minor errors dispersed throughout the text. I noticed a few outright mistakes in the section on the Manhattan Project, and there were a few interpretations I considered dubious. But none of the errors I noticed significantly altered the narrative or Schlosser's key findings. He did his homework. Furthermore, he includes more than 120 pages of discursive end notes, an essay on sources, and an ordered bibliography—a remarkable inclusion for a book aimed at a popular audience. For an expert, or even just a curious reader, that material will help cement the status of this eminently readable book as an important and reliable resource for the future and as an important historical contribution.

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Asian Space Race
Rhetoric or Reality?

Ajey Lele
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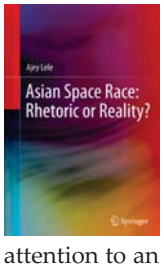
Once the domain of the two Cold War superpowers, space activities now have associations that go beyond the US and Russia. Occupying a growing place in the public imagination is China, which has a modest orbiting space facility that its astronauts regularly visit and that recently sent a sophisticated robotic rover to the surface of the Moon, a feat that displays a mastery of cutting-edge technologies. Meanwhile, an Indian probe on its way to Mars is drawing attention to an impressive array of satellites, launch vehicles, and ground infrastructure that the Indian Space Research Organisation operates. And Japan has one of the largest modules attached to the International Space Station, where Japanese astronauts regularly spend time.



In *Asian Space Race: Rhetoric or Reality?*, Ajey Lele seeks to untangle the complicated moves of those maturing space powers and other smaller ones, including Israel, Pakistan, and the two Koreas, and to "explore the character . . . of the investments made by various Asian states in the space arena." The fundamental question for Lele, a research fellow at the Institute for Defence Studies and Analyses in New Delhi, is a simple one on the surface, although it masks a complicated set of factors at play: "Is the Asian space race for real or is it a subject more of an academic debate?" Other recent, similar books include James Clay Moltz's *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks* (Columbia University Press, 2011) and Eric Seedhouse's *The New Space Race: China vs. the United States* (Springer, 2010). But Lele's is the first from the perspective of an Asian policy specialist.

The first half of the book is organized around the activities of the "big three" nations—China, India, and Japan. They are among the few that have the capacity to launch their own satellites into orbit. Such actions—and more modest activities such as using another nation's remote-sensing data—indicate that a broad spectrum of national and corporate investments is being placed under the rubric of a space program. Lele summarizes many of those efforts using a vast amount of data culled from open sources, principally online.

We learn that China has a large and expanding space program, much of it serving both military and civilian users. In contrast, for many decades, India's space program has been oriented toward domestic development—in the words of the late founding figure of the Indian space program, Vikram Sarabhai, "space for development." Yet, having deployed an extensive array of advanced remote-sensing satellites to assess natural resources, the Indian Space Research Organisation has in recent years proposed and implemented projects that have no immediate developmental value.

Expensive missions to the Moon and Mars may have little obvious practical worth to the general population, but Lele believes that they should be understood as instruments of "soft power." That's especially the case for China, which has engaged in a wide-ranging program of space cooperation with many smaller nations in Asia and Africa. Lele argues that China's cultivation of a "web of space help" generates goodwill and "garner[s] . . . economic, political, and strategic advantages." But he also cautions that soft power only goes so far and that practical considerations—economic development, international cooperation, military applications, and scientific research—will remain important drivers of Asian space activities.