Published in *Contemp.Phys.* **50**, 69 (2009).

B W Petley, "The Josephson Effects", 1969

It must be rare indeed for a PhD student to discover a new phenomenon of such importance that it subsequently bears his/her name and leads a few years later to the award of a Nobel Prize. Yet this is exactly what happened to Brian Josephson. Petley explains how, as a PhD student in Cambridge, Josephson wondered what would happen if the electron gases in two pieces of superconductor were weakly coupled together. The question was intriguing because the electrons in a superconductor link up with each other as Cooper pairs, which then form a Bose-Einstein condensate (BEC). Consequently, they behave as a single quantum object characterised by a macroscopic wave function that fills the whole piece of material. With zero coupling, the wave functions in the two parts would evolve independently. With strong coupling, the two parts would effectively become a single entity with a unified wave function. But what happens if there is a weak coupling, for example via a narrow link, or a very thin insulating barrier?

This was the question that Josephson formulated, and solved theoretically. It led to his 1962 prediction, not of a single new phenomenon, but of the several linked phenomena now known collectively as the Josephson effects. They were demonstrated experimentally within a matter of months. Petley's celebrated review appeared in 1969, only seven years after Josephson's original paper, and it can be considered a classic. He outlines the underlying physics clearly and concisely, sets the discovery in context, and considers some of the possible future consequences.

Of course, much has happened in physics in the last forty years, and there was much that Petley could not possibly have forseen. For example, he discusses the analogous Josephson effects to be anticipated in other BECs. The experiments he describes as demonstrating Josephson effects in superfluid ^{4}He were subsequently found to be based on artifacts that had been misinterpreted, but this hardly matters becasuse the physics that he describes is correct. Josephson effects really were demonstrated experimentally in superfluid ^{4}He later on, and they were also shown to occur in superfluid ^{3}He and, much more recently, in the BECs formed by laser-cooled atomic gases.

Josephson effects have already been put to good use in accordance with Petley's predictions, especially in superconducting quantum interference devices (SQUIDs) to measure extraordinarily weak magnetic fields. They also provide an exact relationship between frequency and voltage and thus, since frequency is known exactly from the Cæsium standard, they can be used to provide an absolute measure of voltage. More recently, they have been suggested as memory elements for quantum computers, and so the story continues.

Despite the huge developments of the last few decades, Petley's paper remains an excellent and accessible introduction to the subject in the best traditions of *Contemporary Physics*.

P V E McClintock
1 November 2008