Brian Josephson: Some Historical Remarks

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I met Brian Josephson for the first time when he visited University of Maryland at College Park in 1966 or 1967, at the time when he was staying at Urbana, IL, where he had got involved with critical phenomena in the group of Kadanoff. At that time, there were two former student friends of his from Cambridge in the solid state group at Maryland; one of them was Brian Willott with whom I shared office. This was the time of “brain drain” from Britain to the USA. I was working with Jack Leibowitz, on a NATO Science Fellowship, from University of Oslo, doing very high resolution measurements and theory on the extremely sharp drop of attenuation of shear waves at the superconducting transition in indium, with submillikelvin temperature resolution.

During his visit, I took Josephson, Brian Willott and Bob Anderson in my old, second hand Plymouth Barracuda and travelled with several others from Maryland on a tour to the Blue Ridge Mountains in the Allegheny range. During stops I noticed Josephson’s youthful manners. But climbing mountains was not in his line, a city boy, obviously not much used to nature trips.

Physicists at Maryland were deeply interested in his work, especially Richard Ferrell and Richard Prange, the leading theorists in the solid state group. Already in 1963, they had published what is known as the Ferrell-Prange equation for the Josephson penetration depth of a magnetic field into the insulating barrier of junctions. The penetration depth here is much longer than in the superconductor since the concentration of Cooper pairs is much lower in the barrier. One finds a Josephson penetration depth of typically 0.1 mm.

My next encounter of significance with Brian Josephson took place in his home in Cambridge in 2003 when I was

interviewing 10 Nobel laureates, particularly in superconductivity, originally for the book with Sudbø on Wiley¹ 2004, later published in full on Springer² 2013. Josephson’s friendly wife was also present, mostly attending her garden. As is well known, Josephson has made some surprising changes of interests after receiving the Nobel price, shared with Esaki and Giaever in 1973. An example of such directions is “intelligent design”, implying a diversion from a physicists usual credo. I chose to stay 100% on course during our conversations, i.e. on his early development and education, and on his great contribution to superconductivity history.

On this Cambridge trip, I also visited Josephson’s thesis adviser Brian Pippard who reminisced about his graduate student’s close relationship with his very caring Jewish mother. She was often on the phone to Pippard, not quite common procedure at this level, most likely due to her son’s relatively young age. Pippard originally assigned some experimental problems in superconductivity to Josephson. In my notes, the exact nature of these experiments is not mentioned since he said they revealed no particular gift on the part of Josephson in such direction. Anderson³ later confirmed this, stating in correspondence with me in 2003 that “...he (Josephson) was unable to demonstrate his effect experimentally”.

In the Springer book, I have touched upon some questions of historical nature that may have been raised in the past, typically of the type “who influenced whom?”, and “who had such and such idea first?”

An important question we might ask is, from where did the idea of tunnelling appear in the context of superconductivity? Phil Anderson³ is very clear: “There is no question whatever that Josephson’s work was consequent to Giaever. No one had any idea that tunnelling would reveal superconducting properties before Giaever”. Anderson adds: “It’s important to

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¹ Kristian Fossheim and Asle Sudbø: *Superconductivity. Physics and Applications*. Wiley 2004

² Kristian Fossheim: *Superconductivity: Discoveries and Discoverers. Ten Physics Nobel Laureates Tell Their Story*. Springer 2013

³ Kristian Fossheim: *Ivar Giaever in Norwegian Nobel Prize Laureates*. Olav Njølstad ed. Universitetsforlaget 2006

realize that Giaever was experimental and that his was the first demonstration that tunnelling between metals really happened”. And “There was a spate of theoretical papers ALL following Giaever - Kane, Harrison, Bardeen, and then Cohen Falicov and Phillips introducing the tunnelling Hamiltonian method. Josephson quite clearly took the latter papers and observed that they were missing a term - that is the way he put it to me when he asked me to check over his work...”.

Since Phil Anderson was at Cambridge at the time, Josephson learned a lot of deep theory from his course on *Concepts in solids*. Broken symmetry was a very important concept in this context. The paper by Anderson on the pseudo-spin model for superconductivity was also important². The concept of phase appears in that model. This led Josephson to believe that similarly the phase of the superconducting wave function was important and convinced himself that it had a real existence. This thinking was present in most of his approaches.

The phase of the wave function became the subject of tea-time discussions with Pippard and Anderson. The latter favoured Josephson’s thinking, while Pippard was sceptical. Details of the discussion are given in². At one point, Josephson found that it could only be the *phase difference* that mattered, and not the absolute phase. But the phase could only matter if there was a transfer of Cooper pairs through the barrier. In Josephson’s recollection, the idea of phase as important in tunnelling was definitely his own.

Also, in the book on Springer², the story of the controversy with Bardeen is given in some detail, known as *The case of the student against the Nobel laureate*. Bardeen even published the claim that Josephson was wrong, which he later corrected. *Physics Today* had a nice cartoon reflecting these events. The photo of Josephson holding the cartoon from *Physics Today* is a picture I took in his home, also shown in².

It is fair to state as common opinion among physicist that Brian Josephson’s work on superconducting tunnelling at Cambridge was a work of true genius.

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