Neil W. Ashcroft

1938–2021

BIOGRAPHICAL *Memoirs*

A Biographical Memoir by
N. David Mermin

NATIONAL ACADEMY OF SCIENCES

NEIL WILLIAM **ASHCROFT**

November 27, 1938–March 15, 2021

Elected to the NAS, 1997

Neil William Ashcroft was a renowned physicist who coauthored the definitive text in solid state physics. He made significant contributions to the research on many-particle systems and superconductivity and predicted future discoveries ranging from the metallic properties of hydrogen to the structure of highly compressed lithium. Ashcroft played an important role in the development of the Cornell High Energy Synchrotron Source. He was Director of Cornell's Laboratory of Atomic and Solid State Physics, and of the Cornell Center for Materials Research.

Photography by Cornell University.

By N. David Mermin

Early Life

Ashcroft was born in London on November 27, 1938. He had memories from childhood of blackouts and bombings during World War II. Two years after the war, the Ashcroft family settled in New Zealand. There Neil received bachelor's and master's degrees in mathematics and physics from what is now the Victoria University of Wellington. He returned to England to do his Ph.D. at Cambridge University with John Ziman and Volker Heine. His 1964 thesis contained one of the earliest calculations of the Fermi surface of aluminum. Lecturing in the United States, he enjoyed explaining that "aluminium" was a transatlantic isotope of aluminum.

The 1960s were halcyon years for academic faculty growth. In 1964, Cornell University's condensed matter theory group had added three new faculty: Geoffrey Chester arrived as a tenured professor, and John Wilkins and I arrived as assistant professors.

Geoffrey and John had both known Neil as a graduate student at Cambridge, and they enthusiastically recommended him for a postdoctoral position after he completed his graduate work. Neil arrived in 1965 and after a single postdoctoral year was himself appointed an assistant professor. He would remain a member of the Cornell Department of Physics for the rest of his life.

Research

Neil's wide-ranging research in theoretical condensed matter physics included density functional theory, matter under extreme pressures, high-temperature superconductivity, metallic hydrogen and its alloys, and metal-insulator transitions. In 1968, he proposed that hydrogen would become metallic, and a high-temperature superconductor, at ultrahigh pressures. Three decades later, experimentalists showed that hydrogen molecules did indeed metallize.

When Neil's research group predicted in the 1990s that highly compressed lithium would change from a highly symmetric, close-packed structure to a less symmetrical form with more conduction electrons per atom, that surprising transition was quickly observed. Two decades ago, he predicted that hydrogen-enriched metallic elements would become

ultrahigh-temperature superconductors under extreme pressures. In the past decade that, too, has been confirmed: Several research groups achieved record high temperatures—room temperature and above—with superconducting LaH_{10} and SH_3.

Neil was also a talented administrator. He was director of Cornell's Laboratory of Atomic and Solid State Physics from 1978–84. I followed him in that office, serving from 1984–90, and I had a much easier time in the job than he did because of the superb administrative staff he had assembled during his own term.

He took it for granted that his successor would carefully read all the laboratory files upon taking the job, as he had done himself. It never occurred to me to undertake such a task. Therefore I did not see the many sticky notes he had left for me in those files until I was almost a year into the job, when the top nonacademic administrator of the laboratory asked me why he had not received the extra raise in salary that Neil had promised to recommend to his successor. To this day I continue to wonder what else I failed to do. The laboratory, however, has survived.

Neil played a vital role in launching the Cornell High Energy Synchrotron Source and served as its co-principal investigator and associate director from 1978–89, and its deputy director from 1990–97. He directed the Cornell Materials Science Center from 1997–2000, which he renamed the Cornell Center for Materials Research.

In March 1987, Neil chaired the famous "Woodstock of Physics," the extraordinary New York meeting of the American Physical Society at which were announced many new materials that superconducted at temperatures spectacularly higher than had ever been achieved. That session of five-minute reports began at 7:30 in the evening and ended at 3:15 the following morning. It was punctuated throughout by cheers and applause. Neil presided over it like the conductor of a symphony. He and the audience all had a wonderful time. One can get a sense of his wit and charm from online recordings of the event.

Neil took ritual and hierarchy seriously. At an online memorial meeting that his many graduate students organized on the anniversary of his death, I learned that he attended the graduation ceremonies of each and every one of them, dressed in his full Cambridge regalia. Throughout their graduate work, they had addressed him as "Professor Ashcroft." But immediately after they received their Ph.D. diplomas, he told each that they should now call him Neil.

Book on Solid State Physics

He and I became close friends soon after he arrived at Cornell. A year or two after Neil became a faculty member, he, John Wilkins, and I decided to write a book. We called the book Wilkins, Ashcroft, and Mermin: WAM (pronounced "wham!"). Soon after we started to produce first drafts of chapters in 1967, it became clear to Neil and me that John was too strongly engaged in his research to devote serious effort to writing an introductory book. We therefore suggested he leave the collaboration. WAM became AM. I believe John was as relieved as we were. The happiest years of my professional life were 1968–76, when Neil and I wrote the book and saw it into print. We called it *Solid State Physics*, but today it is better known as "Ashcroft and Mermin."

What gives our book its special character is that Neil was fascinated with materials. Each was like a personal friend. Although I had little interest in or knowledge of particular materials, I was fascinated by the conceptual structure that encompassed them all. For me, our book is an 800-page record of Neil's efforts to teach me solid state physics. You can get a hint of this in the last paragraph of our Preface. I thank Rudolf Peierls for having "converted [me] to the view that solid state physics is a discipline of beauty, clarity, and coherence." Then Neil adds that "having learnt the subject from John Ziman and Brian Pippard, [he] has never been in need of conversion."

This is a good example of the style of our book: on the one hand, but then on the other hand. It also indicates how we got into the project. I learned physics in graduate school at Harvard University. Solid state physics was not taught in its Physics Department. It was taught only in the College of Engineering. I did not learn about the physics of solids until I was a postdoc and attended Peierls's wonderful lectures, at his remarkable Department of Mathematical Physics in Birmingham, England, from 1961–63. My meager knowledge of the field made me a little nervous in 1964, when I started my faculty job at Cornell's Laboratory of Atomic and Solid State Physics. Fortunately for me, Neil arrived the following year. At that time, I was teaching the solid-state course as an exercise in self-education. I immediately started to learn from him.

The book occupied close to half of our time for the next eight years. Neil wrote most of the first drafts. I would rarely understand what general issue he was trying to get at and would revise it into something broader that made better sense to me. Neil would then correct all the mistakes I had introduced. Back and forth we went, slowly converging on something that looked good to us both. This was before the age of personal computers and text editors. I typed every page on a state-of-the-art IBM "bouncing-ball" typewriter, making revisions with a white "erasing ribbon" and redoing entire pages when revisions were major. It was a slow process. Today it would have taken half the time.

Neil had a wonderful sense of humor. He was a fine mimic and did a superb Hans Bethe. We had great fun dealing with each other's idiosyncrasies throughout the process, and our fun permeates the book. That might explain why it's still thriving, still in its original first edition, nearly half a century after it came out. In 1990, I remarked to Hans that "Ashcroft and Mermin" was still in its first edition. He said this showed "the stability of the subject." True enough. But I believe it's also because unlike almost all technical books, ours entertains the reader, just as Neil and I entertained each other during our six years of writing. We had very different prose styles. But thanks to our bouncing each chapter back and forth many times, our book has a distinctive uniform tone. But it's neither of ours.

The original publisher of our book, long ago swallowed up by successively bigger and bigger publishers, was so eager for us to sign their contract that they offered us terms that were unusually lucrative half a century ago, and entirely unimaginable today. So our financial incentive for producing a new edition with a new contract was always rather low, as long as people were continuing to use our first edition.

But neither of us could have imagined fifty years ago that our first edition would outlive Neil, into his eighties, and still be selling several thousand copies a year. I'm three and a half years older than Neil, so our book is more than likely to outlive me, too. Something of a headache for our children to deal with, but since it paid their college bills for them all, as hoped for on our dedication page, I guess our kids will owe it something in return.

We even had a good time reading page proofs and assembling our enormous index, not an easy job in the 1970s. Every entry was written by hand on a "3-by-5 [inch] card." If we stacked them, the pile would have been a couple of meters high. Neil's favorite index entry is "Cart, before horse, 92," followed nine pages later by "Horse, after cart, 92." My own favorite, on page 808, is "Exclamation marks, 61,185, 219, 224 (twice!), 291, 305, 403, 808."

After being acquired by larger and larger publishers with less and less interest in it, "Ashcroft and Mermin" ended up in the twenty-first century being produced by a mammoth international educational consortium. In 2016, without asking our permission or even informing us, their Asian branch issued a "revised edition" put together by a third "coauthor," who let us know, after we had stumbled upon her finished product, that she was never told that we knew nothing whatever about her project. If we had been asked by the publisher, as our contract required, we would not have permitted it. When we learned of its existence and protested, they said it would be available only in Asia.

Neil and I had only two other collaborations. One was a short memorial article, "Hans Bethe's Contributions to Solid-State Physics," in 2006, the centenary of his birth for the *International Journal of Modern Physics*. The other (with Malvin Kalos) was an obituary of our dear friend Geoffrey Chester in 2014 for *Physics Today*. Our revisions were unbelievably easier in the modern era, but they were just as extensive. It was clear to us that in spite of the advances in literary technology, we no longer had the intellectual energy for a second edition of our book, even if one had been needed.

Later Years

After he retired in 2006, Neil joined Roald Hoffmann's research group in Cornell's Department of Chemistry and Chemical Biology. Over the next decade, they collaborated on almost thirty joint papers. According to Roald, "Neil was wise and perceptive, fascinated by the border between chemistry and physics. We valued his physical insight and remember his gentle wit."

Neil Ashcroft maintained his link to New Zealand throughout his long life at Cornell. He was one of the most eminent New Zealand physicists since Ernest Rutherford. After a few years of debilitating illness, he died of pneumonia in Ithaca, New York, on March 15, 2021. Life in Ithaca without him has been less intellectually stimulating, and significantly less fun. I miss him enormously.

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