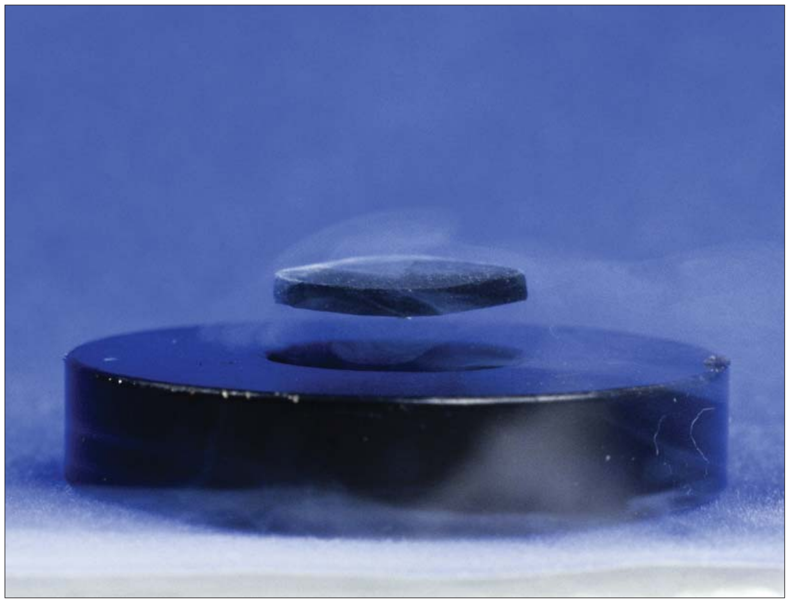
# Superconductor memories




I can still remember the first time I heard the word superconductor. (A great moniker, by the way, catchy and accurate). We were told in school that some chap Onnes discovered that the electrical resistance of mercury disappeared when cooled to 4.2 K (of course, *why* anyone would be conducting experiments at this sort of temperature was not explained, but he got a Nobel prize for this sort of thing). The news puzzled me greatly: what about Ohm's law? Didn't $I = V/R$ imply that an infinitely large current could arise under such circumstances? Wasn't that dangerous? From that point on, I thought of Ohm's law as Ohm's relation-that-is true-for-some-materials-at-some-temperatures. This was an early lesson in the approximate nature of some physical laws.

Superconductivity showed up again in my first year at university. This time around, it was even more mysterious. Apparently, a material in superconducting state could repel an external magnetic field, and even levitate a small magnet (another Nobel prize). Clearly, there was something special about these materials; superconductors were not merely super conductors! However, it was not until I was immersed in the horrors of third-year quantum physics that some sort of explanation was forthcoming.

Superconductors were not merely super conductors

Ah, yes, that business of energy gaps and Cooper pairs; according to the theory of Bardeen, Cooper and Schrieffer (BCS), electrons could get together in pairs and act in concert. Another Nobel prize, but I must confess I didn't really understand the theory at the time. (It was years later that I realized that the point was that electrons in a superconducting phase can form a condensate not unlike a Bose–Einstein condensate.)

Anyway, the boffins must have got something right; there were plenty of successful applications of superconductor technology already in existence when I was a student in the mid-1980s, from memory devices based on Josephson junctions to sensitive magnetometers utilizing the splendidly named SQUIDs (superconducting quantum interference devices, if you must). Of course, the killer application was the superconducting magnet, a technology ideal for the intense magnetic fields required by high-energy particle accelerators to bend particles into a circular path. And how could anyone forget the Superconducting Super Collider (SSC)? I was still an undergraduate when the SSC was approved; sadly, it was destined never to be built.

Around this same time, along came superconductivity mark 2. I had just started a PhD in semiconductor physics at Trinity College Dublin when suddenly everyone was talking about a brand new phenomenon – the discovery of high-temperature superconductors by Müller and Bednorz (yet another Nobel prize). However, it soon transpired that the correct expression should have been *higher*-temperature superconductors; the new materials had critical temperatures of 30 K, which still called for very specialized experimentation. Another snag was that these materials were not simple compounds but complex ceramics with names such as lanthanum–barium–copper-oxide. (Ceramics? I thought ceramics were insulators.) Such materials necessitated skilled chemists and materials scientists on the team, so my supervisor and I decided to stick with semiconductors.

Still, it was a very exciting time in physics, with research teams around the world cooking up ceramics of every combination and reporting superconductors with ever higher critical temperatures. By 1987 materials with critical temperatures above 77 K had been discovered. Suddenly, superconductivity research was no longer the preserve of the world's richest labs; experiments could be done using liquid nitrogen as a refrigerant. I remember colleagues in the research group of Mike Coey, an experimentalist at Trinity, making several significant advances.

Intriguingly, it emerged at around this time that good old BCS theory could not account for the new class of superconductors. Indeed, there seemed to be no sign of an underlying explanation. I have a vivid memory of Coey remarking acidly at a public seminar that there seemed to be as many theories as there were theorists. In the absence of a successful theory, brute empirical work forged ahead in a manner the philosopher Ernst Mach would surely have admired.

All in all, it seemed at the time that materials science was truly at the cutting edge of physics. Anything was possible. It was straight into this atmosphere that Pons and Fleischmann dropped their announcement of cold fusion. The story of the cold-fusion controversy has been told many times, but superconductivity is rarely mentioned. Yet I'm convinced it played a role. Physicists had just been shown how little we knew of the solid lattice and nothing was off the table. Indeed, quite a few of my contemporaries were diverted into cold-fusion research for some months.

What is the state of play with superconductivity now? Progress with novel superconducting materials has continued, but the holy grail of this field – a material that exhibits superconductivity at room temperature – remains as elusive as ever. There is also still no sign of a successful theory for the effect, so there is another superconducting Nobel out there for someone...

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