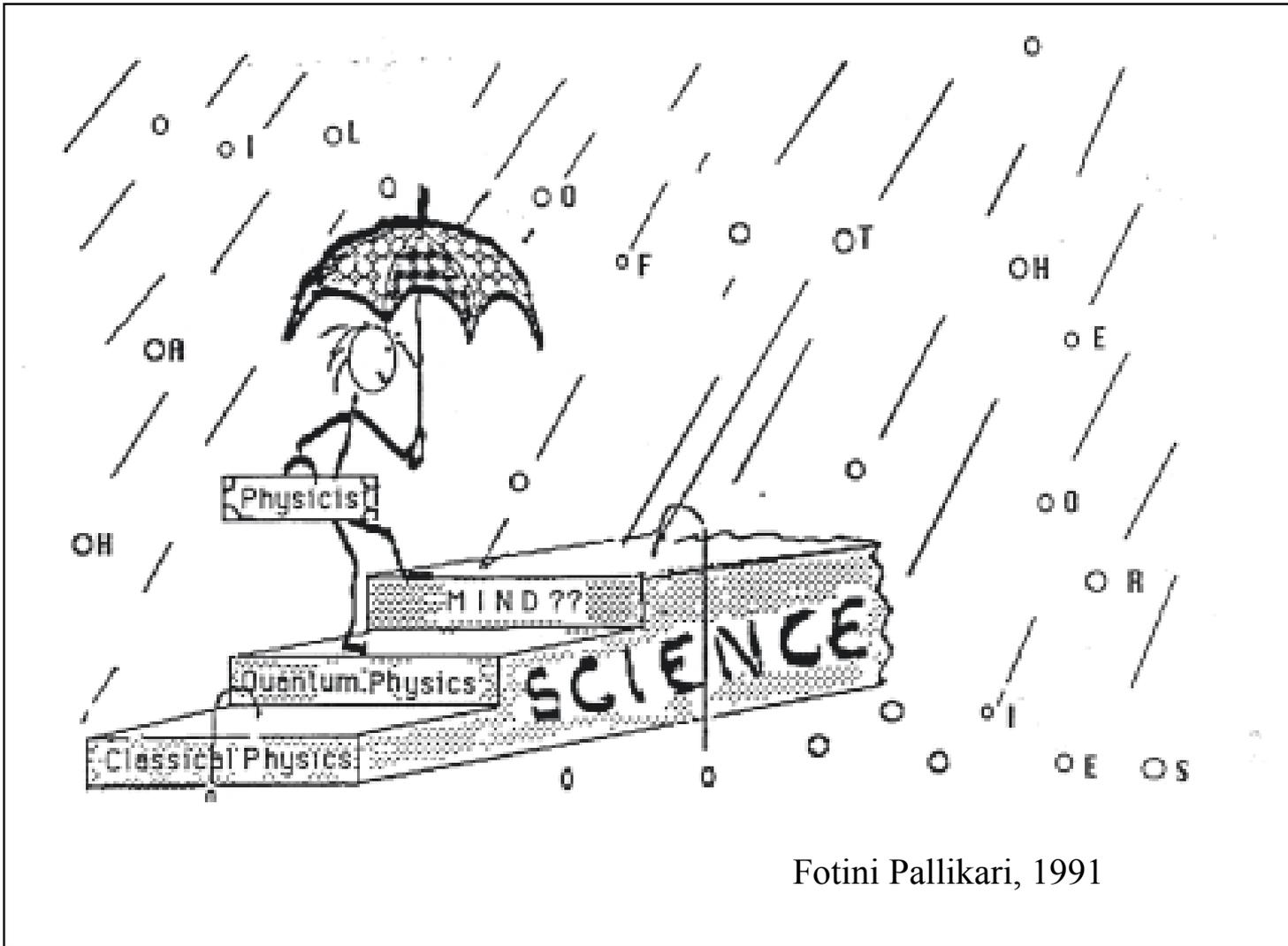


The Path To the Discovery

bdj50 conference

50 years after the discovery

- Developing Ilexa Yardley's *Circular Theory*
- Blends physics and biology to create 'the real M-theory'



Fotini Pallikari, 1991

Just some brief comment on ...
the rocky path after the discovery

Low Temperature Physics/Fizika Nizkikh Temperatur, 2012, v. 38, No. 4, pp. 333–335

Coupled superconductors and beyond

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Received December 19, 2011

This paper describes the events leading to the discovery of coupled superconductors, the author's move in the 1970s to a perspective where mind plays a role comparable to matter, and the remarkable hostility sometimes encountered by those who venture into unconventional areas.

- *This paper describes the events leading to the discovery of coupled superconductors, the author's move in the 1970s to a perspective where mind plays a role comparable to matter, and the **remarkable hostility** sometimes encountered by those who venture into unconventional areas.*

Case 1:

From a conference organiser:

"It has come to my attention that one of your principal research interests is the paranormal ... in my view, it would not be appropriate for someone with such research interests to attend a scientific conference."

Case 2:

from an Observer article:

... some argue that [Josephson's] flirtation with transcendental meditation and the paranormal has been intellectually disastrous.

Case 3:



Cornell University
Library

arXiv.org

1108.4860 is not appropriate for cross-listing

Your arXiv.org account: bdj10

correspondence

Vital resource should be open to all physicists

Putting control in the hands of a few can enforce orthodoxy and stifle innovative ideas.

Sir — Your News story “Rejected physicists instigate anti-arXiv site” (*Nature* **432**, 428–429; 2004) reports a response from Paul Ginsparg, the founder of the preprint server arXiv.org, to criticisms of its publication policies. Ginsparg states that the rules governing who can and cannot publish are clearly stated on the site, and that the archive is designed for “communication among research professionals, not as a mechanism for outsiders to communicate to that community”.

The cases documented by myself and others on the ArchiveFreedom website show that there is more to the story.

The exclusion of particular individuals and particular ideas from arXiv appears to me to be deliberate. If a rule can be invoked in support, however tenuous the link, the rule is quoted; otherwise, submissions are simply ‘deleted as inappropriate’. For example, having stated that a very distinguished physicist’s strong support of a submission carried no weight because this physicist “was not intimately familiar with the work in question”, the moderators simply ignored subsequent support from an endorser with publications on the same subject.

In another example, the moderators’ response to the information that more

than one eminent physicist had an interest in a subject that they wished to bar was: “We are always thrilled to hear when people find an avocation that keeps them off the streets and out of trouble.”

ArXiv has become a vital communicative resource for the physics community. The moderators’ attitude to any challenge to conventional thinking is likely to result in the loss to science of important innovative ideas. Radical changes are required in the way the archive is administered.

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<http://archivefreedom.org/news.htm>

Case 4 (Osborne):

A mathematical formalism has been proposed by Nils Baas[32, 33] in an attempt to define emergence from the 'emergence relative to a model' approach. This may be summarised as follows:

Consider a set of primitive objects - 'first-order structures' - denoted $\{S_i^1\}$, and an observational mechanism, Obs^1 , to 'evaluate, observe and describe the structures $\{S_i^1\}$ '.

A general procedure is then required to construct a new set of structures - second-order structures - $\{S_j^2\}$ from $\{S_i^1\}$. To this end, the observation mechanism is applied to the members of $\{S_i^1\}$.

Using the properties derived from the observations, $Obs^1(\{S_i^1\})$, a set of interactions Int^1 may be defined. By subjecting members of $\{S_i^1\}$ to Int^1 , a new structure is obtained:

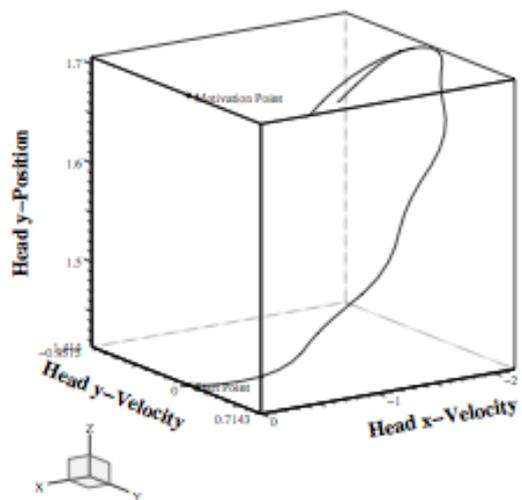
$$S^2 = R(S_i^1, Obs^1(\{S_i^1\}), Int^1) \quad (5.1)$$

where R is the construction process resulting from the interaction Int^1 and S^2 is a second order structure. Second order structures may be observed by a new observational mechanism Obs^2 (it may be equal to, overlap, or disjoint from Obs^1). According to Baas, emergence may now be defined thus:

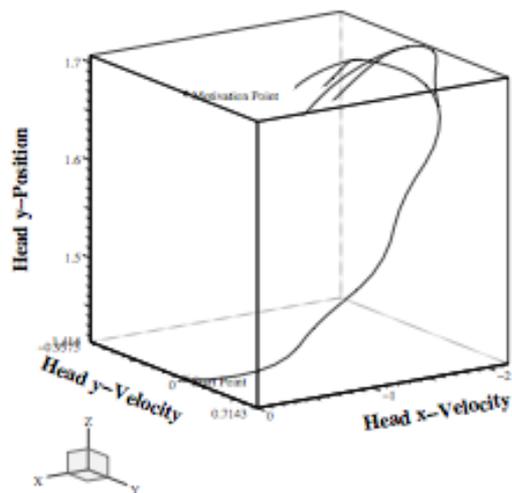
P is an emergent property of S^2 iff

$$P \in Obs^2(\{S_i^2\}) \text{ and } P \notin Obs^2(\{S_j^1\}) \quad (5.2)$$

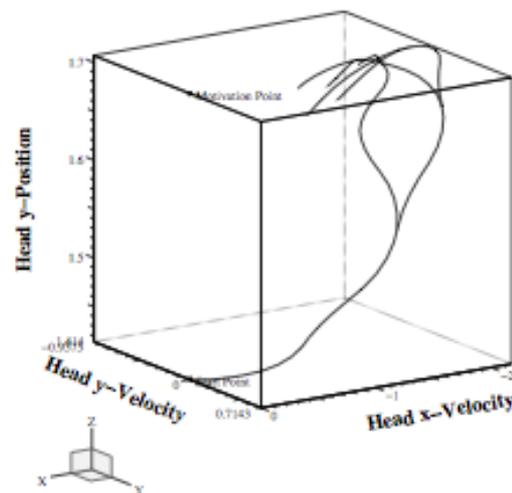
Scheme Development After 3 Attempts



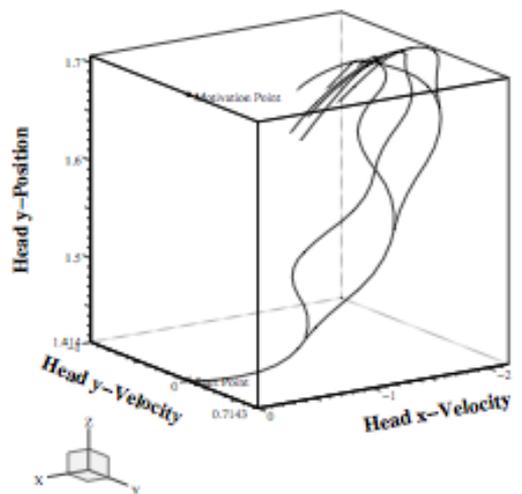
Scheme Development After 21 Attempts



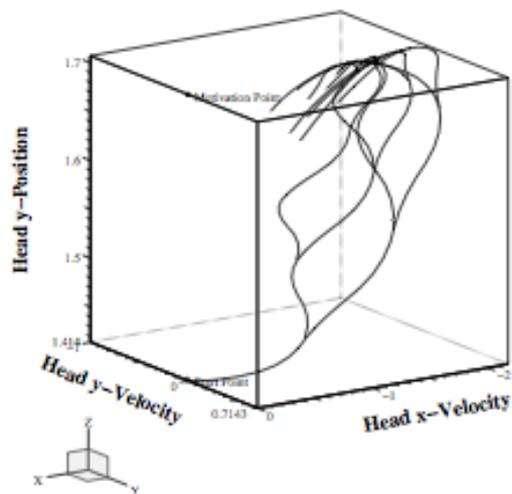
Scheme Development After 24 Attempts



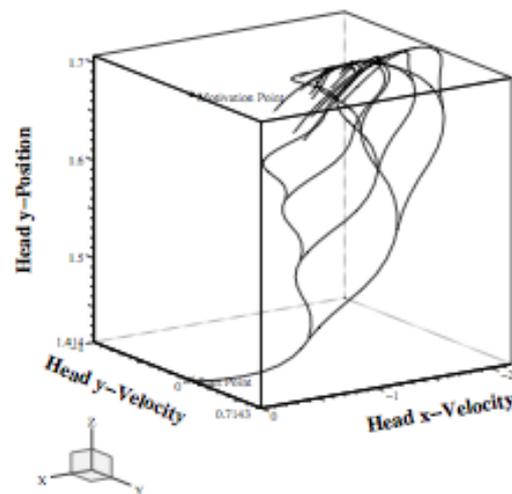
Scheme Development After 27 Attempts



Scheme Development After 51 Attempts



Scheme Development After 55 Attempts



My task as a research student

- My task: make sense of the theory of superconductivity for the benefit of the low-temperature group!
- The big question: why superconductivity?
- Guess: something to do with the ‘phase’ that seemed to pervade theories of superconductivity.

Phase in superconductors

- Ginzburg-Landau theory
- Gor'kov theory
- Anderson pseudospins
- Flux quantisation

What is the phase?

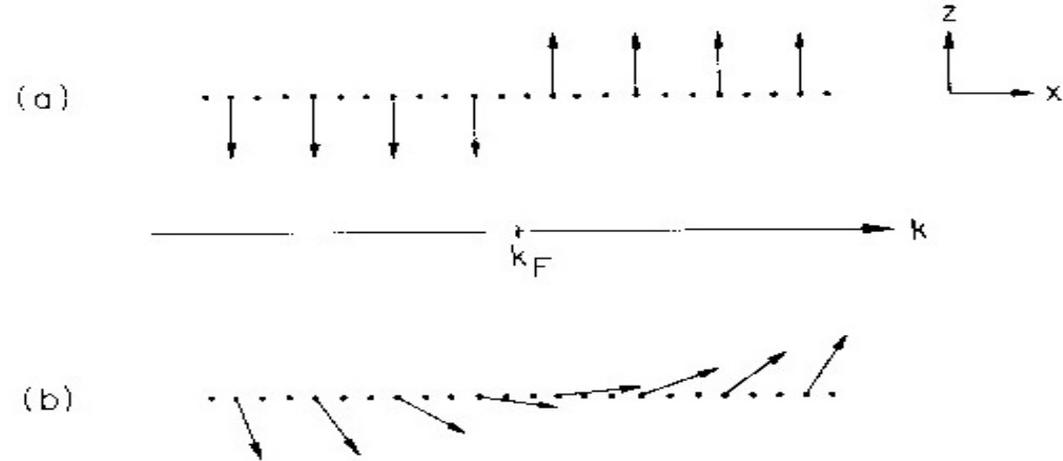


FIG. 1. Pseudospin configurations in (a) a normal metal (b) a superconductor. Here k_F is the Fermi momentum.

- Does phase mean anything?
- Analogy of magnets
- Only relative phase can mean anything
- And even then only if there is transfer of electrons (from gauge symmetry)

When might it happen?

- Weak coupling needed
- SNS systems or Giaever tunnelling
- How to calculate current?
- Cohen, Falicov and Phillips to the rescue
- But they couldn't figure out how to handle the 2-superconductor case!

The answer

- Phase needs to be included in the calculation
- Expected outcome: phase modulates the resistive current
- Actual outcome, additional current at zero voltage:

$$j_z = j_1 \sin \varphi.$$

Here H_T is expressed in the interaction picture and $U(t)$ can be evaluated by writing H_T in terms of quasi-particle operators and using the method of Goldstone ⁶). We also express

$$J_{\text{int}}(t) = ie/\hbar [H_T, N_T] \quad (1)$$

in terms of quasi-particle operators, and by retaining only those terms in $J_H(t)$ which can be expressed in accordance with (1) as products of S and number operators obtain an expression equivalent to the usual one, of the form

$$J_H = J_0 + \frac{1}{2} J_1 S_L^\dagger S_T + \frac{1}{2} J_1^* S_T^* S_L \quad (3)$$

To second order in H_T , J_0 is similar to the expression of Cohen et al. ¹), and reduces for the same reasons to the usual one obtained by neglecting coherence factors. The remaining terms oscillate with frequency $\nu = 2eV/\hbar$ ($V = \lambda_L - \lambda_T$ being the applied voltage), owing to the time dependence of the S operators. J_1 is proportional to the effective matrix element for the transfer of electron pairs across the barrier without affecting the quasi-particle distribution, and typical terms are of the form

$$2ie u_L v_L u_T v_T T_{L,T} T_{-L,-T} [(1 - n_{L0} - n_{T1}) \\ \times \{P \frac{1}{eV - E_L - E_T} + i\pi\delta(eV - E_L - E_T)\}] \\ + (n_{L0} - n_{T0}) \{P \frac{1}{eV + E_L - E_T} + i\pi\delta(eV + E_L - E_T)\}] \quad (4)$$

Was this it?

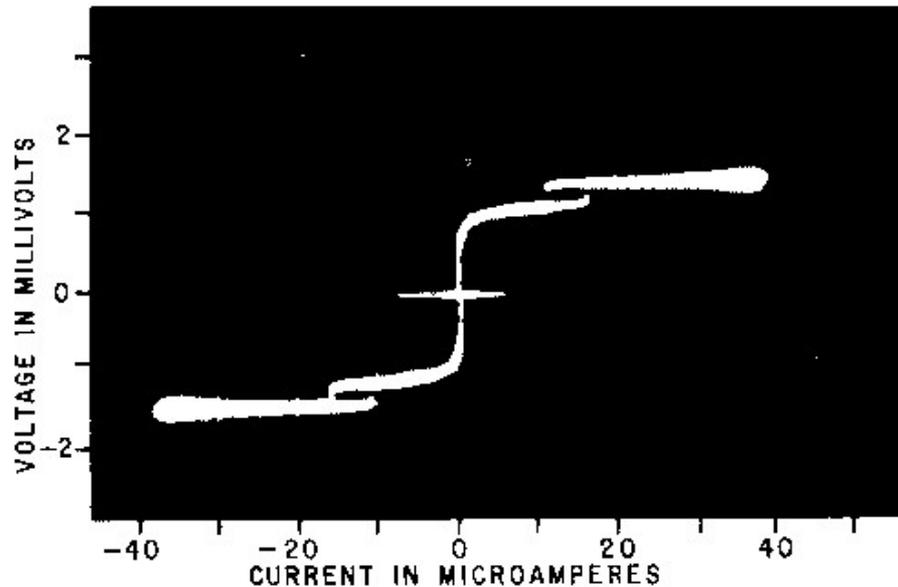


FIG. 3 The first published observation of tunnelling between two evaporated-film superconductors (Smith *et al.*, 1961). A zero-voltage supercurrent is clearly visible. It was not until the experiments of Anderson and Rowell (1963) that such supercurrents could be definitely ascribed to the tunnelling process.

to conduction through metallic shorts through the barrier

Was it real?

Result of Josephson-Adkins investigation:

“no current!”

Or, at least, less than 1nA

Later, Anderson and Rowell claimed success:

(lower resistance, less thermal noise down leads)

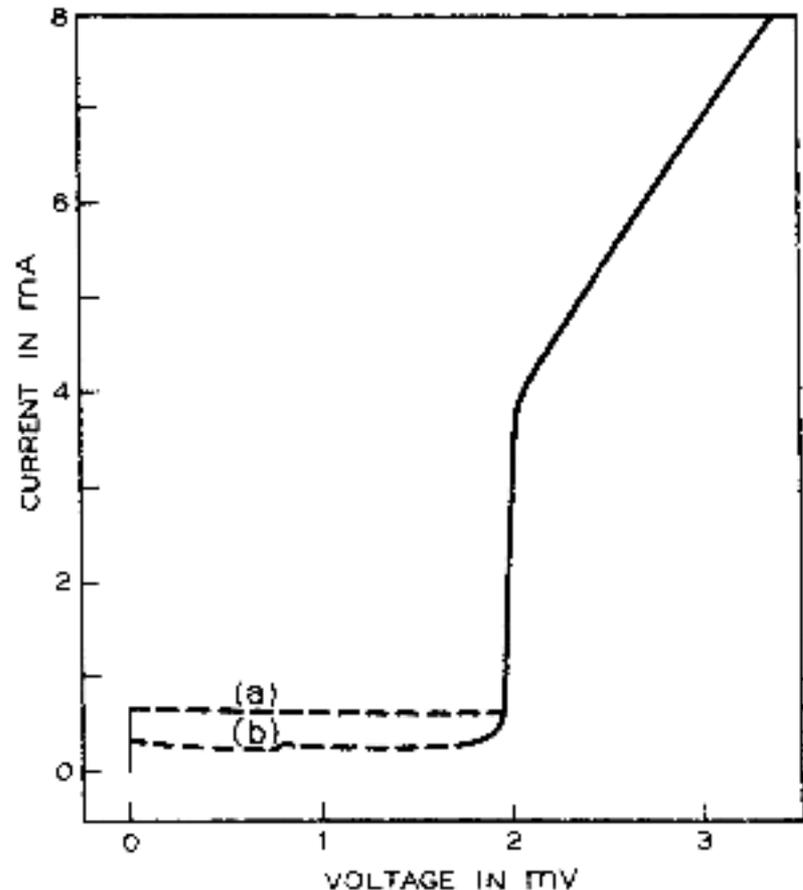
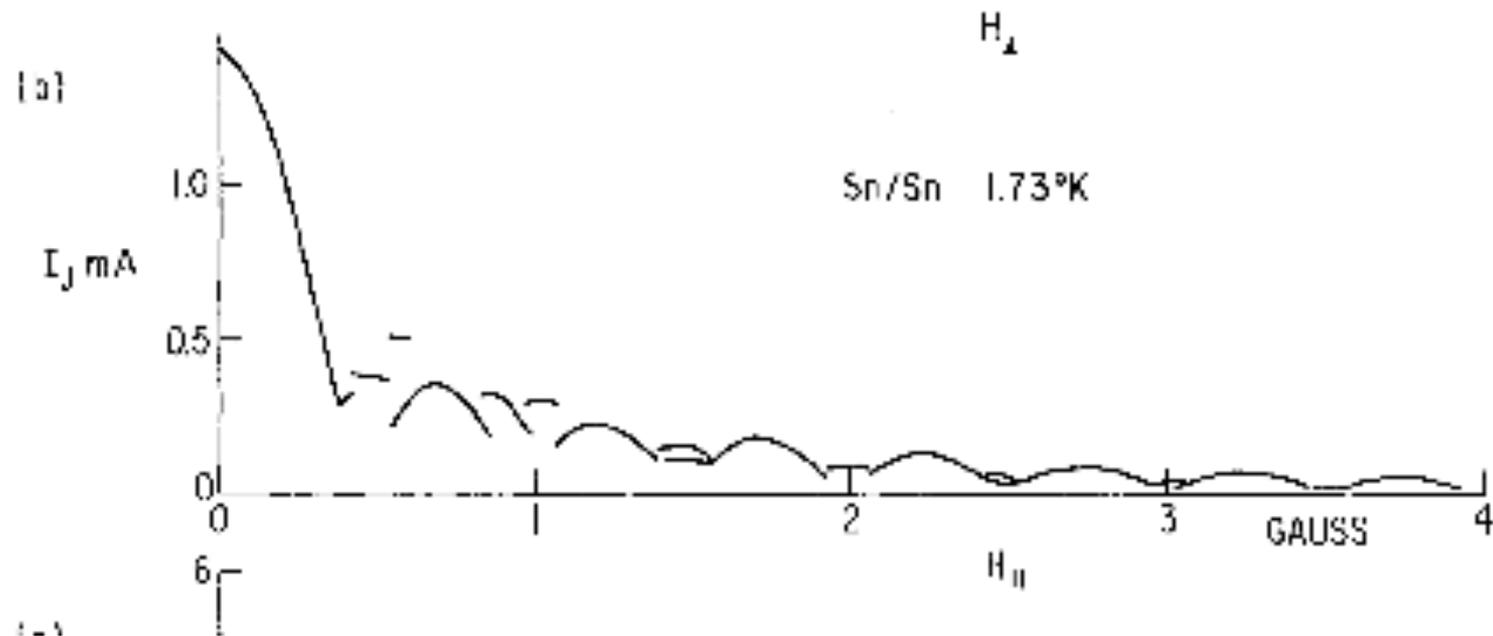


FIG. 1. Current-voltage characteristic for a tin oxide-lead tunnel structure at $\sim 1.5^{\circ}\text{K}$, (a) for a field of 6×10^{-3} gauss and (b) for a field 0.4 gauss.

Fiske expt.



Time dependent effects

HOWEVER, to make a quantitative prediction concerning the time dependence of the current, Gor'kov (1959) had noted that the F function in his theory should be time dependent, being proportional to $\exp(-2i\mu t/\hbar)$, where μ is the chemical potential as before.¹ The phase ϕ should thus obey the relation

$$\partial\phi/\partial t = -2\mu/\hbar, \quad (3)$$

while in a two-superconductor system the phase difference obeys the relation

$$(\partial/\partial t)(\Delta\phi) = 2eV/\hbar, \quad (4)$$

where V is the potential difference between the two superconducting regions, so that

$$\Delta\phi = 2eVt/\hbar + \text{const.} \quad (5)$$

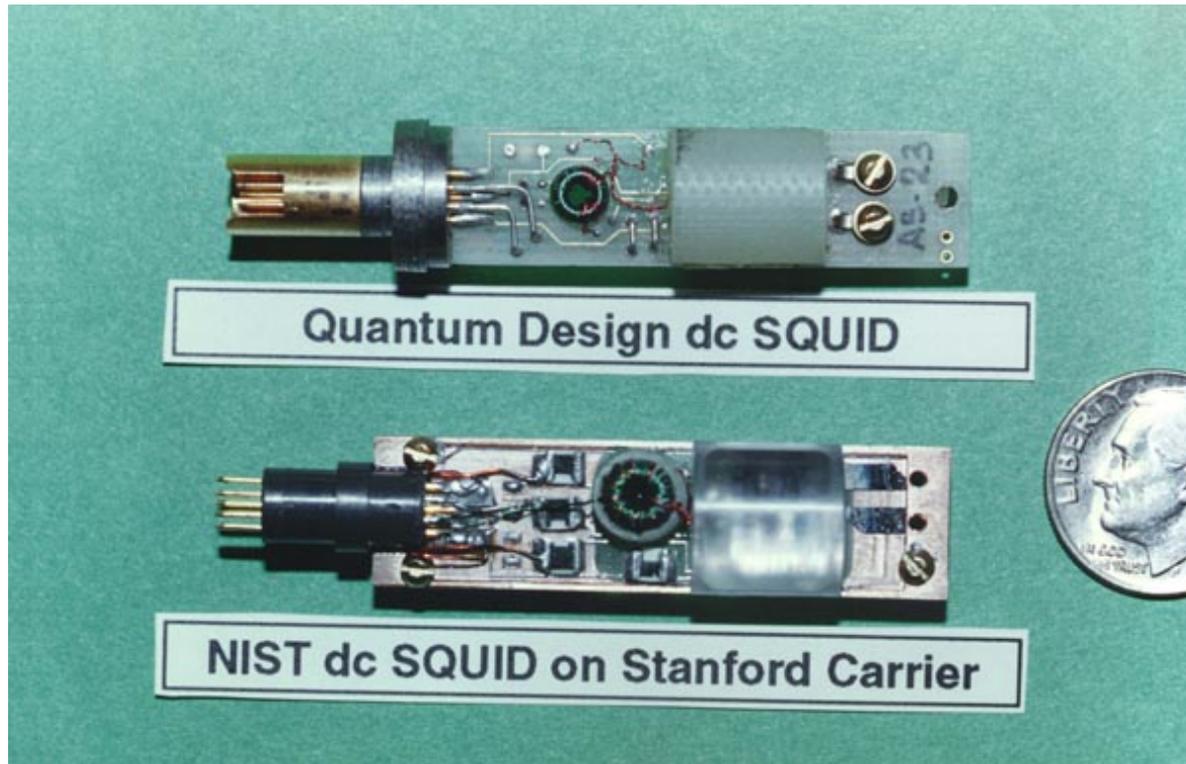
Since nothing changes physically if $\Delta\phi$ is changed by a multiple of 2π , I was led to expect a periodically varying current at a frequency $2eV/\hbar$.

The problem of how to calculate the barrier current

Practical uses

- Voltage-frequency relationship involves fundamental constant e/h
- Hence determine e/h , or use its value to calibrate voltage
- The SQUID (superconducting quantum interference) is very sensitive to magnetic fields

SQUIDs



THE END

