The first time they were written down was in August 1962. Josephson submitted, in support of an application for a research fellowship at Trinity College, Cambridge, a “fellowship thesis” that contained the first really full, account of the general nature and the physical meaning of the Josephson effect. This paper also contained the generalization to nontunneling situations, which I later called “weak superconductivity.” One copy of this thesis remains, I believe, in the Trinity College library; one copy Josephson kept, and for some reason a photostat copy turned up in Chicago. Later on, after we did the experiments, I received a copy also. But the first three copies represented what Josephson felt to be adequate publication. Perhaps I am not being quite fair, because most of these ideas were included in Josephson’s remarks at the LT8 conference in London, September 1962, in a rather famous debate with John Bardeen.

I had reproduced some of these results but, knowing after the fact about Josephson’s thesis, I did not want to call too much attention to my own work of several months later. Therefore I published by own full version in the notes of the Ravello Summer School of May 1963, which took almost two years to appear in print.

Neither of these two roughly equivalent papers is widely quoted, to say the least. That is a pity, because together they contain many things that had to be rediscovered later. I find in my file of letters from Josephson that we discussed the possibility of a joint paper, but this seems not to have come off.

Significance

This is enough reminiscence: what has turned out to be the significance of Josephson’s discovery? I think two analogies may help to show how important it is. Imagine, for one, that we had developed a purely theoretical geophysical model of the earth that predicted the existence of a magnetic field, but imagine in addition that no one had yet invented the compass! I like that analogy because it shows up both aspects of the importance of a measuring instrument and the Josephson effect is first and foremost a measuring instrument. The measuring instrument is important because, first, it verifies the theory, and second, it suggests a host of practical uses.

The second analogy for the significance of the Josephson effect is somewhat deeper. Suppose we understood the wave nature of light theoretically, and had even developed the laser, but no one had ever invented a way to get the light beam out without completely messing up the laser oscillations. That is, suppose no one had invented slits, half-silvered mirrors and all the other paraphernalia of interference experiments. We should then be in the same frustrating position that we were in with regard to superconductivity before Josephson. Then we had a theory and sources of coherent radiation, but no measuring instruments or gadgets to verify the theory and make use of the coherence.

In 1962 we had already postulated that superconductivity consisted of a coherence of the de Broglie waves representing pairs of electrons inside the superconductor. Prior to Josephson, the phase ϕ of these macroscopic waves was thought to be unmeasurable in principle, by the same kind of specious reasoning that has been used to prove such things as the nonexistence of ferroelectricity. In principle the phase varies with magnetic field and current in space according to the equations

\[ \text{velocity of superelectrons } v_s = \frac{\hbar}{m} \left( \nabla \phi - \frac{2\pi}{e} \mathbf{A} \right) \]

and in time according to the Einstein-Josephson equation

\[ \hbar \alpha = \text{energy} \]

That is,

\[ \hbar \frac{d\phi}{dt} = \mu_0 + 2\pi \phi \]

where \( \mu_0 \) is the chemical potential.

It was not yet entirely clear at the time that these two equations are equivalent to our theoretical understanding of superconductivity. The second equation predicts zero resistance in the absence of acceleration \( (d\phi/dt) \), and the first leads to the Meissner effect and to flux quantization.

The four equations in the box on page 24 tell us all we ever need to know about the Josephson effect and most of what we need to know about superconductivity. The first two equations give us a way of comparing the phases of two weakly coupled bits of superconductor, if they are so weakly coupled that they do not seriously perturb one another.

The straightforward way to verify the Josephson effect is simply by observing the superconducting tunnel current between two bits of superconductor. It is important that the junction really be a tunnel junction. Josephson’s theory predicts a certain magnitude for the tunnel current. We began by making this observation, which is simple theoretically but not very elegant experi-