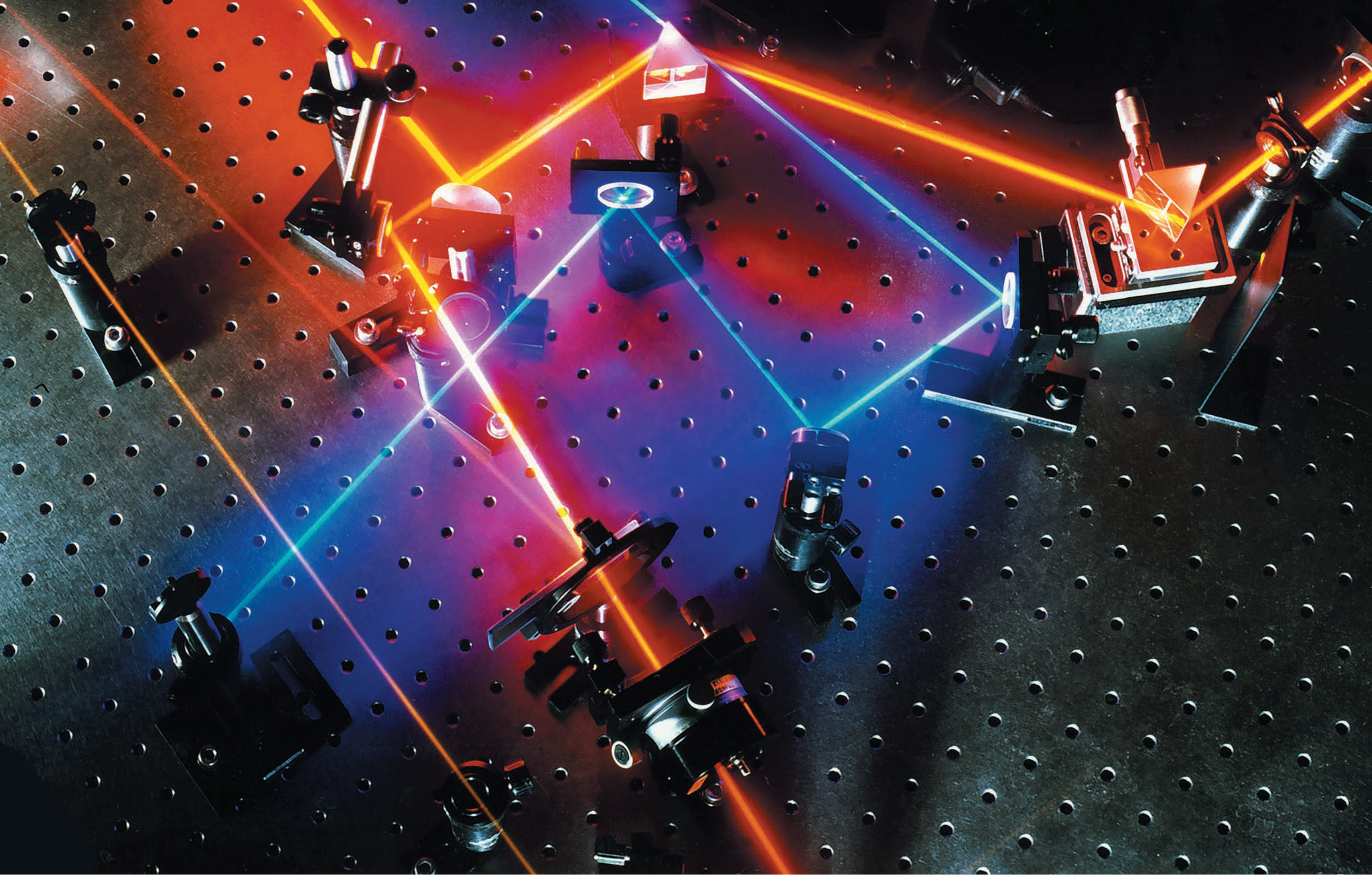


US NATL RENEWABLE ENERGY LAB/DEPT OF ENERGY

Femtosecond laser systems, which emit ultrashort optical pulses, are used to probe fundamental properties of solid-state materials.

PHYSICS

A history of substance

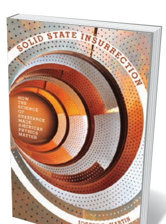
Michael Gordin applauds a study tracing 70 tumultuous years of solid-state physics.

What is "physics"? From the birth of the nuclear age at the end of the Second World War, physics has often been portrayed as the quest to penetrate the atom; to divine the secrets of the subnuclear realm of mesons and quarks with ever more impressive accelerators and ever more gargantuan particle detectors. High-energy physics was the glamorous stuff that attracted Nobel prizes and lavish press coverage. Most books on the history of physics consider it the backbone of the field.

Studying elementary particles is not, however, what most physicists do. By almost all metrics — PhD degrees, articles in flagship journals, memberships in professional societies — the majority were not, and are not, high-energy physicists. Instead, they plough the furrows of what was once known as solid-state physics — better known since the 1970s as condensed-matter physics. This is the science that brought us superconductivity, superfluidity, magnetic memory, liquid-crystal displays and more.

This is the physics that the science historian Joseph Martin presents in *Solid State Insurrection* — but his focus is not those landmarks. For him, "physics is what physicists decide it is". This is not some slogan of radical relativism. It is a recognition that physics is a profession, and it is the business of professional groups to police their boundaries.

In the United States, the motivation of much of that policing was access to funding: high-energy physicists got loads of it from the government, and solid-state physicists were shunted to industry. For decades, condescension blossomed on one side and resentment festered on the other. Matters came to a head in a decision by Congress to cancel what would have been the crown jewel of US high-energy physics, the Superconducting Super Collider (SSC), in 1993. That cancellation was influenced by criticisms before congressional committees from eminent condensed-matter specialists, such as Nobel laureate Philip Anderson of Bell Labs.



Solid State Insurrection: How the Science of Substance Made American Physics Matter
JOSEPH D. MARTIN
University of Pittsburgh Press (2018)

This dispute was about more than resources. Already in the 1970s, solid-state physicists such as Anderson and Alvin Weinberg had articulated an alternative vision of the science of physics. Particle physicists justified themselves through a commitment to "pure science" that dated back to the origins of the American Physical Society (APS) in the late nineteenth century. Because high-energy physics probed the smallest constituents of matter, a reductionist would say that such physics was the most "fundamental". Anderson disagreed. As Martin explains in an excellent chapter, for Anderson "fundamental physics" was about ferromagnets as well as about quarks.

Then came the SSC. "The original Star Wars trilogy tells the story of a ragtag band of misfits, many of whom are adept at manipulating a force pervading in everyday matter, who ally to mount an insurrection against the established order and help destroy a giant, partially built beam machine," writes Martin. The trajectory of US solid-state physics, he notes, "followed much the same plot". Although he concedes that the SSC was more drastically affected by the end of the cold war than by intradisciplinary critique, there is no doubt where Martin's sympathies lie.

He devotes most of his book to a detailed reconstruction of the intense struggle, half a century earlier, for recognition by solid-state physicists against the leadership of the APS, which was itself frustrated and challenged by the rapid growth in their ranks during the 1940s. Physicists who worked on metals, ceramics and other domains straddling fundamental and applied physics wanted representation at APS meetings, leading to the creation of the Division of Solid State Physics in 1947. The institutional gerrymandering had significant implications for the APS, especially for its flagship journal, *Physical Review*. (Publishing is a fascinating leitmotif in Martin's account.)

This organizational innovation was achieved only after substantial resistance from some APS stalwarts, who perceived the purity of their ranks as becoming sullied by industrial scientists. The stalwarts included Harvard University's John Van Vleck, even though he had trained many of the leaders of the next generation, including Anderson. Van Vleck's objections were littered with political language: he protested against the "Balkanization" of the APS, and he thought the solid-state division was a "new-deal-bureaucratic" scheme that ought to be resisted. The conservative Van Vleck was unhappy about the direction that the United States — and with it physics — was going.

This raises a broader point about Martin's engaging book: the politics in it are exclusive to the profession. He keeps his gaze tightly trained on physicists as they define physics to each other. The Vietnam War (and scientific work in support of it), anti-Communism, civil rights and other political fault lines — which affected physicists no less than other citizens — are mentioned in passing, if at all. Yet they must have mattered. Physics is defined not just by what physicists decide it is, but by what the broader society will (or won't) support. That decision is made within the halls of the APS, but also in those of Congress. ■

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Forgotten heroes of the Enigma story

Joanne Baker enjoys a tale of the Polish cryptographers who paved the way for Alan Turing's wartime feats.

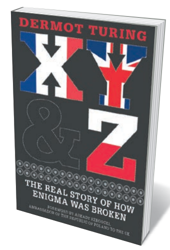
Alan Turing's crucial unscrambling of German messages in the Second World War was a tour de force of codebreaking. From 1940 onwards, Turing and his team engineered hundreds of electronic machines, dubbed bombes, which decrypted the thousands of missives sent by enemy commanders each day to guide their soldiers. This deluge of knowledge shortened the war. Bletchley Park, UK — the secret centre where it all happened — rightly gained its place in history. But as with all breakthroughs, many more people laid the foundations.

In his book *X, Y & Z*, Dermot Turing, the great mathematician's nephew, tells the gripping story of a band of Polish mathematicians who worked out much about how German Enigma encoding machines operated, years before Alan Turing did. The Poles shared their secrets with French and British intelligence services before and during the Second World War — the letters X, Y and Z were shorthand for the French, British and Polish codebreaking teams, respectively.

The author's research is painstaking. After the war, military documents were scattered across Europe, and key French records were declassified only in 2016. Many original Polish papers were destroyed, but

Mathematician Marian Rejewski in 1942.

ANNA ZYGALSKA-CANNON



X, Y & Z: The Real Story of How Enigma Was Broken
DERMOT TURING
The History Press (2018)

the mathematicians' families have shared personal letters. Turing unearths a remarkable tale of intellect, bravery and camaraderie that reads like a nail-biting spy novel.

Polish skills in cryptography and radio engineering came together during the 1920 Russo-Polish War. Signallers decoded a telegram from Red Army military commander Joseph Stalin, which indicated that an attack on Warsaw was imminent. Jamming the Russians' radio communications bought enough time to secure and save the city. Maksymilian Ciężki and Antoni Palluth were among those signallers. After the 1920 conflict, Ciężki became leader of a radio-intelligence unit. Palluth set up a business making electronic equipment, including radios the size of a credit card for Polish secret agents.

In 1926, the German navy began to send messages that were scrambled in a more random way, making them almost impossible to decipher. They were encoded using the typewriter-like Enigma machine. The keyboard was wired so that typing one letter lit up a different one in a set of bulbs on top. Rotors altered the path of the electric circuit with every keystroke. The machines were commercially available, but modified for German military use. Without knowing the precise setting of a machine, there was no way to unpick the code.

The book tells how Ciężki hired a group of mathematics students to crack the problem. They worked quietly in basements and in a bunker deep in the woods. Marian Rejewski, an alumnus of Poznań University in Poland, was one of them. At the helm was Gwido Langer, a Pole who had worked in radio intelligence for the Austrian army.

Meanwhile, in France, Gustave Bertrand headed the equivalent unit. The French had a more conventional approach to gathering information: good agents, clandestine meetings and generous pay-offs. Bertrand managed two formidable spies. Rudolf ▶