

## **Lecture 5:**

### **Classical Josephson effect**

**(Meissner, SQUIDs, Fraunhofer, Josephson radiation, Shapiro)**

# DC SQUID

PHYSICAL REVIEW

VOLUME 140, NUMBER 5A

29 NOVEMBER 1965

## Macroscopic Quantum Interference in Superconductors

R. C. JAKLEVIC, J. LAMBE, J. E. MERCEREAU, AND A. H. SILVER

*Scientific Laboratory, Ford Motor Company, Dearborn, Michigan*

(Received 12 July 1965)

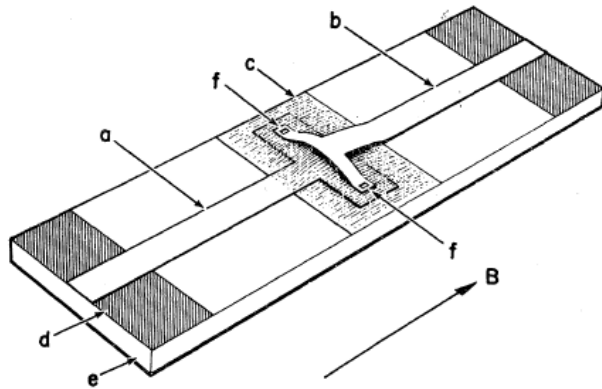


FIG. 1. Reproduction of an oscilloscope trace of a single Sn-SnO<sub>2</sub>-Sn junction showing the single-particle (Giaever) tunneling characteristic ( $V \neq 0$ ) and the dc Josephson supercurrent at  $V=0$ . Current and voltage scales are 0.5 mA/div and 1 mV/div, respectively. The arrows indicate the switching path along the circuit load line taken when the applied current exceeds  $I_{\max}$ .

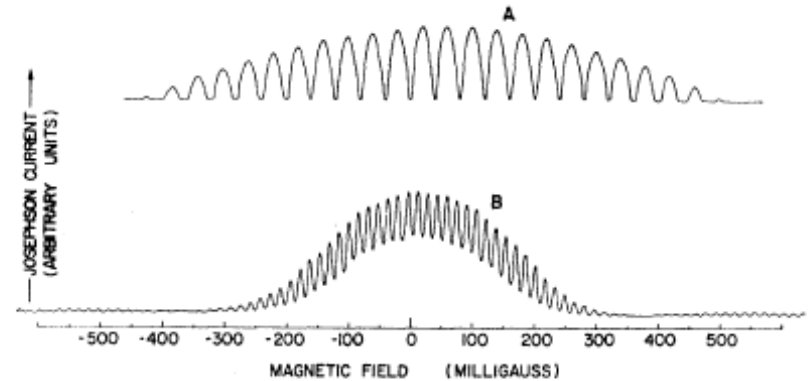
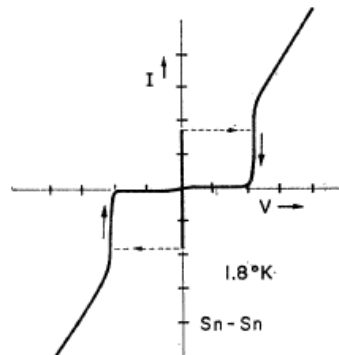


FIG. 7. Experimental trace of  $I_{\max}$  versus magnetic field showing interference and diffraction effects. The field periodicity is 39.5 and 16 mG for  $A$  and  $B$ , respectively. Approximate maximum currents are 1 mA ( $A$ ) and 0.5 mA ( $B$ ). The junction separation is  $W=3$  mm and junction width  $w=0.5$  mm for both cases. The zero offset of  $A$  is due to a background magnetic field.

# Fraunhofer pattern

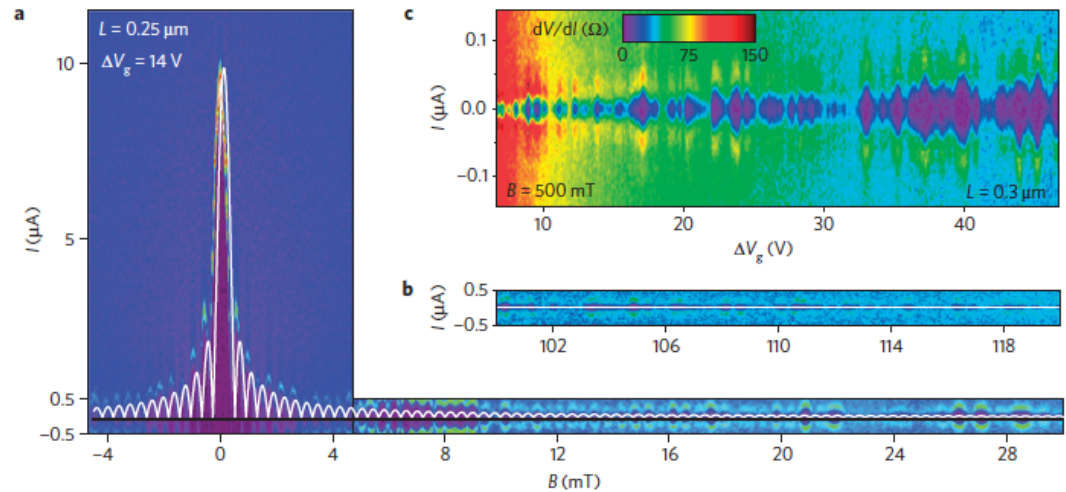
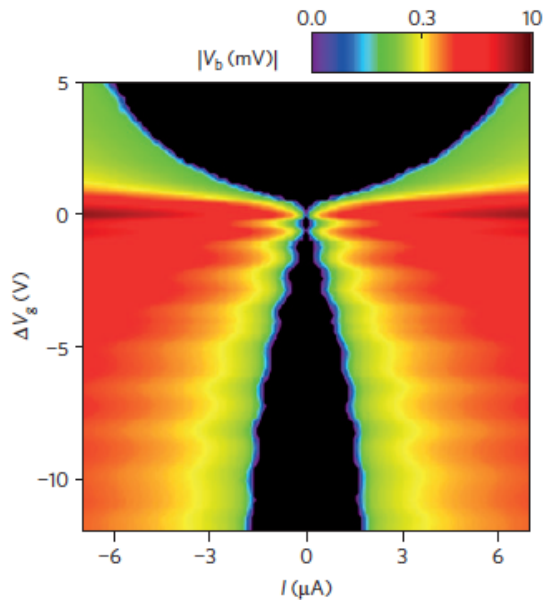
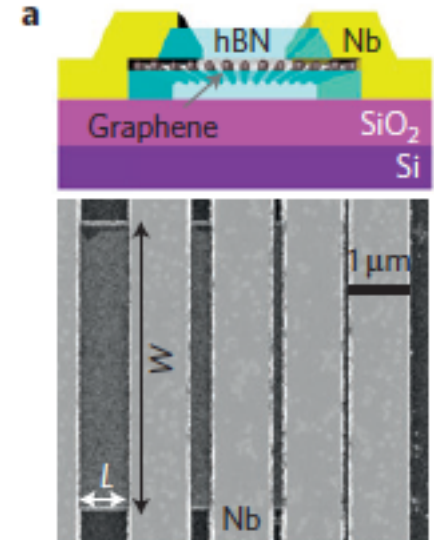
LETTERS

PUBLISHED ONLINE: 14 DECEMBER 2015 | DOI: 10.1038/NPHYS3592

nature  
physics

## Quantum oscillations of the critical current and high-field superconducting proximity in ballistic graphene

M. Ben Shalom<sup>1,2</sup>, M. J. Zhu<sup>1,2</sup>, V. I. Fal'ko<sup>1,2\*</sup>, A. Mishchenko<sup>1,2</sup>, A. V. Kretinin<sup>1</sup>, K. S. Novoselov<sup>1</sup>, C. R. Woods<sup>2</sup>, K. Watanabe<sup>3</sup>, T. Taniguchi<sup>3</sup>, A. K. Geim<sup>1,2\*</sup> and J. R. Prance<sup>4</sup>



# Abrikosov and Josephson vortices

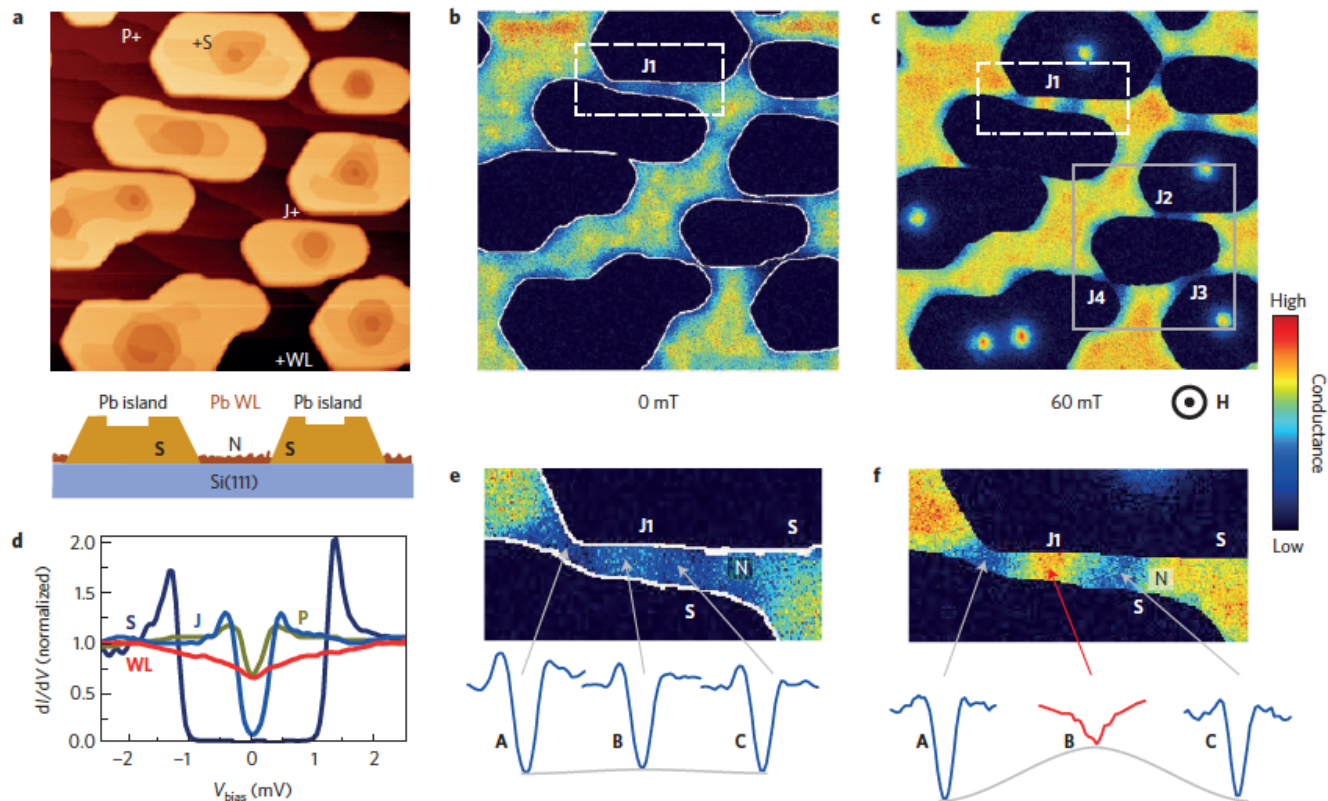
LETTERS

PUBLISHED ONLINE: 23 FEBRUARY 2015 | DOI: 10.1038/NPHYS3240

nature  
physics

## Direct observation of Josephson vortex cores

Dimitri Roditchev<sup>1,2</sup>, Christophe Brun<sup>1</sup>, Lise Serrier-Garcia<sup>1</sup>, Juan Carlos Cuevas<sup>3</sup>,  
Vagner Henrique Loiola Bessa<sup>4</sup>, Milorad Vlado Milošević<sup>4,5</sup>, François Debontridder<sup>1</sup>,  
Vasily Stolyarov<sup>1</sup> and Tristan Cren<sup>1\*</sup>



**Figure 1 | Josephson vortices imaged by scanning tunnelling spectroscopy at 0.3 K.** **a**, Topographic STM image of a 1,000 nm x 1,000 nm area of the

# Shapiro steps

PHYSICAL REVIEW

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10 MAY 19

## Millimeter-Wave Mixing with Josephson Junctions

C. C. GRIMES AND SIDNEY SHAPIRO\*

*Bell Telephone Laboratories, Murray Hill, New Jersey*

(Received 3 November 1967)

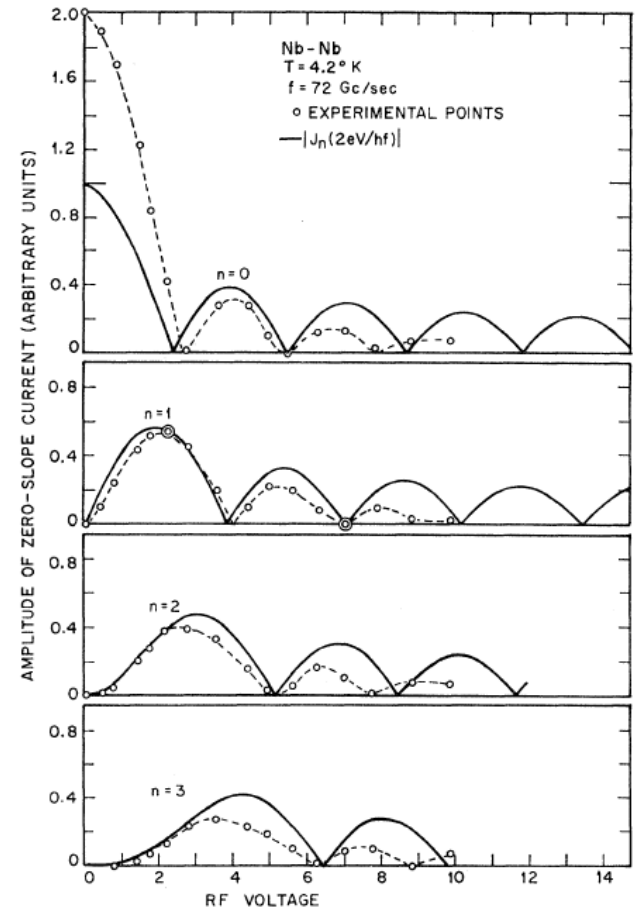
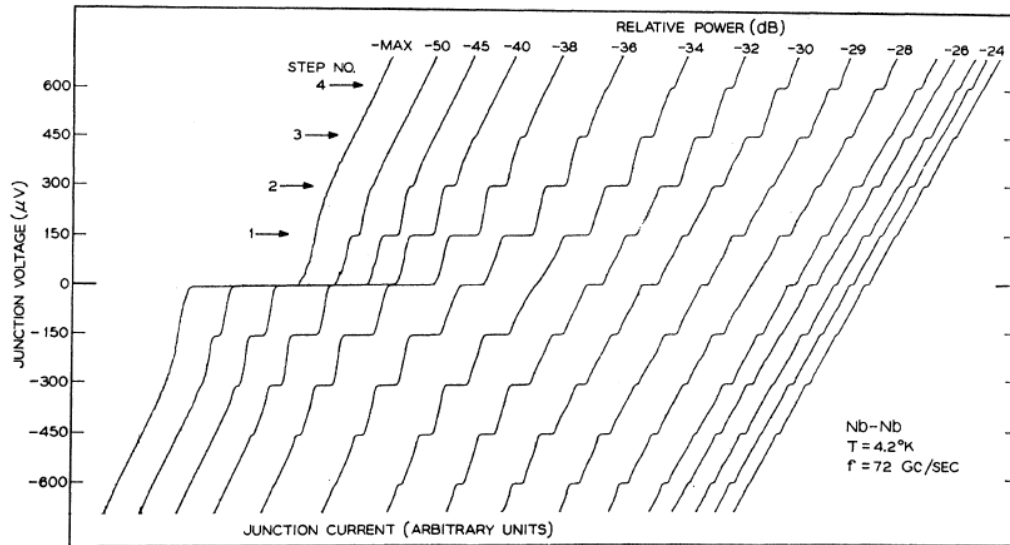


FIG. 1. Voltage-current curves for a Nb-Nb point-contact Josephson junction exposed to a 72-Gc/sec signal at various power levels.

# Photon assisted tunneling (Tien-Gordon)

PHYSICAL REVIEW

VOLUME 129, NUMBER 2

15 JANUARY 1963

## Multiphoton Process Observed in the Interaction of Microwave Fields with the Tunneling between Superconductor Films

P. K. TIEN AND J. P. GORDON

*Bell Telephone Laboratories, Murray Hill, New Jersey*

(Received 28 August 1962)

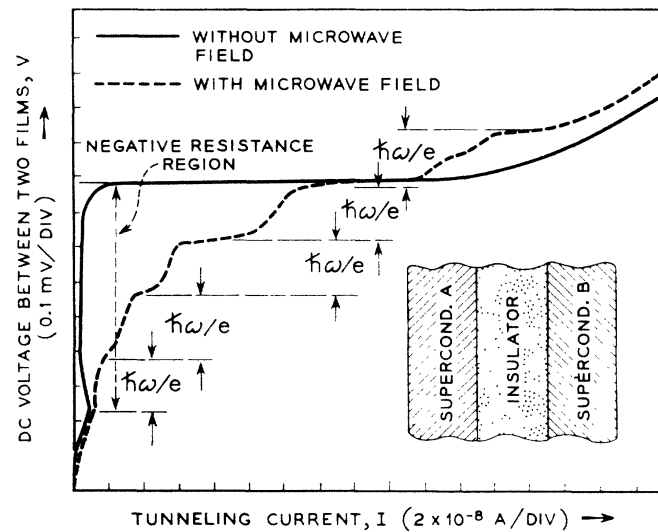
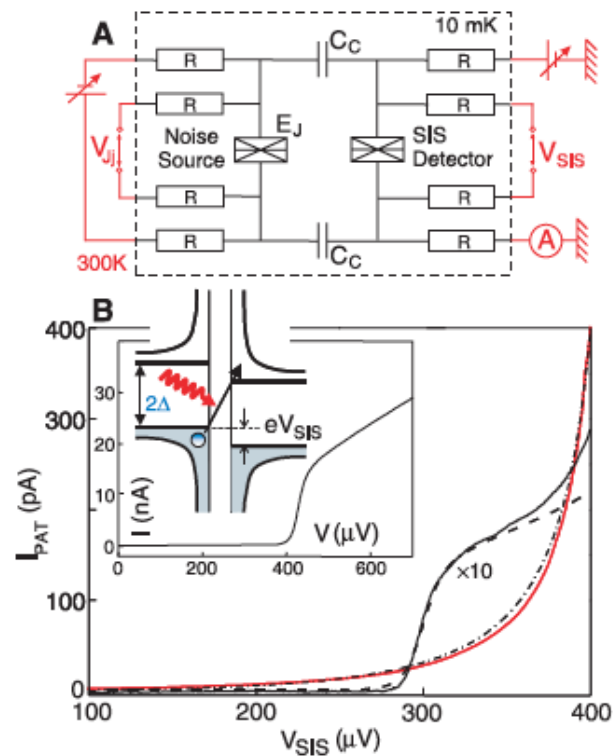


FIG. 1. Bias voltage vs tunneling current of a superconducting Al-Al<sub>2</sub>O<sub>3</sub>-In diode as measured by Dayem and Martin with and without the microwave field.  $\hbar\omega/e=0.16$  mV.

# Detection of Quantum Noise from an Electrically Driven Two-Level System

Richard Deblock,<sup>\*†</sup> Eugen Onac, Leonid Gurevich, Leo P. Kouwenhoven<sup>†</sup>

Science 301, 203 (2003)



# Inelastic Cooper pair tunneling

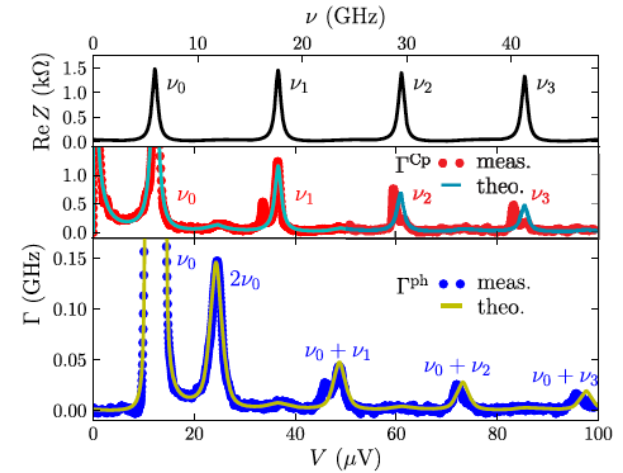
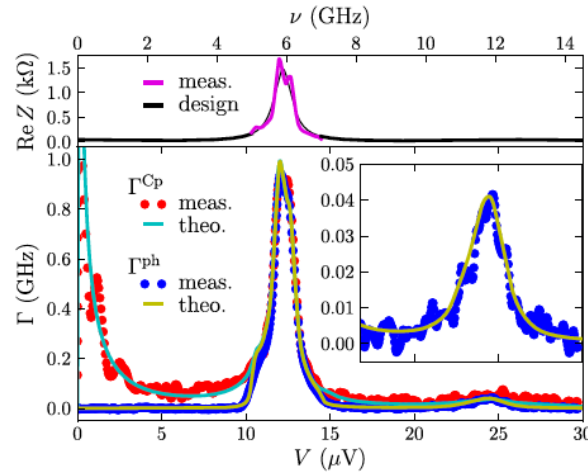
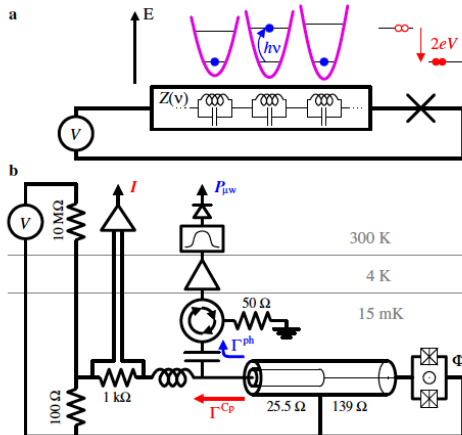
PRL 106, 217005 (2011)

PHYSICAL REVIEW LETTERS

week ending  
27 MAY 2011

## Bright Side of the Coulomb Blockade

M. Hofheinz, F. Portier, Q. Baudouin, P. Joyez, D. Vion, P. Bertet, P. Roche, and D. Esteve  
*Service de Physique de l'Etat Condensé (CNRS URA 2464), IRAMIS, CEA Saclay, 91191 Gif-sur-Yvette, France*  
 (Received 28 January 2011; published 27 May 2011)





# Stimulated Josephson radiation

## Demonstration of an ac Josephson junction laser

M. C. Cassidy,<sup>1</sup> A. Bruno,<sup>1</sup> S. Rubbert,<sup>2</sup> M. Irfan,<sup>2</sup> J. Kammhuber,<sup>1</sup> R. N. Schouten,<sup>1,2</sup>  
 A. R. Akhmerov,<sup>2</sup> L. P. Kouwenhoven<sup>1,2\*</sup>

*Science* **355**, 939–942 (2017)

