Michael Tinkham

(1928–2010)

Physicist who helped to unravel the mysteries of superconductivity.

Almost 100 years after superconductivity was discovered in 1911, the field has lost one of its finest contributors and certainly its most important contemporary articulator of how the phenomenon works.

Throughout his life, Michael Tinkham, who died on 4 November, never lost his remarkable ability to recognize the essentials and explain them to the rest of us. A colleague of his once said you could take him data that looked like pigeon droppings and leave with flakes of gold. Irreverent perhaps, but legions of graduate students and postdocs shared this experience. Tinkham's classic book *Introduction to Superconductivity*, first published in 1975, remains to this day the definitive treatment of the subject— making it accessible to a wide range of scientists and engineers.

Tinkham started his academic career as an undergraduate at Ripon College in Wisconsin, near where he grew up. After graduating, he went to the Massachusetts Institute of Technology in Cambridge, where he received his master's and his PhD, before completing a postdoc at the University of Oxford, UK.

When he returned to the United States in 1955, he took a faculty position at the University of California, Berkeley. It was here that he began to develop his life-long interest in superconductivity — the astonishing property that some metals have at very low temperatures of allowing current to flow through them with no resistance.

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Tinkham recognized that many properties of solids might usefully be studied spectroscopically using far-infrared radiation — until this point, its use had been confounded by poor sources and detectors. Specifically, he suspected that changes in the absorption of this radiation would occur when solids become magnetic or superconductive.

In the same way that electrons in atoms have energy levels, so do conventional metals. However, for metals, the distribution of these energy levels is essentially continuous. A characteristic property of a superconductor is that an energy gap forms in this continuous distribution. We now know that this gap results from electrons in the metal binding into pairs — a phenomenon fundamental to superconductivity — but

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in the mid-1950s, there wasn't even direct evidence that such a gap existed.

In 1956, Tinkham and fellow postdoc Rolfe Glover found the first direct evidence for this energy gap in the form of a sharp rise in the absorption spectrum of a superconductor. They also noted that aspects of the absorption data were counter-intuitive. For instance, the amount of radiation absorbed didn't just steadily rise as Tinkham and his group increased the energy of the radiation beyond that needed for any absorption to occur. It rose above the level of absorption one might expect for a non-superconducting metal before decreasing to the expected value. Tinkham loved to tell the story of how, when he mentioned these peculiar observations to John Bardeen, who was already working with Leon Cooper and Robert Schrieffer on what turned out to be the correct theory of superconductivity (the BCS theory, proposed in 1957), Bardeen simply commented that such behaviour was "not unexpected".

Bardeen was right: these observations were a direct consequence of the celebrated 'coherence factors' of the BCS theory. Bardeen and his colleagues soon established that when superconducting electron pairs are broken apart (for example, by radiation), instead of producing two separate electrons, a combination of electrons and 'holes' results — a 'hole' being the conceptual and mathematical absence of an electron. This observation, along with other unusual phenomena, measured for instance by passing sound waves through superconductors, provided the first substantive experimental confirmation of the BCS theory. Bardeen, Cooper and Schrieffer went on to win the 1972 Nobel Prize in Physics.

REAL-WORLD EFFECTS

This spectacular role in the early history of the BCS theory behind him, Tinkham continued to work with far-infrared spectroscopy but also began to study the macroscopic quantum behaviour of superconductors. Quantum mechanics is normally thought of as important only in the microscopic world of atoms, but in superconductors it manifests itself in very large objects, such as in the superconducting magnets used in magnetic resonance imaging. After Tinkham took up a professorship in 1966 at Harvard University in Cambridge, Massachusetts, one question emerged that remained of central interest to him: what is the nature and origin of resistance in a superconductor? Or put more simply, when is a superconductor really a superconductor?

As it turns out, when superconductors are carrying a current, they don't stay in a fixed macroscopic quantum state, but cascade down from one energy level to another. As energy is lost with each transition, this is equivalent to saying that superconductors have resistance, although it is extremely small under most conditions. In the latter stages of his career, Tinkham was examining the conditions under which these transitions happen and how they happen in very thin wires of a superconductor.

Despite all these achievements, being elected to the US National Academy of Sciences and winning the prestigious Oliver E. Buckley prize of the American Physical Society, Mike was a modest man with an exceptional sense of humour. The same legions of students who witnessed his alchemy with data will remember how they first knocked nervously on his door to be greeted by a somewhat gruff "Come in", only to learn that he was a very warm and witty mentor.

I was privileged to be in Mike's group at Harvard from 1968 to 1974. His breadth of skills — as part theorist, part experimentalist — made him seem to me the archetype of a complete physicist. ■

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