Claudio Puglia

V

ESPERIENZA LAVORATIVA

03/2022 – ATTUALE – Pisa, Italia

RICERCATORE POST-DOC – CNR

Responsabilità tecnica di evaporatore a fascio elettronico.
Installazione, test e modifica di criostati a GM a ciclo chiuso e criostati a diluizione 3He/4He
Disegno, nanofabbricazione, caratterizzazione e misure eletrriche di dipositivi logici superconduttivi metallici controllati tramite gating elettrostatico con tecniche di:
Litografia elettronica (EBL)
Microscopia elettronica (SEM)
Litografia ottica
Deposizione ad angolo (Shadow Mask Evaporation)
Deposizione con evaporatori termico e a fascio elettronico
Etching a umido e a secco (RIE e ICP-RIE)
Deposizione con magneto sputtering di metalli e meteriali isolanti
Profilometria a stilo
Atomic layer deposition (ALD)

02/2022 – ATTUALE – Pisa, Italia

CEO – DSQM

DSQM è uno spin-off del Consiglio Nazionale delle Ricerche (CNR) che sviluppa dispositivi elettronici basati su superconduttori per applicazioni quantistiche e classiche.

03/2021 – 02/2022 – Pisa, Italia

ASSEGNISTA DI RICERCA – CNR

Fabbricazione e caratterizzazione a temperature criogeniche di giunzioni ibride ferromagnete isolante/ superconduttore e controllo elettrostatico di giunzioni monolitiche realizzate con superconduttori elementali.

01/2020 – 03/2020 – Pisa, Italia

TUTOR UNIVERSITARIO – UNIVERSITÀ DI PISA

Esercitatore per il corso di Fisica del CdL in Scienze Biologiche

10/2018 – 12/2018 – Pisa, Italia

TUTOR UNIVERSITARIO – UNIVERSITÀ DI PISA

Esercitatore per il corso di Fisica con Elementi di Matematica e Statistica del CdL in Scienze dei Prodotti Erboristici e della Salute

01/2017 – 10/2017
TRAINEESHIP IN EXPERIMENTAL PHYSICS RESEARCH – LABORATORIO NEST

- Tecniche criogeniche con frigoriferi a diluizione (Triton 200 Oxford Instruments)
- Misure elettriche a temperature criogeniche (< 4 K)

Indirizzo Pisa, Italia

10/2015 – 10/2017
INSEGNANTE – CONSORZIO CNA SERVIZI PER GLI INSTALLATORI

Principi basilari di fisica tecnica e di termodinamica

Indirizzo Trapani, Italia

ISTRUZIONE E FORMAZIONE

04/07/2022 – ATTUALE – Toronto, Canada
CREATIVE DESTRUCTION LAB QUANTUM STREAM CANDIDATE – Rotman School of Management

Bootcamp tecnico e commerciale in ambito quantistico istruito da leader industriali e accademici nelle tecnologie quantistiche con enfasi sul trasferimento tecnologico dall'ambito di ricerca a quello industriale.

Indirizzo 105 St George St, Toronto, Toronto, Canada |

Sito Internet |

Campo di studio Gestione e amministrazione

11/2017 – 06/2021 – Pisa, Italia
DOTTORATO IN FISICA – Università di Pisa

- Criogenia (Criostati a diluizione 3He/4He: CF-CS110 Leiden Cryogenics e Triton 200 Oxford Instruments)
- Misure a bassa temperatura (caratterizzazione di giunzioni Josephson e misure di trasporto elettronico e termico su dispositivi mesoscopici superconduttivi)
- Nano e micro fabbricazione (litografia elettronica, DC magneto-sputtering, deposizione ad angolo con evaporatori a fascio eletronico, scanning electron microscopy, reactive ion etching)

Indirizzo Pisa, Italia | **Campo di studio** Superconduttività sperimentale | **Voto finale** Ottimo con Lode |

Livello EQF Livello 8 EQF | **Tesi** Gate control of superconductivity in elemental BCS systems

02/2021 – 05/2021 – Italia
CYB+ 2020 – Università di Pisa

E' il programma avanzato del CLab ed è strutturato in seminari action-learning utili a rafforzare il processo di costruzione, formazione e sviluppo dei progetti innovativi che nasceranno poi con il supporto del CLab.

Indirizzo Italia | **Sito Internet** |

Campo di studio Programmi e qualifiche interdisciplinari inerenti alleconomia, alla tecnica aziendale e al diritto

01/2021 – 03/2021 – Pisa, Italia
PHD+ 2020 – Università di Pisa

Programma dell'Università di Pisa finalizzato a promuovere e incoraggiare lo spirito imprenditoriale e di innovazione tra studenti di laurea magistrale, dottorandi, dottori di ricerca e docenti.

Indirizzo Pisa, Italia | **Sito Internet** |
Campo di studio Programmi e qualifiche interdisciplinari inerenti alleconomia, alla tecnica aziendale e al diritto

09/2015 – 10/2017 – Pisa, Italia
LAUREA MAGISTRALE IN FISICA DELLA MATERIA – Università di Pisa

Caratterizzazione delle proprietà di trasporto elettrico e termico in sistemi mesoscopici superconduttori caloritronici.

Indirizzo Pisa, Italia | **Campo di studio** Fisica della materia condensata | **Voto finale** 106 |

Livello EQF Livello 7 EQF | **Tesi** Phase-Coherent Josephson Thermal Router

09/2012 – 09/2015 – Pisa, Italia
LAUREA TRIENNALE IN FISICA – Università di Pisa

Indirizzo Pisa, Italia | **Livello EQF** Livello 6 EQF

COMPETENZE LINGUISTICHE

Lingua madre: **ITALIANO**

Altre lingue:

	COMPRENSIONE		ESPRESSIONE ORALE		SCRITTURA
	Ascolto	Lettura	Produzione orale	Interazione orale	
INGLESE	C1	C1	C1	C1	C1

Livelli: A1 e A2: Livello elementare B1 e B2: Livello intermedio C1 e C2: Livello avanzato

PUBBLICAZIONI

Electrostatic Field-Driven Supercurrent Suppression in Ionic-Gated Metallic Superconducting Nanotransistors

Paolucci, F., Crisá, F., De Simoni, G., Bours, L., Puglia, et al. Nano Letters, 21(24), 10309–10314
https://pubs.acs.org/doi/10.1021/acs.nanolett.1c03481 – 2021
Recent experiments have shown the possibility of tuning the transport properties of metallic nanosized superconductors through a gate voltage. These results renewed the longstanding debate on the interaction between electrostatic fields and superconductivity. Indeed, different works suggested competing mechanisms as the cause of the effect: an unconventional electric field-effect or quasiparticle injection. Here, we provide conclusive evidence for the electrostatic-field-driven control of the supercurrent in metallic nanosized superconductors, by realizing ionic-gated superconducting field-effect nanotransistors (ISFETs) where electron injection is impossible. Our Nb ISFETs show giant suppression of the superconducting critical current of up to ∼45%. Moreover, the bipolar supercurrent suppression observed in different ISFETs, together with invariant critical temperature and normal-state resistance, also excludes conventional charge accumulation/depletion. Therefore, the microscopic explanation of this effect calls upon a novel theory able to describe the nontrivial interaction of static electric fields with conventional superconductivity.

Phase slips dynamics in gated Ti and V all-metallic supercurrent nano-transistors

C Puglia et al 2022 J. Phys. D: Appl. Phys. 55 055301
https://iopscience.iop.org/article/10.1088/1361-6463/ac2e8b/meta – 2021

The effect of electrostatic gating on metallic elemental superconductors was recently demonstrated in terms of modulation of the switching current and control of the current phase relation in superconducting quantum interferometers. The latter suggests the existence of a direct connection between the macroscopic quantum phase (φ) in a superconductor and the applied gate voltage. The measurement of the switching current cumulative probability distributions is a convenient and powerful tool to analyze such relation. In particular, the comparison between the conventional Kurkijärvi–Fulton–Dunkleberger model and the gate-driven distributions give useful insights into the microscopic origin of the gating effect. In this paper, we summarize the main results obtained in the analysis of the phase slip events in elemental gated superconducting weak-links in a wide range of temperatures between 20 mK and 3.5 K. Such a large temperature range demonstrates both that the gating effect is robust as the temperature increases, and that fluctuations induced by the electric field are not negligible in a wide temperature range.

Gate Control of Superconductivity in Mesoscopic All-Metallic Devices

Puglia, C., De Simoni, G., & Giazotto, F. (2021). Materials, 14(5), 1243.
https://www.mdpi.com/1996-1944/14/5/1243 – 2021
The possibility to tune, through the application of a control gate voltage, the superconducting properties of mesoscopic devices based on Bardeen–Cooper–Schrieffer metals was recently demonstrated. Despite the extensive experimental evidence obtained on different materials and geometries, a description of the microscopic mechanism at the basis of such an unconventional effect has not been provided yet. This work discusses the technological potential of gate control of superconductivity in metallic superconductors and revises the experimental results, which provide information regarding a possible thermal origin of the effect: first, we review experiments performed on high-critical-temperature elemental superconductors (niobium and vanadium) and show how devices based on these materials can be exploited to realize basic electronic tools, such as a half-wave rectifier. Second, we discuss the origin of the gating effect by showing gate-driven suppression of the supercurrent in a suspended titanium wire and by providing a comparison between thermal and electric switching current probability distributions. Furthermore, we discuss the cold field-emission of electrons from the gate employing finite element simulations and compare the results with experimental data. In our view, the presented data provide a strong indication regarding the unlikelihood of the thermal origin of the gating effect.

Gate-Controlled Suspended Titanium Nanobridge Supercurrent Transistor

M. Rocci, G. De Simoni, C. Puglia et al., ACS Nano 14, 12621 (2020).
https://pubs.acs.org/doi/10.1021/acsnano.0c05355 – 2020
Under standard conditions, the electrostatic field-effect is negligible in conventional metals and was expected to be completely ineffective also in superconducting metals. This common belief was recently put under question by a family of experiments that displayed full gate-voltage-induced suppression of critical current in superconducting all-metallic gated nanotransistors. To date, the microscopic origin of this phenomenon is under debate, and trivial explanations based on heating effects given by the negligible electron leakage from the gates should be excluded. Here, we demonstrate the control of the supercurrent in fully suspended superconducting nanobridges. Our advanced nanofabrication methods allow us to build suspended superconducting Ti-based supercurrent transistors which show ambipolar and monotonic full suppression of the critical current for gate voltages of VGC ≃ 18 V and for temperatures up to ∼80% of the critical temperature. The suspended device architecture minimizes the electron–phonon interaction between the superconducting nanobridge and the substrate, and therefore, it rules out any possible contribution stemming from charge injection into the insulating substrate. Besides, our finite element method simulations of vacuum electron tunneling from the gate to the bridge and thermal considerations rule out the cold-electron field emission as a possible driving mechanism for the observed phenomenology. Our findings promise a better understanding of the field effect in superconducting metals.

Vanadium gate-controlled Josephson half-wave nanorectifier

C. Puglia, G. De Simoni, N. Ligato, and F. Giazotto, Appl. Phys. Lett. 116, 252601 (2020).
https://aip.scitation.org/doi/10.1063/5.0013512 – 2020
Recently, the possibility to tune the critical current of conventional metallic superconductors via electrostatic gating was shown in wires, Josephson weak-links, and superconductor-normal metal–superconductor junctions. Here, we exploit such a technique to demonstrate a gate-controlled vanadium-based Dayem nano-bridge operated as a half-wave rectifier at 3 K. Our devices exploit the gate-driven modulation of the critical current of the Josephson junction and the resulting steep variation of its normal-state resistance, to convert an AC signal applied to the gate electrode into a DC one across the junction. All-metallic superconducting gated rectifiers could provide the enabling technology to realize tunable photon detectors and diodes useful for superconducting electronics circuitry.

Niobium Dayem nano-bridge Josephson gate-controlled transistors

G. De Simoni, C. Puglia, and F. Giazotto, Appl. Phys. Lett. 116, 242601 (2020).
https://aip.scitation.org/doi/10.1063/5.0011304 – 2020
We report on the realization of Nb-based all-metallic Dayem nano-bridge gate-controlled transistors (Nb-GCTs). These Josephson devices operate up to a temperature of ∼3 K and exhibit full suppression of the supercurrent thanks to the application of a control gate voltage. The dependence of the kinetic inductance and of the transconductance on gate voltage promises a performance already on par with so far realized metallic Josephson transistors and leads us to foresee the implementation of a superconducting digital logic based on the Nb-GCT. We conclude by showing the practical realization of a scheme implementing an all-metallic gate-tunable half-wave rectifier to be used for either superconducting electronics or photon detection applications.

Electrostatic Control of Phase Slips in Ti Josephson Nanotransistors

C. Puglia, G. De Simoni, and F. Giazotto, Phys. Rev. Appl. 13, 054026 (2020).
https://journals.aps.org/prapplied/abstract/10.1103/PhysRevApplied.13.054026 – 2020
The investigation of the switching-current probability distribution of a Josephson junction is a conventional tool to gain information on the dynamics of the phase slips as a function of the temperature. Here we adopt this well-established technique to probe the impact of an external static electric field on the occurrence of phase slips in gated all-metallic titanium (Ti) Josephson weak links. We show, in a temperature range between 20 and 420 mK, that the evolution of the dynamics of the phase slips as a function of the electrostatic field starkly differs from that observed as a function of the temperature. This fact demonstrates, on the one hand, that the electric field suppression of the critical current is not simply related to a conventional thermal-like quasiparticle overheating in the weak-link region. On the other hand, our results may open the way to operate an electrostatic-driven manipulation of phase slips in metallic Josephson nanojunctions, which can be pivotal for the control of decoherence in superconducting nanostructures.

Field-effect control of metallic superconducting systems

F. Paolucci, G. De Simoni, P. Solinas, E. Strambini, C. Puglia et al., AVS Quantum Sci. 1, 016501
https://avs.scitation.org/doi/10.1116/1.5129364 – 2019
Static electric fields have a negligible influence on the electric and transport properties of a metal because of the screening effect. This belief was extended to conventional metallic superconductors. However, recent experiments have shown that the superconductor properties can be controlled and manipulated by the application of strong electrostatic fields. Here, the authors review the experimental results obtained in the realization of field-effect metallic superconducting devices exploiting this phenomenon. The authors start by presenting the pioneering results on superconducting Bardeen–Cooper–Schrieffer wires and nanoconstriction Josephson junctions (Dayem bridges) made of different materials, such as titanium, aluminum, and vanadium. Then, the authors show the mastering of the Josephson supercurrent in superconductor-normal metal-superconductor proximity transistors, suggesting that the presence of induced superconducting correlations is enough to see this unconventional field-effect. Later, the authors present the control of the interference pattern in a superconducting quantum interference device, indicating the coupling of the electric field with the superconducting phase. The authors conclude this review by discussing some devices that may represent a breakthrough in superconducting quantum and classical computation

Josephson Field-Effect Transistors Based on All-Metallic Al/Cu/Al Proximity Nanojunctions

G. De Simoni, F. Paolucci, C. Puglia, and F. Giazotto, ACS Nano 13, 7871 (2019).
https://pubs.acs.org/doi/10.1021/acsnano.9b02209 – 2019
We demonstrate proximity-based all-metallic mesoscopic superconductor-normal metal-superconductor (SNS) field-effect controlled Josephson transistors (SNS-FETs) and show their full characterization from the critical temperature Tc down to 50 mK in the presence of both electric and magnetic fields. The ability of a static electric field—applied by means of a lateral gate electrode—to suppress the critical current Is in a proximity-induced superconductor is proven for both positive and negative gate voltage values. Is reached typically about one-third of its initial value, saturating at high gate voltages. The transconductance of our SNS-FETs obtains values as high as 100 nA/V at 100 mK. On the fundamental physics side, our results suggest that the mechanism at the basis of the observed phenomenon is quite general and does not rely on the existence of a true pairing potential, but rather the presence of superconducting correlations is enough

for the effect to occur. On the technological side, our findings widen the family of materials available for the implementation of all-metallic field-effect transistors to synthetic proximity-induced superconductors.

Phase-Tunable Josephson Thermal Router

G.F. Timossi, A. Fornieri, F. Paolucci, C. Puglia, and F. Giazotto, Nano Lett. 18, 1764 (2018).
https://pubs.acs.org/doi/10.1021/acs.nanolett.7b04906 – 2018
A fundamental aspect of electronics is the ability to distribute a charge current among different terminals. On the other hand, despite the great interest in dissipation, storage, and conversion of heat in solid state structures, the control of thermal currents at the nanoscale is still in its infancy. Here, we show the experimental realization of a phase-tunable thermal router able to control the spatial distribution of an incoming heat current, thus providing the possibility of tuning the electronic temperatures of two output terminals. This ability is obtained thanks to a direct current superconducting quantum interference device (dc SQUID), which can tune the coherent component of the electronic heat currents flowing through its Josephson junctions. By varying the external magnetic flux and the bath temperature, the SQUID allows us to regulate the size and the direction of the thermal gradient between two drain electrodes. Our results offer new opportunities for all microcircuits requiring an accurate energy management, including electronic coolers, quantum information architectures, and thermal logic components.

Proceedings of the event IPSP2018: Industrial Problem Solving with Physics

https://event.unitn.it/ipsp2018/IPSP2018_Proceedings_Ebook (1).pdf – 2018

CONFERENZE E SEMINARI

22/07/2019 – 26/07/2019 – Donostia-San Sebastian

NanoQI'19: Nanotechnology meets Quantum Information

Poster contribution: **Field-effect metallic superconducting electronics**

25/07/2018 – 31/07/2018 – Schools at the Ettore Majorana Foundation and Centre for Scientific Culture, Erice, Italia

International School of Statistical Physics: New Trends in Nonequilibrium Statistical Mechanics: Classical and Quantum Systems

Poster contribution: **Phase-Tunable Josephson Thermal Router**

16/07/2018 – 21/07/2018 – Polo Scientifico e Tecnologico "Fabio Ferrari", via Sommarive 9 - Povo, Trento.

Industrial Problem Solving with Physics 2018

Industrial Problem Solving with Physics (IPSP) è un evento della durata di una settimana, organizzato dal Dipartimento di Fisica, dalla Scuola di Dottorato in Fisica e dalla Divisione Supporto Ricerca Scientifica e Trasferimento Tecnologico dell'Università di Trento, in collaborazione con Confindustria Trento, Polo Meccatronica - Trentino Sviluppo e con il coinvolgimento di Contamination Lab Trento.
Scopo dell'evento è quello di promuovere la connessione tra il mondo della ricerca in fisica e il mondo delle imprese. I giovani ricercatori avranno l'opportunità di mettere alla prova le proprie conoscenze e capacità, mentre le aziende sperimenteranno l'opportunità unica di collaborare con cervelli di talento.

26/02/2018 – 02/03/2018 – Mauterndorf, 5570, Austria
Mauterndorf Winterschool 2018

PROGETTI

05/2022 – ATTUALE
SPECTRUM: Horizon Europe Transition 2 Innovation (2.5 M€)

Stesura della proposta
Design, nanofabricazione e test di un Single Pole Forur Throw switch a radiofrequenza per applicazioni di Computazione Quantistica e Telecomunicazioni

05/2021 – ATTUALE
GENESIS: H2020 FET Innolvation Launchpad (0.15 M€)

https://cordis.europa.eu/project/id/101034849
Stesura della poposta
Nanofabbricazione e caratterizzazione a temperature criogeniche di dispositivi mesoscopici a superconduttore

03/2021 – ATTUALE
SUPERGATE: H2020 FET Open (3 M€)

https://cordis.europa.eu/project/id/964398/it
Nanofabbricazione e caratterizzazione a temperature criogeniche di dispositivi mesoscopici a superconduttore

ONORIFICENZE E RICONOSCIMENTI

12/2020
Finalista Premio Nazionale dell'innovazione

https://www.pnicube.it/pni-2020

10/2020
3° posto Start Cup Toscana 2020

http://www.startcuptoscana.it/news/proclamati-i-vincitori-della-start-cup-toscana-2020

07/2018
Membro del team vincitore dell'IPSP2018 – Università di Trento in collaborazione con Confindustria Trento e Polo Meccatronica-Trentino S.

https://webmagazine.unitn.it/news/ateneo/44154/ipsp2018-vince-il-team-lemur

BREVETTI

10/2022 – ATTUALE
Superconducting variable inductance transistor

Patent Cooperation Treaty: PCT/IB2022/060270

10/2021 – ATTUALE
Superconducting variable inductance transistor

Brevetto per invenzione industriale IT n°102021000027515

Autorizzo il trattamento dei miei dati personali presenti nel CV ai sensi dell'art. 13 d. lgs. 30 giugno 2003 n. 196 - "Codice in materia di protezione dei dati personali" e dell'art. 13 GDPR 679/16 - "Regolamento europeo sulla protezione dei dati personali".

Pisa, *03/11/2022*

Claudio Puglia