J. Robert Schrieffer (1931–2019)

With the passing away of Robert Schrieffer a few days ago, one of the pioneering figures in modern theoretical physics is no more. Schrieffer, as a Ph D student, working with his mentor John Bardeen and postdoctoral colleague Leon Cooper, gave to the world the microscopic theory of superconductivity in 1957. (Their theory, unbreakably supported by a host of experiments, is considered the gold standard for the atomic-level understanding of the behaviour of electrons in matter, indeed of all fermions.) The flow of electrical current without any resistance, suddenly turning on in a very cold metal (close to, but above the absolute zero of temperature) is one of the most spectacular and mysterious phenomena in physical sciences. Discovered in 1911, its seductive appeal lured almost all the great names of physics into (unsuccessful) efforts at making sense of the phenomenon.

Young 'Bob' Schrieffer chose, for his Ph D work, the tenth and last problem in the list of possible ones which Bardeen showed him. It was superconductivity. This was no accident or malice. Bardeen, already a legendary figure in solid state physics (he was to be awarded, very soon, his first Nobel Prize in Physics with Brattain and Shockley for the co-discovery of the point contact transistor), was at that time one of the leading figures internationally in the field of superconductivity, a storehouse of experimental knowledge and insights. He was possessed with the belief that the nut would be cracked soon, though it had not been cracked for nearly half a century. Cooper had just shown that the weakest attraction between electrons bound them into pairs; Bardeen had an idea about what this glue could be. It was Schrieffer's proposal of a novel quantum mechanical wave function for the superconductor viewed as a collection of a near Avogadro number of pairs of electrons which broke the logjam. The wave function flew in the face of one's expectations; not only were all the electrons paired, it described a system without a definite electrical charge. The theory of superconductivity, and our atomic-level explication of the belief that a macroscopic piece of matter can be described by a single wave function, flowed out of this breakthrough.

The Bardeen–Cooper–Schrieffer (BCS) theory is not just a microscopic description of superconductivity in metals; it is a paradigm which describes a likely state of all matter consisting of fermions. It may be fundamentally involved in the generation of all the mass that we see, and of dark energy in the universe that we do not see. Out there, superfluid neutron stars exhibit phenomena which persuasively identify them as such. We owe

to this theory the discovery and understanding of amazing phenomena such as the appearance of an alternating current with its frequency determined by fundamental physical constants when a steady (DC) voltage is applied across a junction of two superconductors (the Josephson effect).

Just this would have ensured Schrieffer immortality in science. Certainly, the recognition which flowed showed what the world thought. He, along with Bardeen and Cooper, was awarded the Nobel Prize in Physics in 1972 for this work (the theory is universally known by the acronym BCS). Schrieffer was awarded the National Medal of Science of USA in 1983. He was successively the Director of two national science institutions in the US – the (Kavli) Institute of Theoretical Physics in Santa Barbara, California and the National High Magnetic Field Laboratory in Tallahassee, Florida.

The fact that one's Ph D work won the Nobel Prize sets a nearly impossible standard for that person's future professional efforts. Schrieffer's greatness lies also in the way he integrated this into his life. Through his professional work and his leadership, he enriched physics. It is hard to choose among his many subsequent pioneering contributions. Just one example is the following. Schrieffer's proposal for the nature of trans-polyacetylene was the first explication of a topological state in condensed matter.

Schrieffer's high-quality leadership in the two national institutions mentioned above was transformative. He was a leading figure in the activities of the International Centre for Theoretical Physics, Trieste, Italy, for decades.

Schrieffer wore his distinction lightly. He was courteous, humble, easily approachable, listened to people and was equally at home with kings and commoners. For one who had climbed the highest peaks of creativity, he was amazingly patient with students taking the first steps.

Schrieffer's humility and openness were not put on. One of us remembers an occasion when, as a referee of a paper by him submitted for publication, Schrieffer took time out to discuss the issues threadbare, at great length. (The paper was on a contribution by Schrieffer and colleagues and was constructively critical.) The work was published, in the same journal, and with the approval of the referee.

Schrieffer's professional legacy and his humanism will survive for long.

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