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How technology made condensed matter physics boring

Joseph D. Martin

Condensed matter is one of the largest and most prolific areas of physics, but it looms small in the public imagination. In this Comment, historian Joseph D. Martin argues that its relationship with technology might be to blame.

Tell someone at a cocktail party that you study physics, and they are apt to recoil, as if to open up wider angles for escape. But worse, reveal that you study solid-state physics and watch the flame of an already dying conversation sputter into smoke. The science writer, Sidney Perkowitz, observed this 'step-back'[1] effect in 1995. Three decades on, solid-state physics – or condensed-matter physics (CMP) as it has been renamed[2] – still struggles to grab the public imagination like high-energy or astrophysics. A common explanation is the just-so story: space and elementary particles just are fascinating, and those fields can lean on that inherent interest. But have you ever watched a child play with a magnet? Humans clearly have a deep, intrinsic fascination with materials. So why does CMP fail to attract public interest?

Various other explanations have been proposed. Perhaps CMP is just too complex to communicate clearly. Yet the dizzying complexity of string theory has been key to its popular success. And the canard that only a dozen people worldwide could understand general relativity helped catapult Einstein to fame[3]. Complexity and esotericism often supplement science's appeal, rather than impede it.

What about a lack of effort? Fields that rely on large amounts of public funding and huge scientific facilities, like high-energy physics, must invest in popularization to ensure public support. That is true to an extent, but it doesn't explain the poor market performance of the efforts condensed-matter physicists have made. Philip Anderson, Robert Laughlin, Leon Cooper, and others have all written popular books, but none have performed so well as similar fare from Lisa Randall, Carl Sagan, or Steven Weinberg.

These explanations go some of the way to explaining CMP's lack of popular appeal, but for this historian they don't quite scratch the itch. They all look like symptoms of something deeper. When condensed-matter physicists bemoan their popular obscurity, they often point out that the field is closely connected to the technologies people know so well. Shouldn't that make it easier to grab public interest? I've come to believe that the opposite is true: a close relationship with technology has conspired to obscure the intellectual accomplishments of CMP. Seeing how requires a historical lens.

[H1] A historical quirk

Much of how, and why, one part of science gains prominence over others owes a great deal to historical accident. In the 1940s, a distinction between 'basic' and 'applied' science began to emerge in the USA—just as the new field of solid-state physics was getting its start. The military relevance of science, physics especially, became evident during World War II. But work on military applications demanded restrictive government control of research. 'Basic research' was a powerful rhetorical tool. It implied undirected and curiosity-driven research exploring the foundations of knowledge—and yet, many scientists argued, basic science was also the rich soil from which useful applications grew. Such arguments were used to hold classification regimes at arm's length as the military relevance of science became ever more evident in the 20th century[4].

This so-called 'linear model of innovation', in which practical advantage follows linearly from unprogrammed basic research, is what scientists invoked to explain the importance of fundamental science in a context hungry for new technologies[5]. But one consequence was that fields like CMP that regularly intermingled basic inquiry with applied objectives were stigmatised as mere technological development. As the Nobel laureate Philip W. Anderson lamented, CMP was 'caught between the Scylla of the glamorous big science projects ... and the Charybdis of the programmed research, where you have deliverables, where you are asked to do very specific pieces of research aimed at some very short-term goal'[6]. Anderson and his colleagues complained that university researchers in CMP enjoyed less funding for curiosity-driven research, that industrial researchers were pushed toward applied research, and that both struggled to share in the popular acclaim physicists enjoyed in the Cold War era. Basic research on complex matter was both funded and appreciated less during the Cold War decades when physics enjoyed its most lavish support, particularly from government agencies like the Atomic Energy Commission in the United States and CERN in Europe.

[H1] The banality of technology

Around the same time as the categories of basic and applied science were emerging, new technology was also becoming increasingly ordinary. In the West, the post-war decades saw the growth of consumer culture and a flood of new gadgets, many of which were a direct result of materials research. The transistor revolutionized computing and electronic communication, new understanding of metals transformed aviation, and polymers—including plastics—were suddenly everywhere. Ironically, this technological abundance made it harder to muster reverence for the science that lay behind it.

Through the middle decades of the 20th century, most public engagement with science was mediated through print. But even when reporting on abstract advances in CMP, newswriters would almost always search for a technological hook. When Anderson, John Van Vleck, and Nevill Mott won the Nobel Prize for their fundamental research into magnetic and disordered systems, the New York Times cited their work's importance to "the development of computer memories, office copying machines and many other devices of modern electronics," despite the fact that none of the three ever pursued applied research[7]. Popular audiences were invited to focus on commonplace technological artefacts at the expense of intellectual accomplishments.

The story that encapsulates this best ran in the Los Angeles Times in 1972. John Bardeen had just won his second Nobel Prize, for the BCS theory of superconductivity—one of the landmark theoretical achievements of the century. His first Nobel, in 1956, had come for the invention of the transistor, a technology that was ubiquitous by the early 1970s. But when Bardeen tried to drive to the celebration the University of Illinois held in his honour, his transistorised garage door failed to open. "Door Ignores Physics Prize," the LA Times announced[8]. Once a marvel of modern science, the transistor was now just another part in another household gadget that occasionally needed to be repaired. New technologies hold their mystique only until they break.

[H1] The future of condensed matter

The close association between technology and CMP, rather than contributing to appreciation of the field, helped disguise its most profound intellectual accomplishments. It didn't have to be that way. Notably, the opposite dynamic played out in the Soviet Union. There, the distinction between basic and applied research never took hold. The influence of Soviet ideology on science had many damaging consequences, but, because Soviet science was explicitly organised to serve the state, it did encourage linking fundamental insights to practical outcomes in a way that favoured the sciences of materials. We still use language steeped in communist ideology—such as 'collective phenomena'—that trace to a time when CMP held a comparatively prestigious place in Soviet society[9].

The question of why CMP remains so much more obscure that its more hyped cousins is complex, but the close association with technology is at its core. Crucially, though, the relationships among science, society, and technology that contribute to these dynamics are historically contingent. Those relationships are already changing in the twenty-first century. Materials, previously the source of new technological wonders that matured into ordinary objects, are now core to our responses to some of our most pressing global challenges—better batteries, more efficient electronics, carbon capture. They have also caused some of those challenges, such as plastics polluting the oceans. All indications are that the future of science is material. That just might make it newly possible to highlight the intellectual achievements of a science not by emphasising how 'basic' it is, but by showing how it links intimately with our most urgent problems. If condensed-matter physicists crave popular recognition, contributing to this recalibration of the relationship between technology and society would be one way to pursue it.

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References

1. Sidney Perkowitz, "Stealth Science," The Sciences 36, no. 6 (Nov–Dec 1995): 40.
2. Joseph D. Martin, "What's in a Name Change?: Solid State Physics, Condensed Matter Physics, and Materials Science," Physics in Perspective 17, no. 1 (2015): 3–32.
3. Marshall Missner, "Why Einstein Became Famous in America," Social Studies of Science 15, no. 2 (1985): 267–91.
4. Mario Daniels and John Krige, "Beyond the Reach of Regulation?," Technology and Culture 59, no. 2 (2018): 226–50.
5. Benoît Godin, Models of Innovation: The History of an Idea (Cambridge, MA: MIT Press, 2017).
6. United States Senate. 1989. Proposed Fiscal Year 1990 Budget Request (DOE's Office of Energy Research): Hearing before the Subcommittee on Energy Research and Development of the Committee on Energy and Natural Resources, 134, February 24, 101st Cong., 1st sess.,
7. New York Times, "2 from U.S. among 4 Nobel Science Winners," 12 October 1977.
8. "Door Ignores Physics Prize," Los Angeles Times, October 21, 1972, 8.
9. Alexei Kojevnikov, "Freedom, Collectivism, and Quasiparticles: Social Metaphors in Quantum Physics," Historical Studies in the Physical and Biological Sciences 29, no. 2 (1999): 295–331.

Competing interests

The authors declare no competing interests.

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