Quantum computation boosting novel superconducting and hybrid solutions and the impact of PNRR in Italy

Davide Massarotti, Halima G. Ahmad, Domenico Montemurro, Roberta Satariano, Anna Levochkina, Pasquale Mastrovito, Carlo Cosenza, Viviana Stasino, Giuseppe Serpico, Ciro Bruscino, Pasquale Ercolano, Zafar Iqbal, Alessandro Miano Giovanni Ausanio, Loredana Parlato, Giampiero Pepe & Francesco Tafuri

Martina Esposito, Pegah Darvehi, Isita Chatterjee (SPIN)
Carmine Granata, Antonio Vettoliere (ISASI)

Alessandro Bruno, Raffaella Ferraiuolo

Marco Arzeo, Luigi Di Palma and Oleg Mukanhov

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Università degli Studi di Napoli Federico II

IEEE 16th Workshop on Low Temperature Electronics WOLTE16

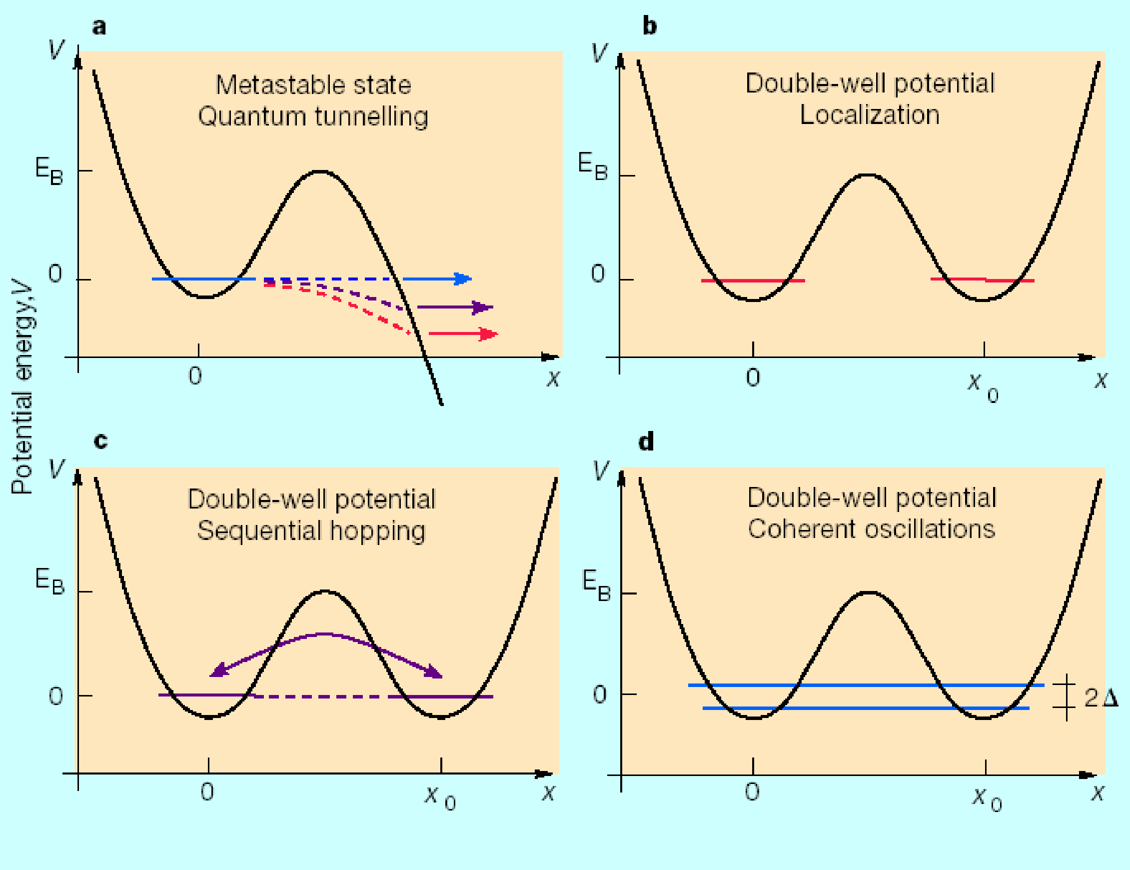
IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at WOLTE-16 2024, June 2024, Cagliari, Italy.

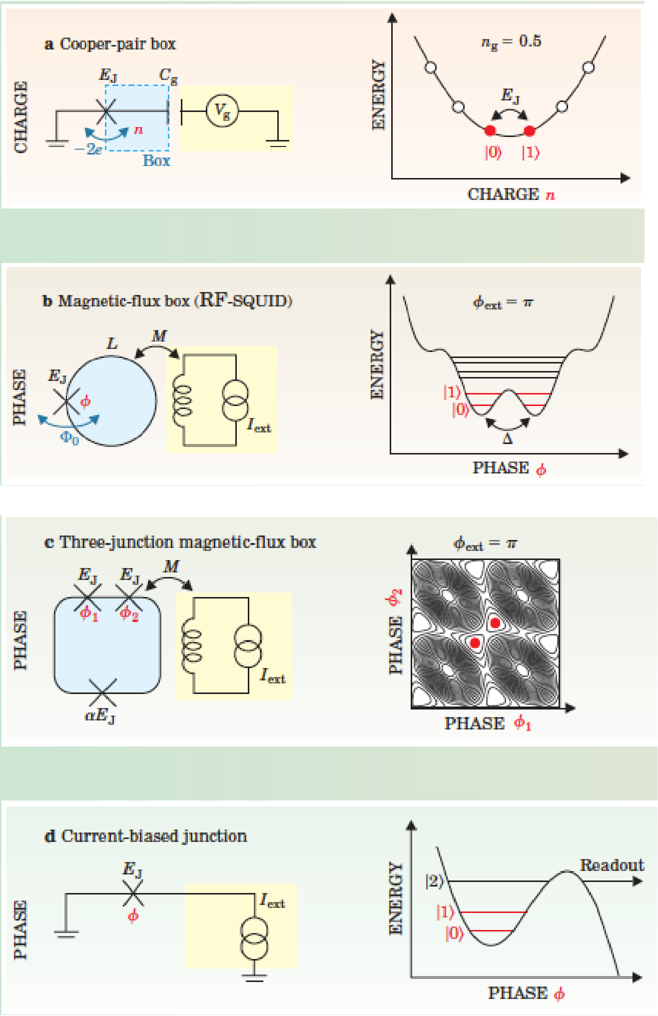
https://www.qtlab.unina.it/

Schrödinger's cat is now fat

Gianni Blatter

Schrödinger's dead-and-alive cat was a thought experiment applying the physics of electrons and atoms to our macroscopic world. New experiments with superconductors narrow the gap between theoretical ideas and reality.





Superconducting Circuits and Quantum Information

Superconducting circuits can behave like atoms making transitions between two levels. Such circuits can test quantum mechanics at macroscopic scales and be used to conduct atomic-physics experiments on a silicon chip.

J. Q. You and Franco Nori

J. Q. You and Franco Nori

2005 Physics Today

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
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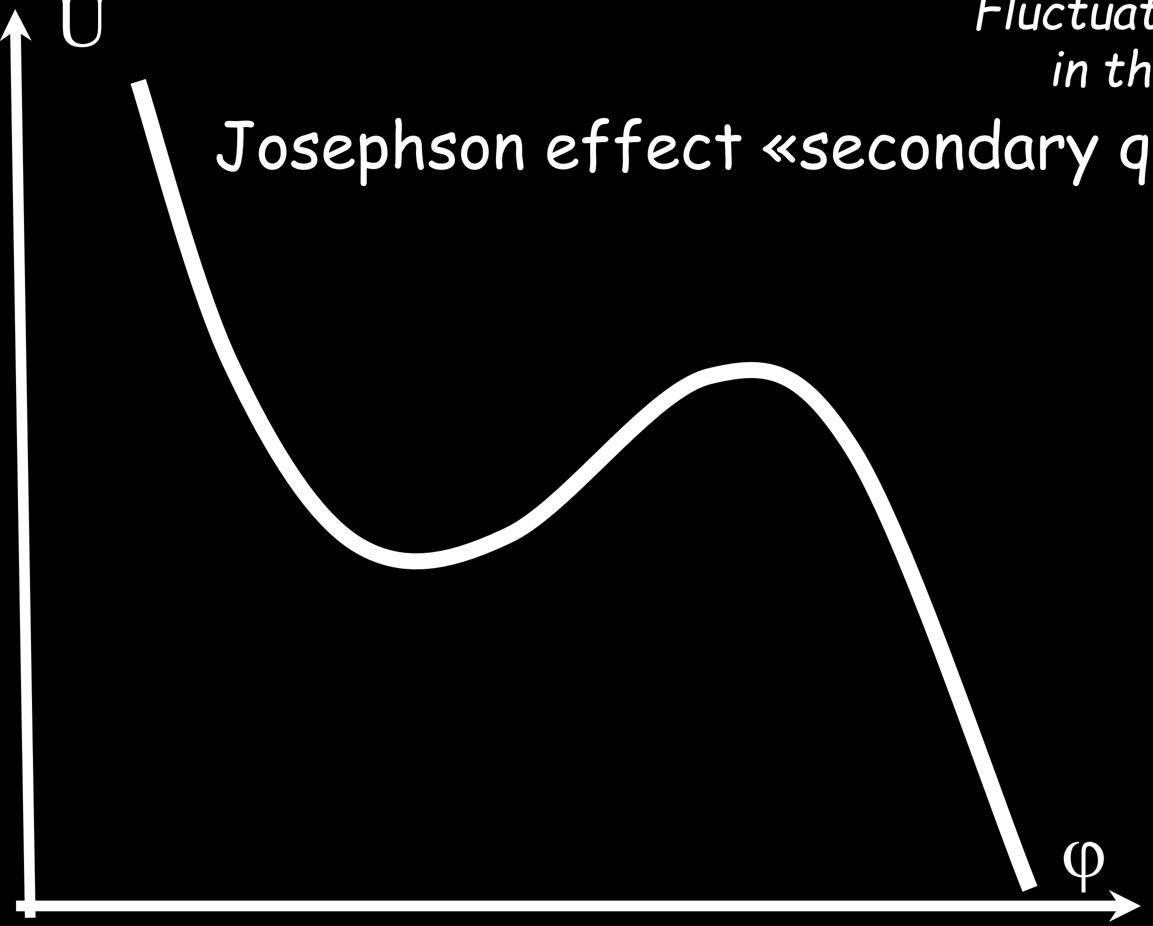
Fluctuations and escape dynamics in the washboard potential

Josephson effect «secondary quantum effects»



Quantum Inf Process (2009) 8:81–103
DOI 10.1007/s11128-009-0105-1

Superconducting phase qubits

John M. Martinis

Superconducting qubit research began in the 1980s motivated by the question, posed by Anthony Leggett, whether macroscopic variables would behave in a quantum mechanical fashion [23]. Initial experiments verified quantum behavior via the phenomenon of tunneling out of the zero-voltage state of a current-biased Josephson junction [7]. At UC Berkeley, quantum mechanical behavior was also demonstrated by the existence of quantized energy levels [28]. This observation provided stronger proof of quantum behavior, and established at an early stage (before the ideas of qubits were even widely established) that superconducting circuits could be used as general quantum systems [3].

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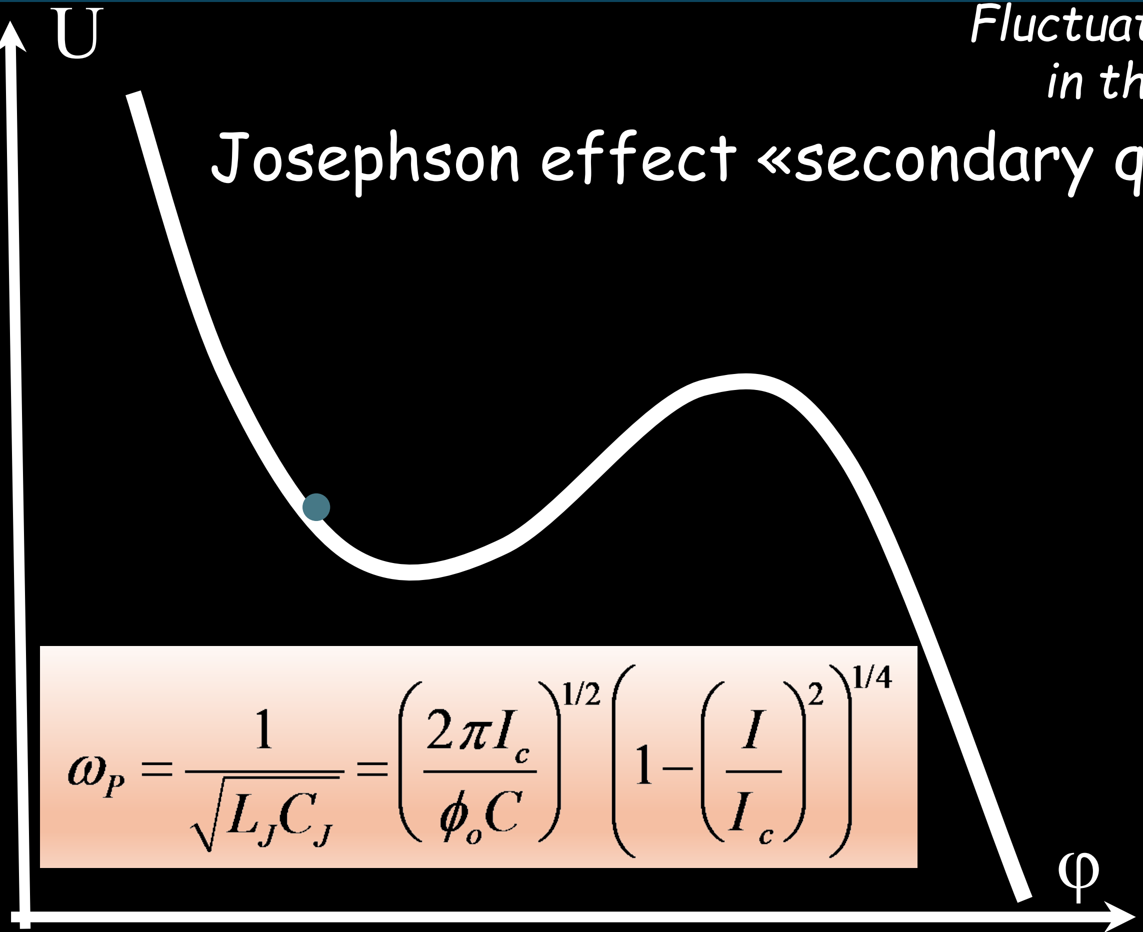

$$\omega_P = \frac{1}{\sqrt{L_J C_J}} = \left(\frac{2\pi I_c}{\phi_o C}\right)^{1/2} \left(1 - \left(\frac{I}{I_c}\right)^2\right)^{1/4}$$

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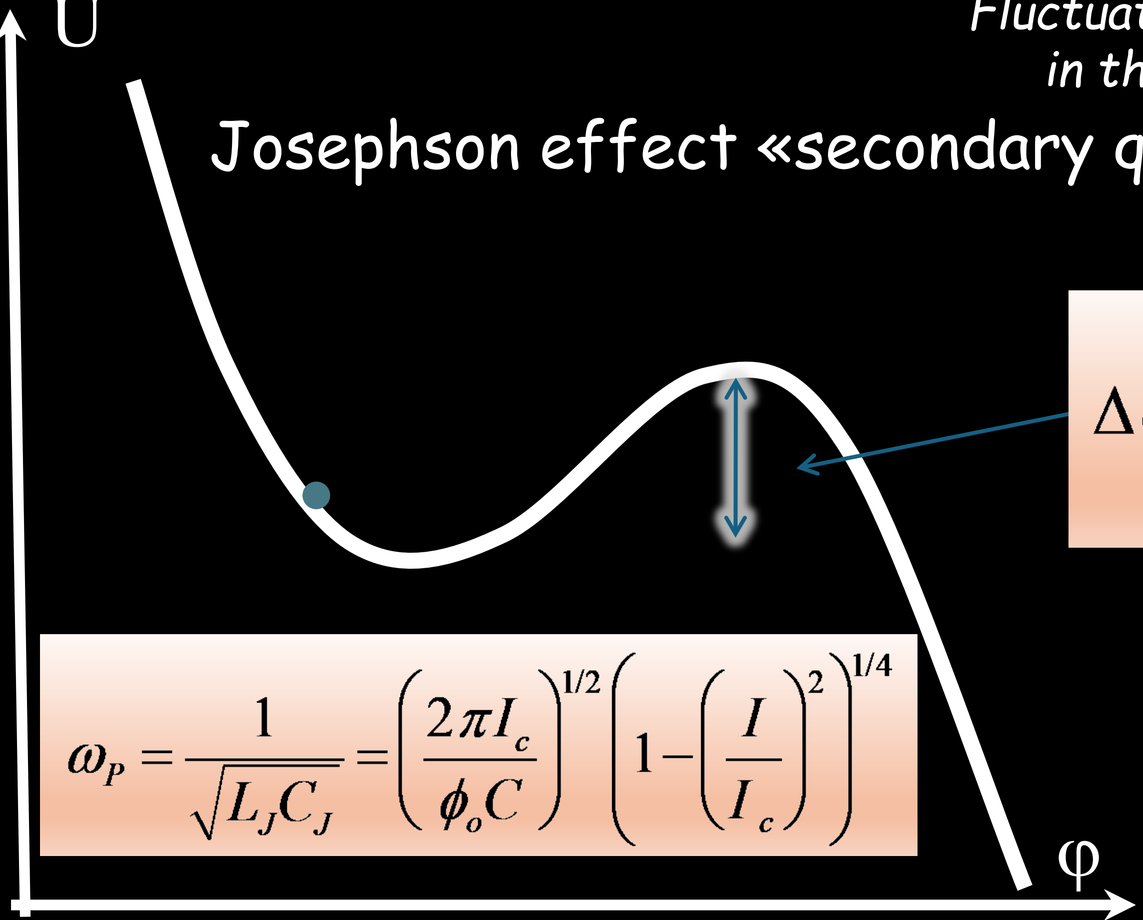

$$\Delta U(I) = \frac{4\sqrt{2}}{3} E_J \left(1 - \frac{I}{I_c}\right)^{3/2}$$

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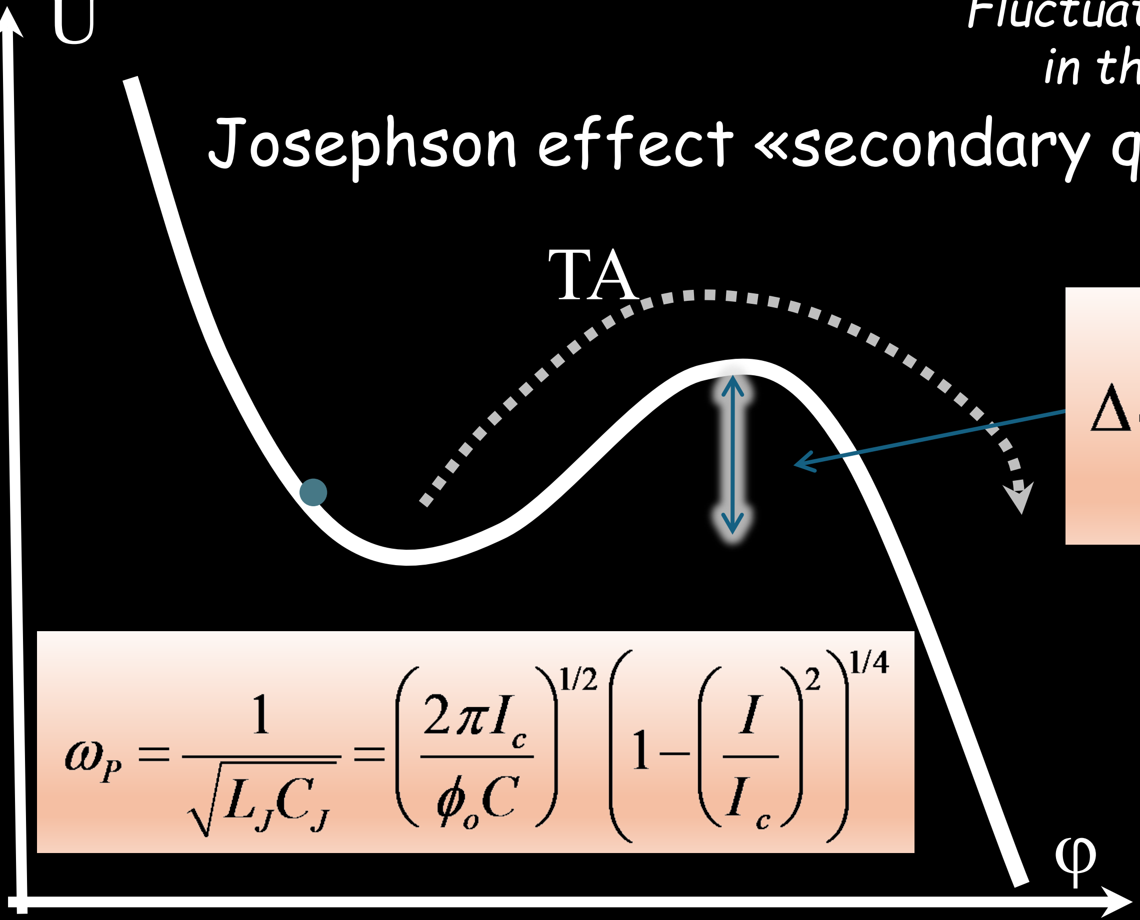

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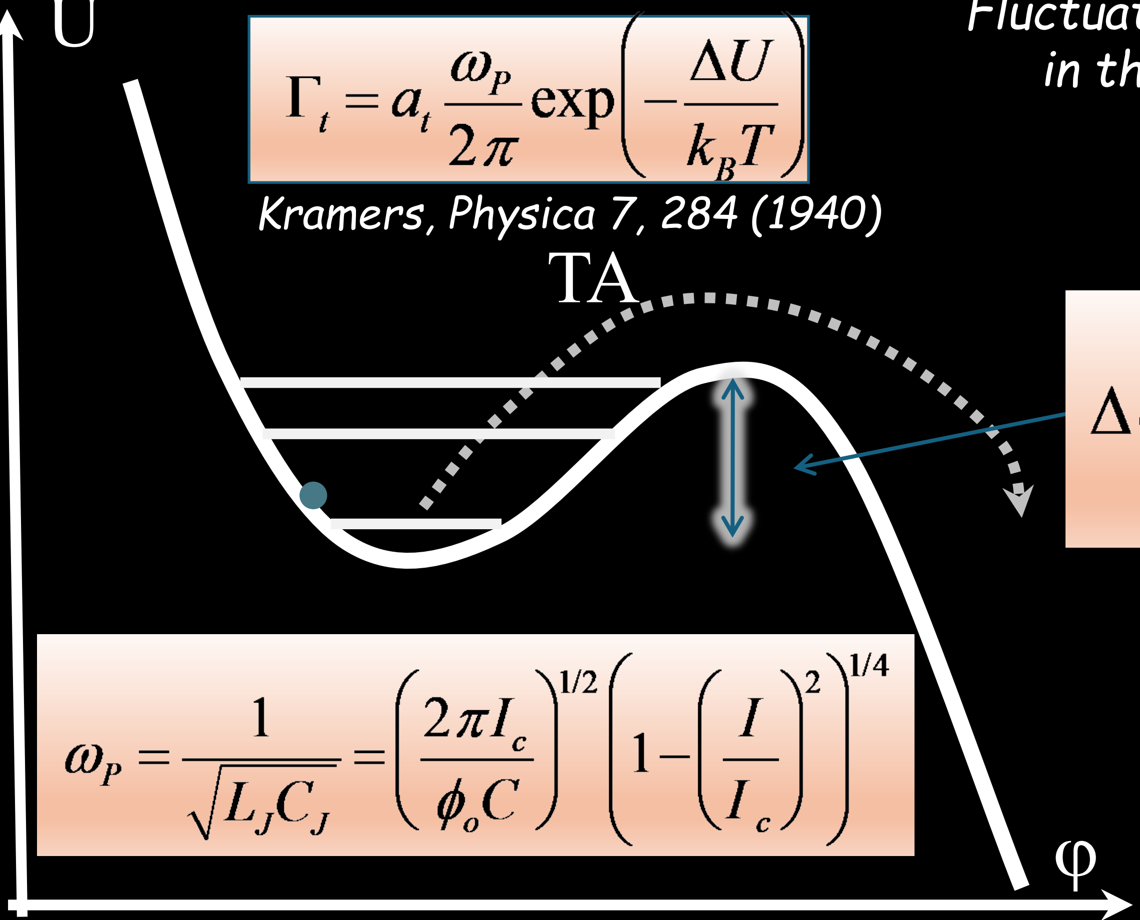
Fluctuations and escape dynamics in the washboard potential

$$\Gamma_t = a_t \frac{\omega_P}{2\pi} \exp\left(-\frac{\Delta U}{k_B T}\right)$$

Kramers, Physica 7, 284 (1940)



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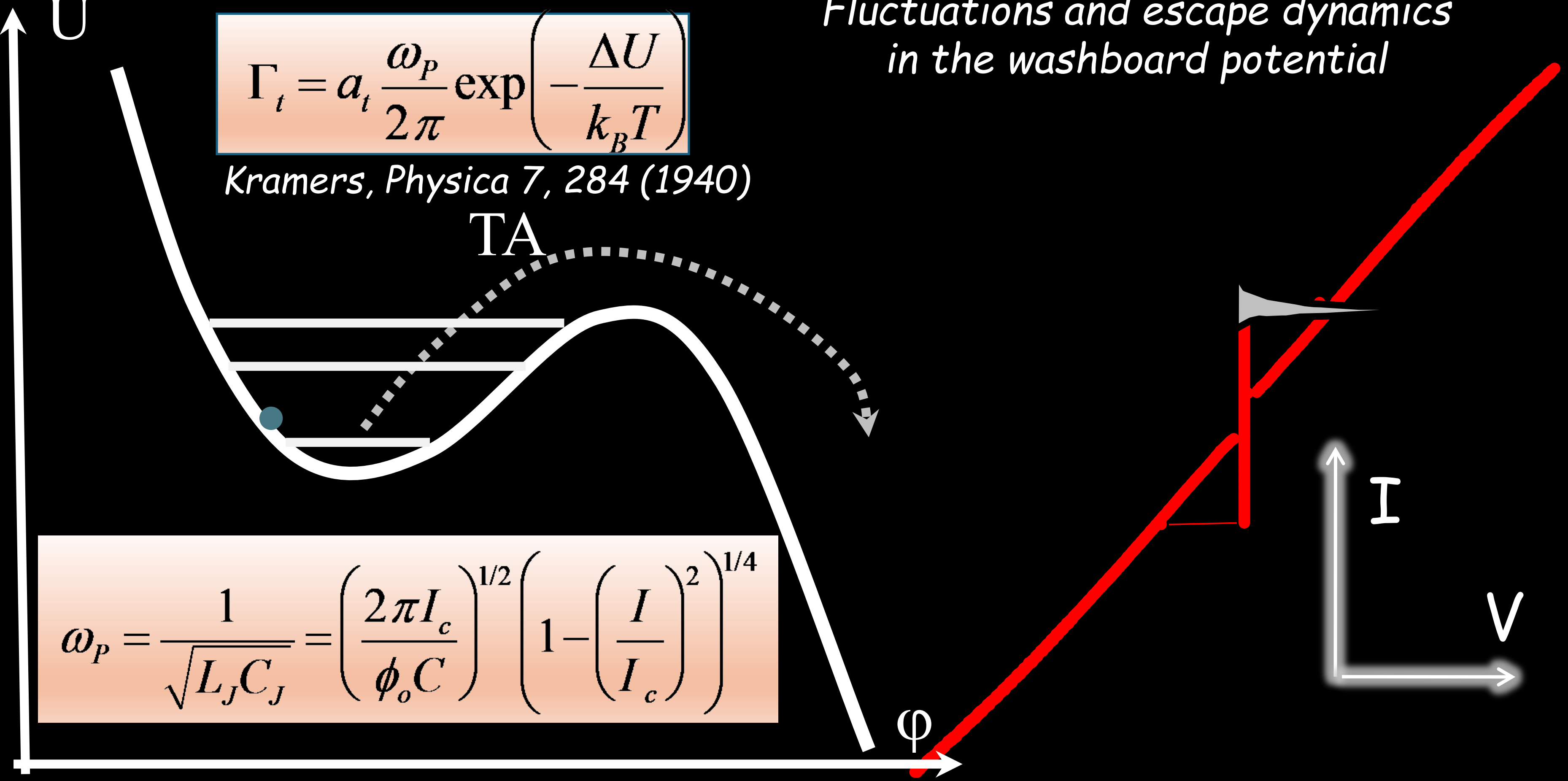

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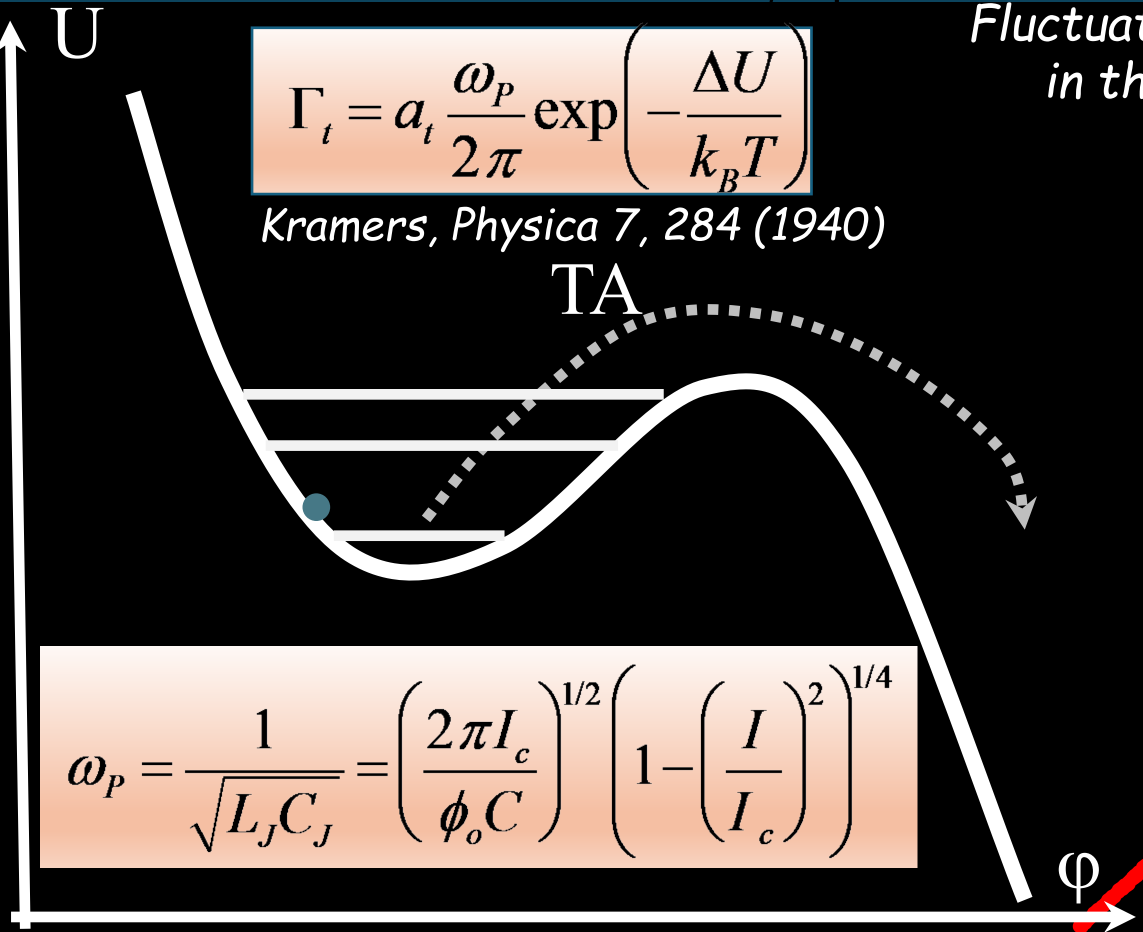

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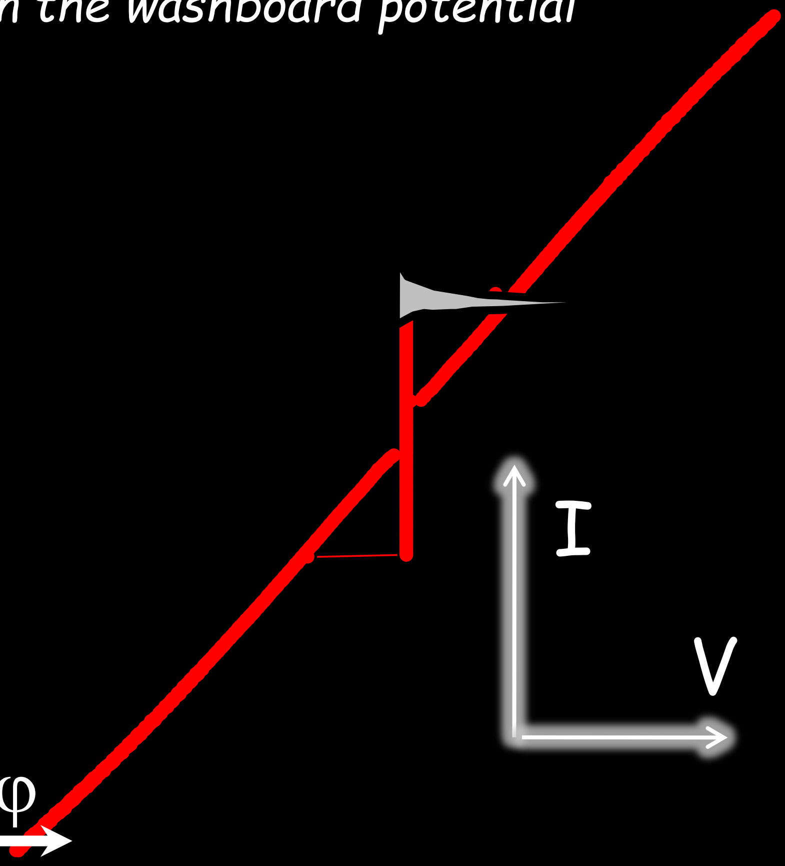

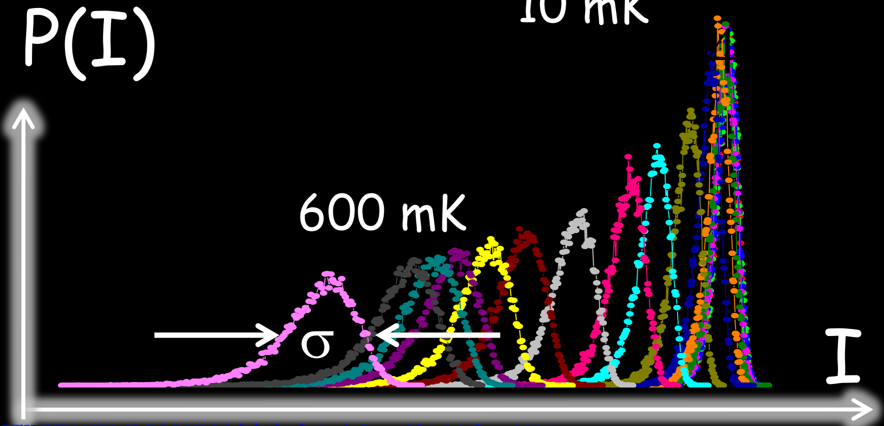

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Caldeira & Leggett, PRL 46, 211 (1981)

$$\Gamma_q = A\exp(-B)$$

$$A = \frac{\omega_P}{2\pi}\left(\frac{\Delta U}{h\omega_P}\right)^{1/2}\chi(\alpha);\ B = \frac{\Delta U}{h\omega_P}s(\alpha)$$

$$\alpha = \frac{1}{2Q} = \frac{1}{2\omega_P RC}$$

$$Q = \frac{C\omega_P}{\mathrm{Re}(Y)} \approx \omega_P RC$$

$$\Gamma_t = a_t\frac{\omega_P}{2\pi}\exp\left(-\frac{\Delta U}{k_B T}\right)$$

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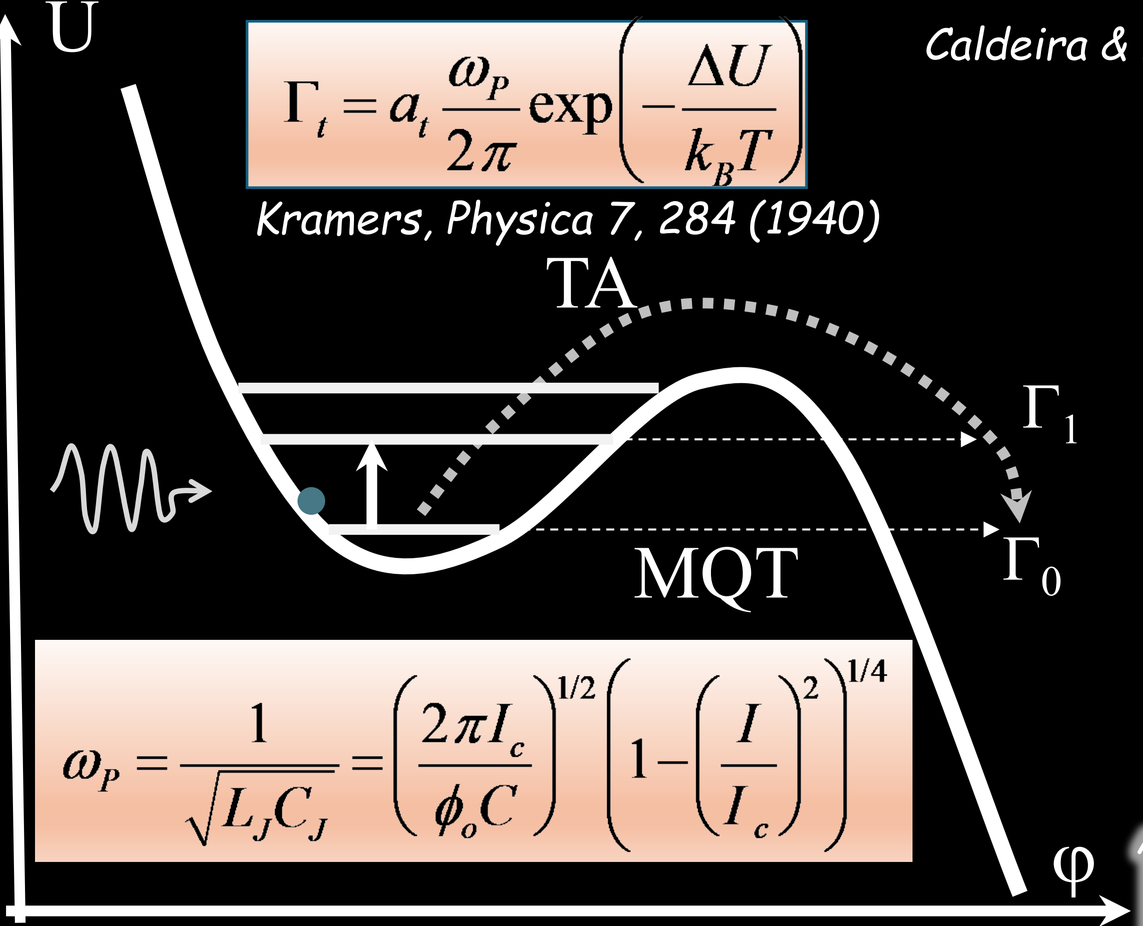
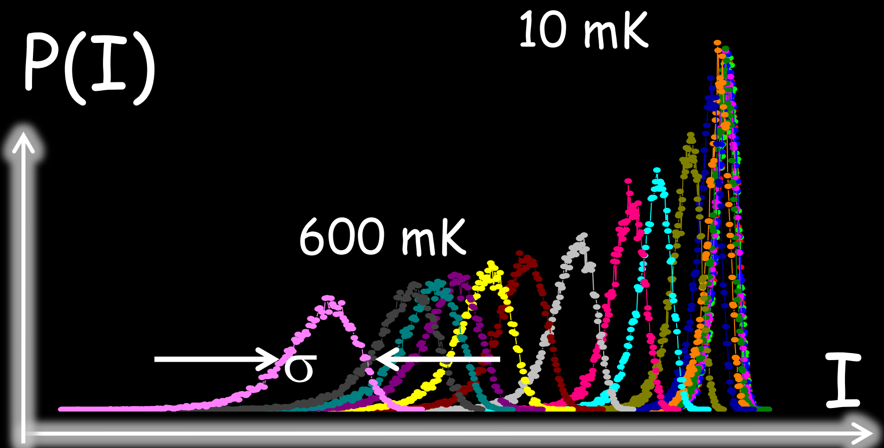
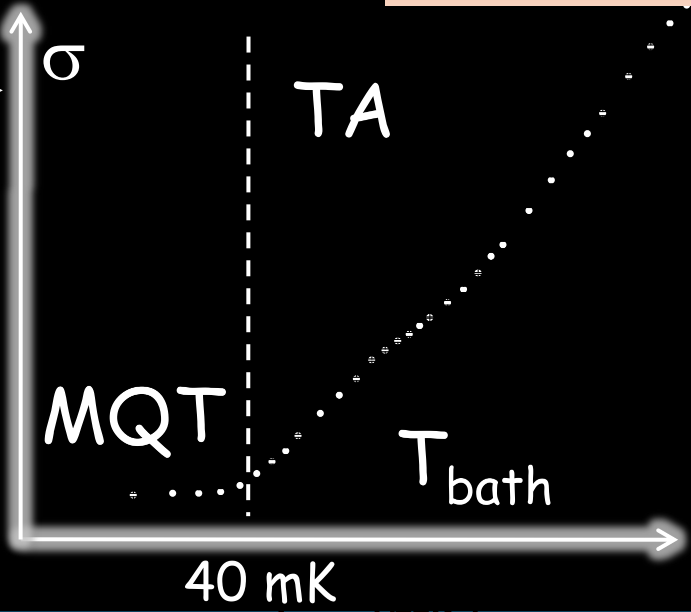
$$\omega_P = \frac{1}{\sqrt{L_J C_J}} = \left(\frac{2\pi I_c}{\phi_o C}\right)^{1/2}\left(1-\left(\frac{I}{I_c}\right)^2\right)^{1/4}$$







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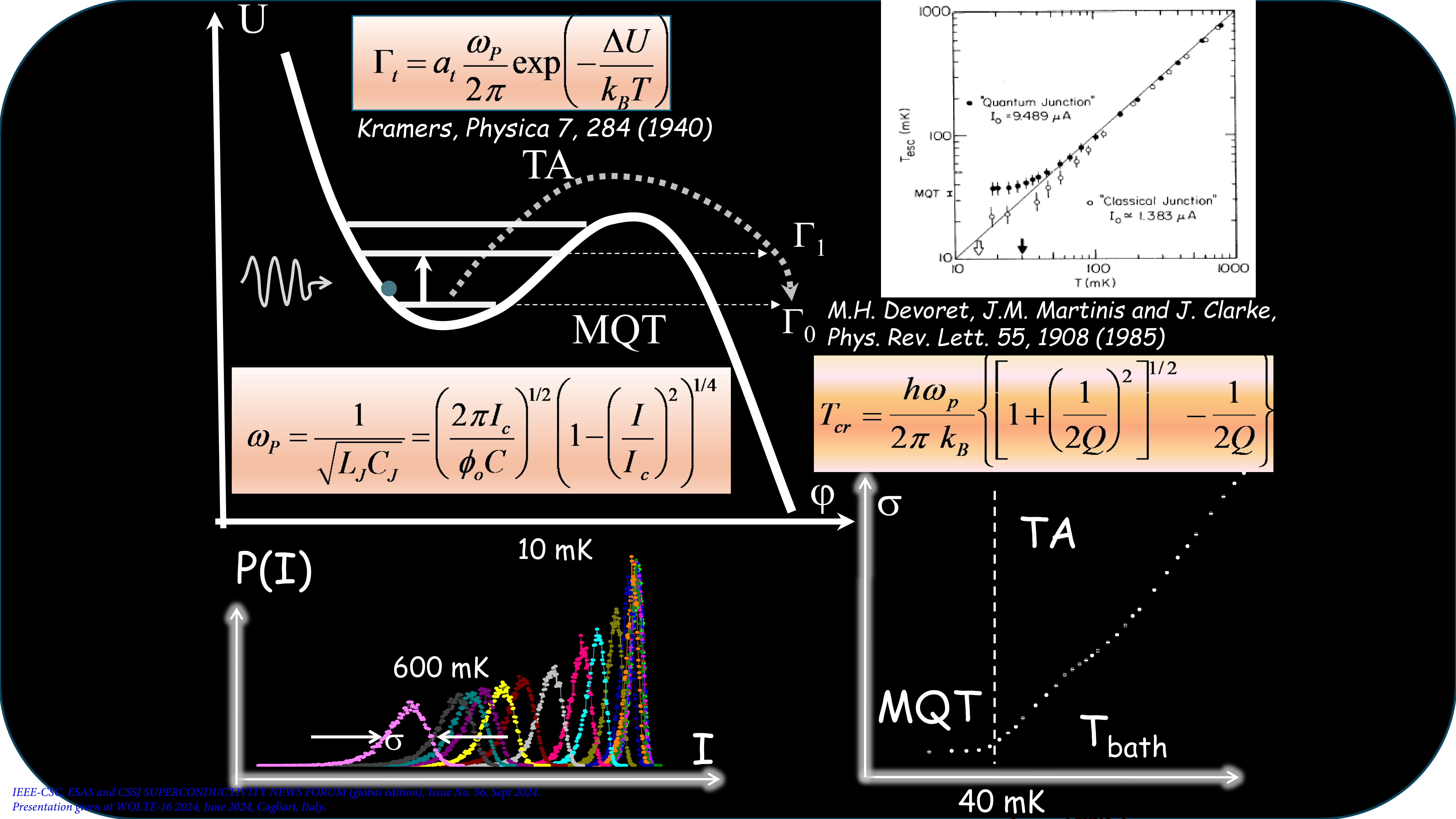

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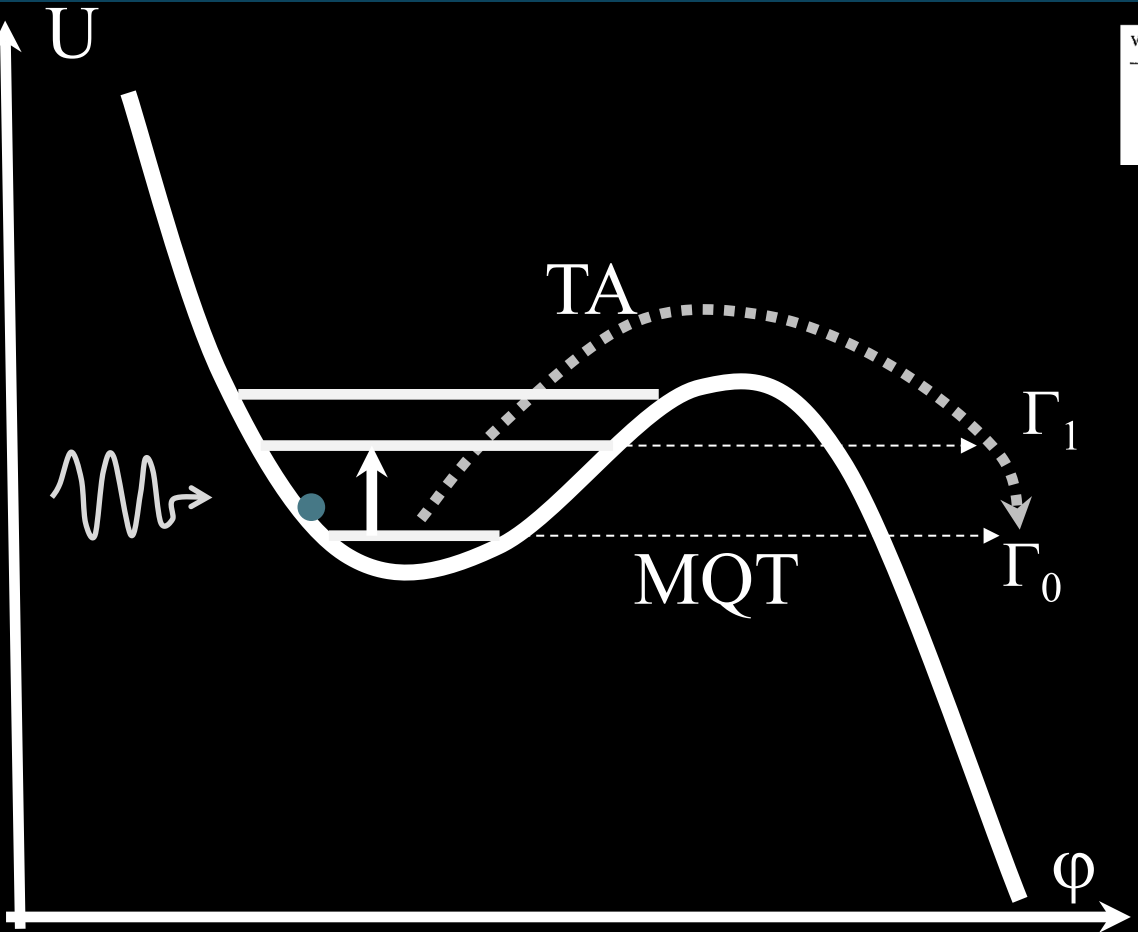
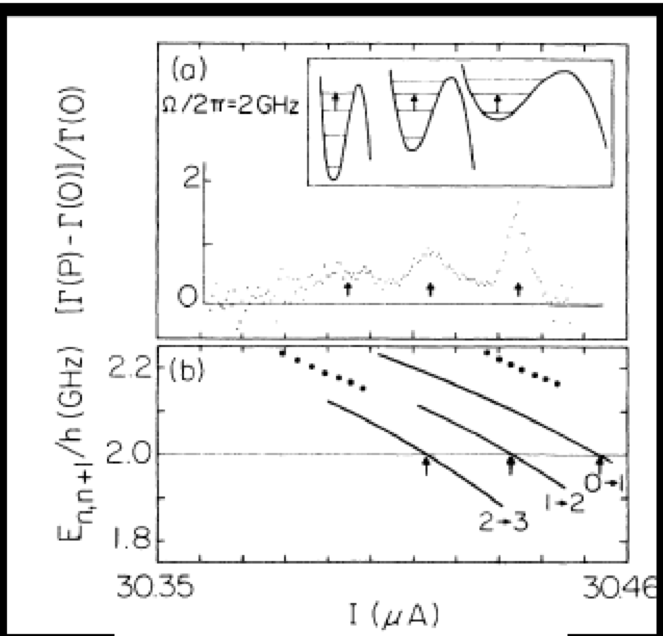
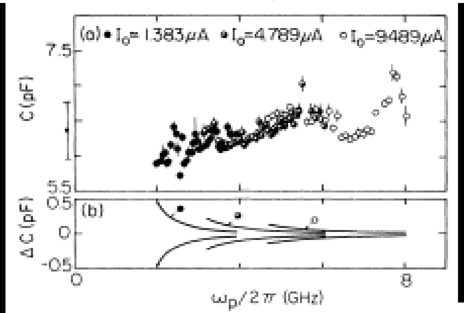


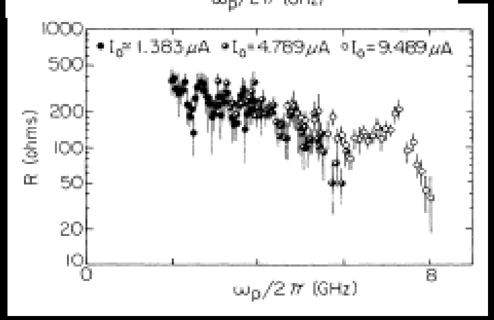
VOLUME 55, NUMBER 18 PHYSICAL REVIEW LETTERS 28 OCTOBER 1985

Measurements of Macroscopic Quantum Tunneling out of the Zero-Voltage State of a Current-Biased Josephson Junction

Michel H. Devoret,[a] John M. Martinis, and John Clarke







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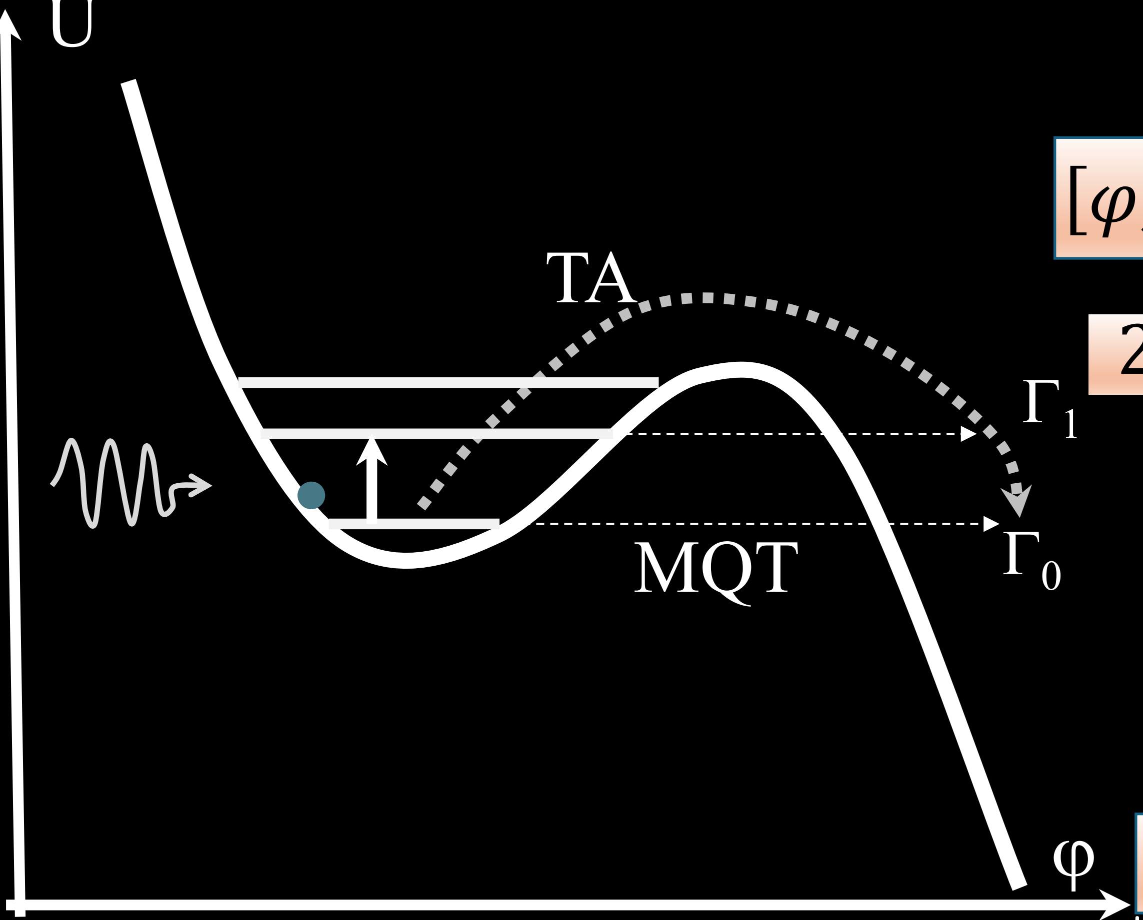


$$[\varphi, Q] = i2e$$

$$n \rightarrow E_c = \frac{e^2}{2C}$$

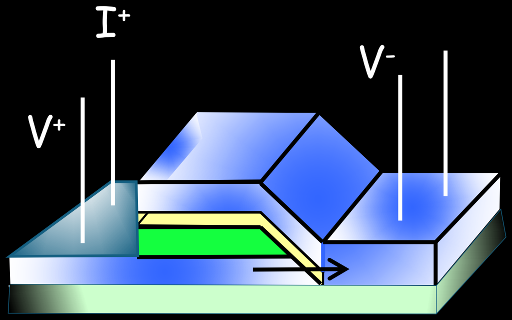
$$2en = Q$$

$$\varphi \rightarrow E_J = \frac{I_c \Phi_o}{2\pi}$$

$$H = \frac{(2en)^2}{2C} - E_J \cos(\varphi) - \frac{\hbar}{2e} I\varphi$$

$E_c >> E_J$
well-defined charge

$E_c << E_J$
well-defined phase



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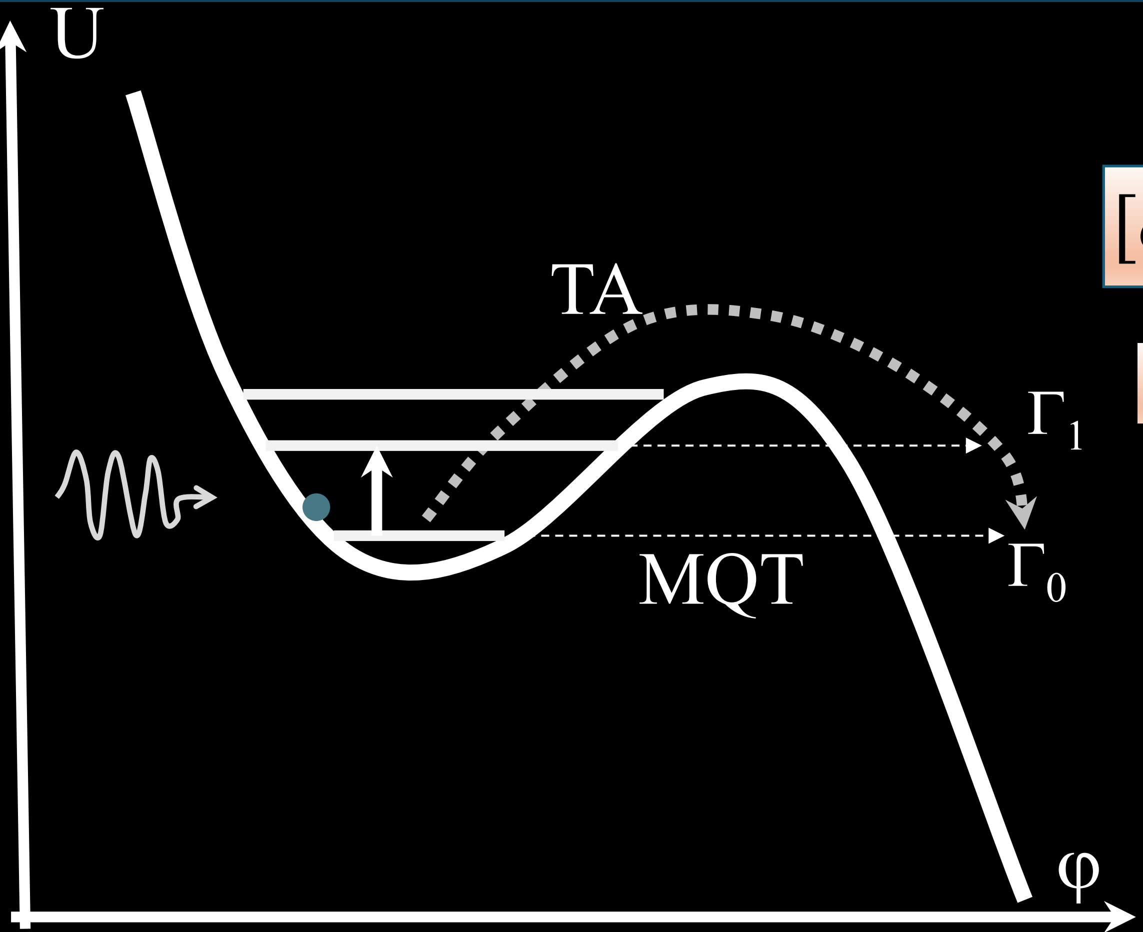

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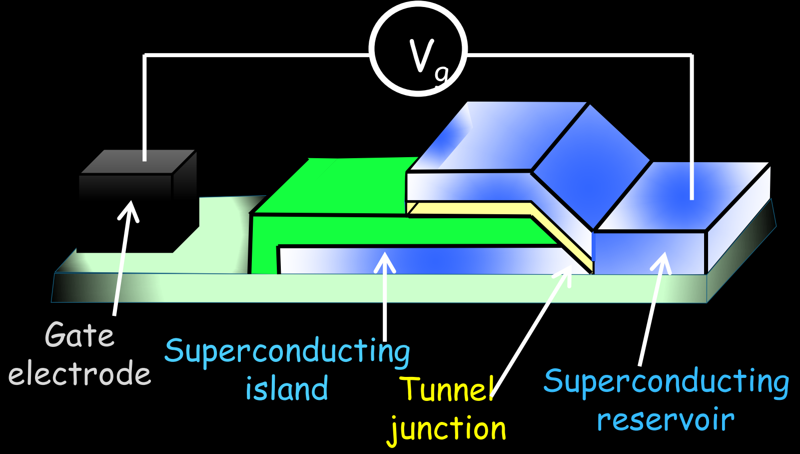

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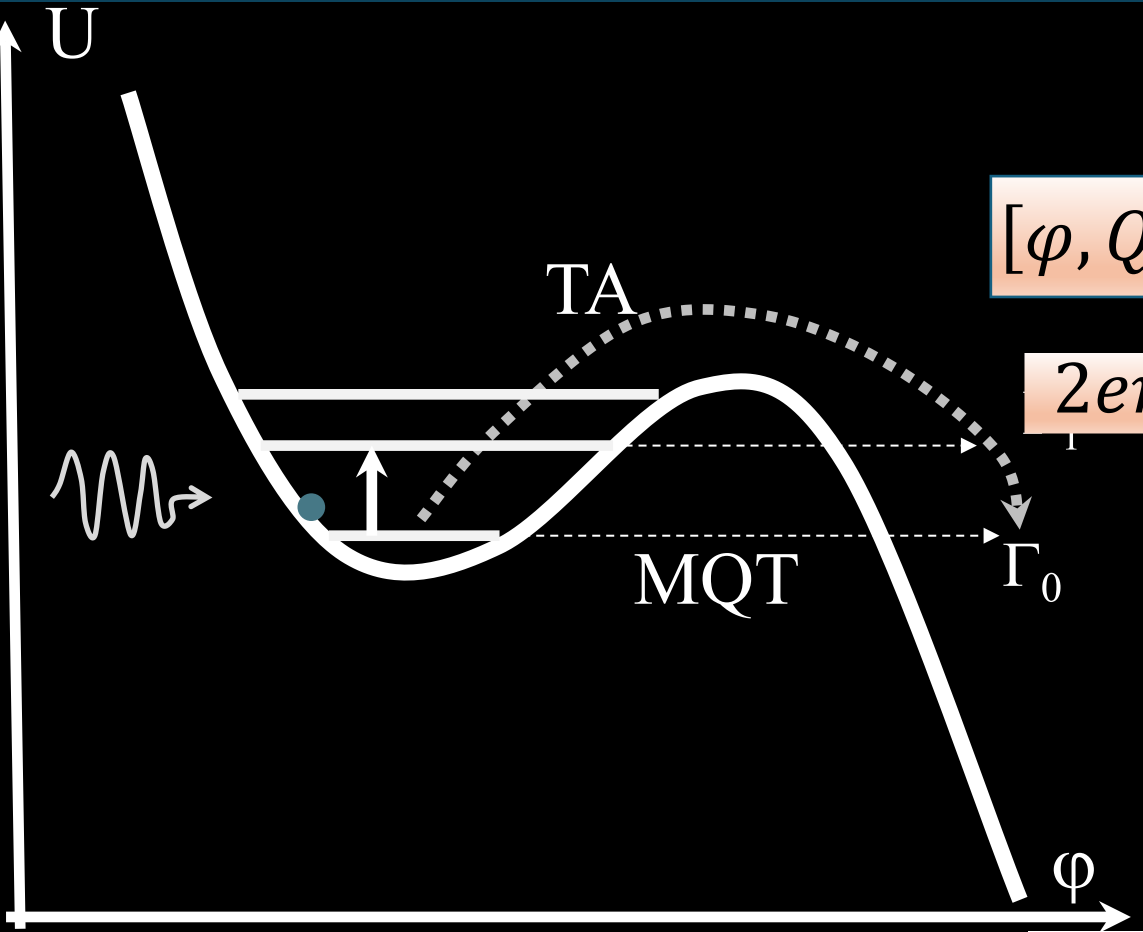

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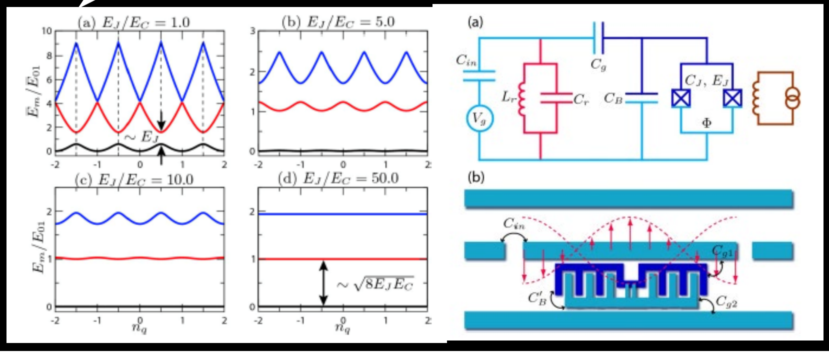

PHYSICAL REVIEW A **76**, 042319 (2007)

Charge-insensitive qubit design derived from the Cooper pair box

Jens Koch,[1] Terri M. Yu,[1] Jay Gambetta,[1] A. A. Houck,[1] D. I. Schuster,[1] J. Majer,[1] Alexandre Blais,[2] M. H. Devoret,[1] S. M. Girvin,[1] and R. J. Schoelkopf[1]

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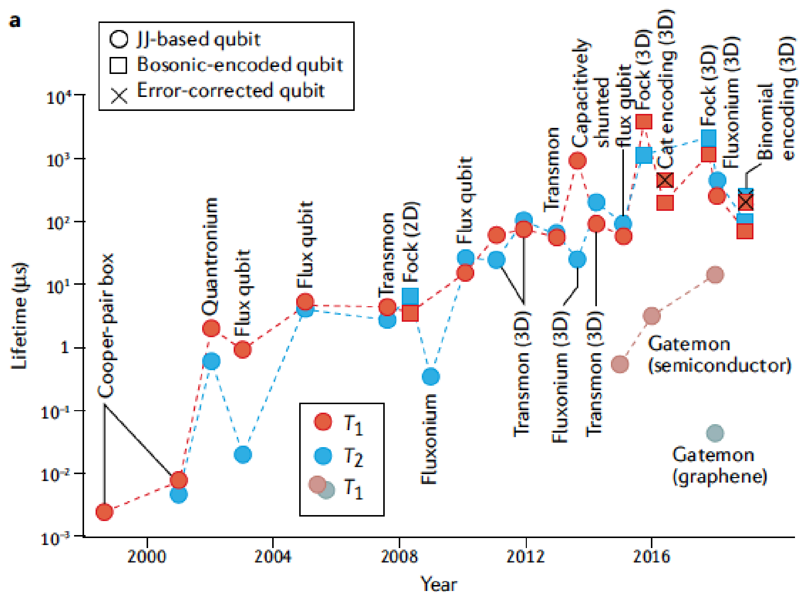
Superconducting Qubit-oriented hardware activities



- Topology of the circuit
- Optimization of architecture, of every single step in fabrication, including read-out and control
- Quality of the Josephson junctions, reducing noise

Engineering high-coherence superconducting qubits

Irfan Siddiqi[1,2]

NATURE REVIEWS | MATERIALS
VOLUME 6 | OCTOBER 2021 | 875

REVIEW

SCIENCE VOL 339 8 MARCH 2013

Superconducting Circuits for Quantum Information: An Outlook

M. H. Devoret[1,2] and R. J. Schoelkopf[1]*

nature communications

Article https://doi.org/10.1038/s41467-022-34727-2

Engineering superconducting qubits to reduce quasiparticles and charge noise

Received: 3 February 2022

Accepted: 2 November 2022

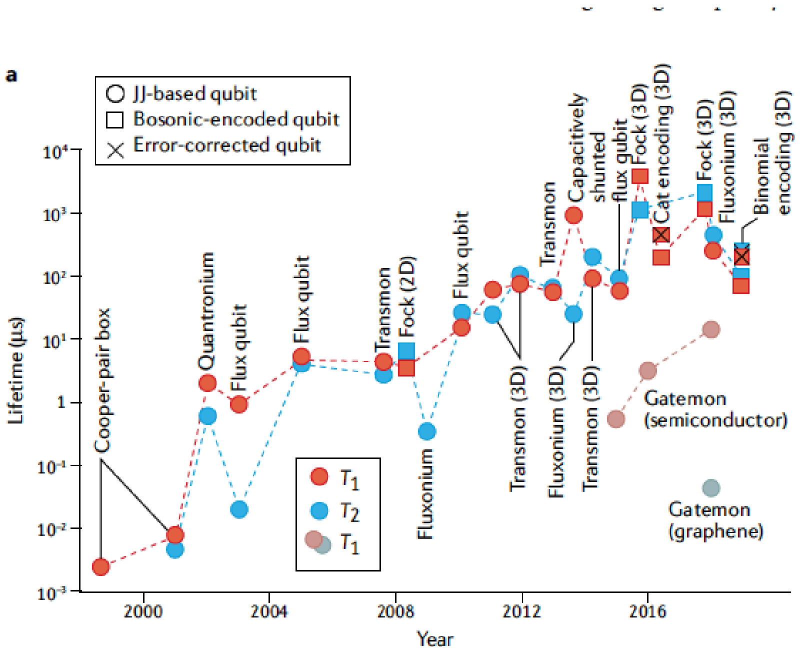
Published online: 23 November 2022

Check for updates

Xianchuang Pan[1,2,3,8], Yuxuan Zhou[1,2,3,4,8], Haolan Yuan[1,2,3,4], Lifu Nie[1,2,3], Weiwei Wei[1,2,3], Libo Zhang[1,2,3], Jian Li[1,2,3], Song Liu[1,2,3], Zhi Hao Jiang[5], Gianluigi Catelani[6,7], Ling Hu[1,2,3], Fei Yan[1,2,3] & Dapeng Yu[1,2,3,4]

Identifying, quantifying, and suppressing decoherence mechanisms in qubits are important steps towards the goal of engineering a quantum computer or simulator. Superconducting circuits offer flexibility in qubit design; however,

Superconducting Qubit-oriented hardware activities



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Unimon qubit

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Eric Hyyppä[1], Suman Kundu[2], Chun Fai Chan[1], András Gunyhó[2], Juho Hotari[1], David Janzso[1], Kristinn Juliusson[1], Olavi Kiuru[2], Janne Kotilahti[1], Alessandro Landra[1], Wei Liu[1], Fabian Marxer[1], Akseli Mäkinen[1], Jean-Luc Orgiazzi[1], Mario Palma[1], Mykhailo Savytskyi[1], Francesca Tosto[1], Jani Tuorila[1], Vasilii Vadimov[2], Tianyi Li[1], Caspar Ockeloen-Korppi[1], Johannes Heinsoo[1,4], Kuan Yen Tan[1,4], Juha Hassel[1,4] & Mikko Möttönen[1,2,3,4]

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Granular aluminium nanojunction fluxonium qubit

Received: 18 February 2022
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Published online: 8 December 2022
Check for updates

D. Rieger[1,4], S. Günzler[1,2,4], M. Spiecker[1], P. Paluch[1,2], P. Winkel[1,2], L. Hahn[3], J. K. Hohmann[3], A. Bacher[3], W. Wernsdorfer[1,2] & I. M. Pop[1,2]

Mesoscopic Josephson junctions, consisting of overlapping superconducting electrodes separated by a nanometre-thin oxide layer, provide a precious source of nonlinearity for superconducting quantum

Novel types of qubits

nature communications
Article
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Superconducting Qubit-oriented hardware activities

nature nanotechnology

Letter https://doi.org/10.1038/s41565-022-01223-z

Quantum-noise-limited microwave amplification using a graphene Josephson junction

Received: 29 March 2022

A list of authors and their affiliations appears at the end of the paper

News & views

Superconducting devices https://doi.org/10.1038/s41565-022-01239-5

Graphene amplifier reaches the quantum limit

Kin Chung Fong

Check for updates

Graphene Josephson junctions enable parametric amplification at the quantum noise limit with gate-tuneable working frequency.

tracking quantum trajectory, and even searching for the rare event when the axion dark matter converts into a microwave photon under a high magnetic field. Writing in *Nature Nanotechnology*, two independent reports by Guilliam Butseraen et al.[5] and Joydip Sarkar et al.[6], now

nature physics

Article https://doi.org/10.1038/s41567-022-01929-w

Broadband squeezed microwaves and amplification with a Josephson travelling-wave parametric amplifier

Received: 22 February 2022

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Quantum integrated solutions and components

nature communications

Article https://doi.org/10.1038/s41467-022-34614-w

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Check for updates

Xianchuang Pan[1,2,3,8], Yuxuan Zhou[1,2,3,4,8], Haolan Yuan[1,2,3,4], Lifu Nie[1,2,3], Weiwei Wei[1,2,3], Libo Zhang[1,2,3], Jian Li[1,2,3], Song Liu[1,2,3], Zhi Hao Jiang[5], Gianluigi Catelani[6,7], Ling Hu[1,2,3], Fei Yan[1,2,3] & Dapeng Yu[1,2,3,4]

Identifying, quantifying, and suppressing decoherence mechanisms in qubits are important steps towards the goal of engineering a quantum computer or simulator. Superconducting circuits offer flexibility in qubit design; however,

Superconducting Qubit-oriented hardware activities

nature nanotechnology

Letter https://doi.org/10.1038/s41565-022-01223-z

Quantum-noise-limited microwave amplification using a graphene Josephson junction

Received: 29 March 2022

Accepted: 18 August 2022

A list of authors and their affiliations appears at the end of the paper

News & views

Superconducting devices https://doi.org/10.1038/s41565-022-01239-5

Graphene amplifier reaches the quantum limit

Kin Chung Fong

Check for updates

Graphene Josephson junctions enable parametric amplification at the quantum noise limit with gate-tuneable working frequency.

tracking quantum trajectory, and even searching for the rare event when the axion dark matter converts into a microwave photon under a high magnetic field. Writing in *Nature Nanotechnology*, two independent reports by Guilliam Butseraen et. al.[5] and Joydip Sarkar et. al.[6], now

nature communications

Article https://doi.org/10.1038/s41467-022-34614-w

Unimon qubit

Received: 4 May 2022

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Published online: 12 November 2022

Check for updates

Eric Hyyppä[1], Suman Kundu[2], Chun Fai Chan[1], András Gunyhó[2], Juho Hotari[1], David Janzso[1], Kristinn Juliusson[1], Olavi Kiuru[2], Janne Kotilahti[1], Alessandro Landra[1], Wei Liu[1], Fabian Marxer[1], Akseli Mäkinen[1], Jean-Luc Orgiazzi[1], Mario Palma[1], Mykhailo Savytskyi[1], Francesca Tosto[1], Jani Tuorila[1], Vasilii Vadimov[2], Tianyi Li[1], Caspar Ockeloen-Korppi[1], Johannes Heinsoo[1,4], Kuan Yen Tan[1,4], Juha Hassel[1,4] & Mikko Möttönen[1,2,3,4]

nature materials

Article https://doi.org/10.1038/s41563-022-01417-9

Granular aluminium nanojunction fluxonium qubit

Received: 18 February 2022

Accepted: 20 October 2022

Published online: 8 December 2022

Check for updates

D. Rieger[1,4], S. Günzler[1,2,4], M. Spiecker[1], P. Paluch[1,2], P. Winkel[1,2], L. Hahn[3], J. K. Hohmann[3], A. Bacher[3], W. Wernsdorfer[1,2] & I. M. Pop[1,2]

Mesoscopic Josephson junctions, consisting of overlapping superconducting electrodes separated by a nanometre-thin oxide layer, provide a precious source of nonlinearity for superconducting quantum circuits. Here we show that in a fluxonium qubit, the role of the Josephson

nature physics

Article https://doi.org/10.1038/s41567-022-01929-w

Broadband squeezed microwaves and amplification with a Josephson travelling-wave parametric amplifier

Received: 22 February 2022

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Published online: 9 February 2023

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Jack Y. Qiu, Arne Grimsmo, Kaidong Peng, Bharath Kannan, Benjamin Lienhard, Youngkyu Sung, Philip Krantz, Vladimir Bolkhovsky, Greg Calusine, David Kim, Alex Melville, Bethany M. Niedzielski, Jonilyn Yoder, Mollie E. Schwartz, Terry P. Orlando, Irfan Siddiqi, Simon Gustavsson, Kevin P. O'Brien & William D. Oliver

Novel types of qubits

Quantum interfaces

nature physics

Article https://doi.org/10.1038/s41567-023-02071-x

Direct manipulation of a superconducting spin qubit strongly coupled to a transmon qubit

Received: 1 September 2022

Accepted: 26 April 2023

Published online: 22 May 2023

Marta Pita-Vidal[1,9], Arno Bargerbos[1,9], Rok Žitko[2,3], Lukas J. Splitthoff[1], Lukas Grünhaupt[1], Jaap J. Wesdorp[1], Yu Liu[4], Leo P. Kouwenhoven[1], Ramón Aguado[5], Bernard van Heck[6,7], Angela Kou[8] & Christian Kraglund Andersen[1]

simulator. Superconducting circuits offer flexibility in qubit design; however,

Quantum integrated solutions and components

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at WOLTE-16 2024, June 2024, Cagliari, Italy.

Some kind of Univ. Napoli Roadmap

Quantum computation

Quantum communication

Superconducting quantum circuits and qubit architectures

Alternative qubit layouts, hybrid JJs, transmon and fluxonium

Tunable emerging electronic configurations in hybrid/topological systems, Twisted 2D layered materials hosting angle-dependent bands

Ferro-transmon, based on JJs with ferromagnetic barriers

FERROMON

Co-funded by the European Union

Standard approach Al technology

QUANTERA ERA-NET Cofund in Quantum Technologies

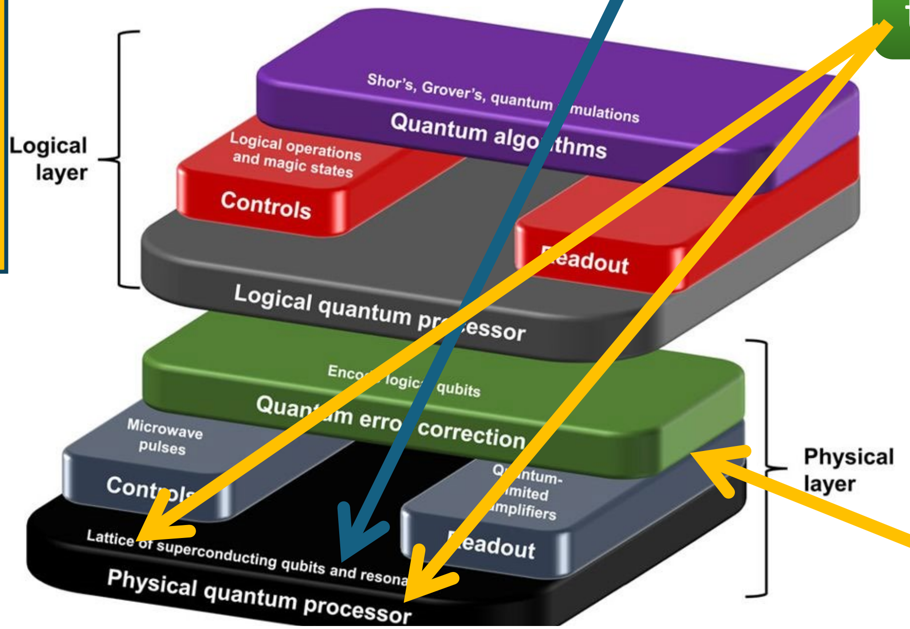
SeeQC

control and readout and phase-sensitive devices

running 25 (→40) qubits computer

ICSC

NQSTI National Quantum Science and Technology Institute



Jay M. Gambetta , Jerry M. Chow & Matthias Steffen
npj Quantum Information **3**, Article number: 2 (2017)

Running classical/quantum algorithms

1. **HEALTH**
2. **HUMANISTIC CULTURE, CREATIVITY, SOCIAL TRANSFORMATION AND THE SOCIETY OF INCLUSION**
3. **SECURITY FOR SOCIAL SYSTEMS**
4. **DIGITAL, INDUSTRY AND AEROSPACE**
    - **Digital transition - i4.0**:
    - **High performance computing and big data**:
    - **Artificial intelligence**:
    - **Robotics**:
    - **Quantum technologies**: Salvatore De Pasquale (coordinator), Stefano Carretta, Francesco Saverio Cataliotti, Paolo De Natale, Marco Fanciulli, Gaetano Scamarcio, Fabio Sciarrino, Francesco Tafuri, Alessandro Tredicucci, Raffaele Tripiccione
    - **Innovation for the manufacturing industry**:
    - **Aerospace**:
5. **CLIMATE, ENERGY AND SUSTAINABLE MOBILITY**
6. **FOOD PRODUCTS, BIOECONOMICS, NATURAL RESOURCES, AGRICULTURE, AND THE ENVIRONMENT**

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at WOLTE-16 2024, June 2024, Cagliari, Italy.

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Home | Stampa | Notizie e comunicati stampa | PNRR: nascono i 5 centri nazionali per la ricerca

PNRR: nascono i 5 centri nazionali per la ricerca

Mercoledì, 15/06/2022

Il ministro Messa li ha presentati questa mattina nel corso del Consiglio dei Ministri. Con 1,6 miliardi di euro complessivi coinvolgono 144 tra università, enti di ricerca e imprese in tutta Italia

Nascono i **5 Centri Nazionali** per la ricerca in filiera previsti dalla Componente “dalla ricerca al business” della Missione “Istruzione e Ricerca” del Piano nazionale di ripresa e resilienza grazie a **1,6 miliardi di euro**.

Naviga la sezione

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PNRR, MUR: selezionati i 14 partenariati per attività di ricerca

Mercoledì, 03/08/2022

I progetti sottoposti alla valutazione tecnico-scientifica sono stati 24. Ora si apre la fase negoziale.
L'investimento complessivo è di 1,61 miliardi di euro

Sono stati **selezionati i 14 grandi Partenariati estesi** alle università, ai centri di ricerca, alle

Naviga la sezione

Notizie e comunicati stampa

• Articulation 1. Quantum technologies for computers and simulators

- Quantum computing represents a radical change in computational paradigms. Computers and quantum simulators have revolutionary potential in many areas, from the optimisation of production and social processes to the solution of complex problems, from chemistry to biology, from the development of innovative materials and new drugs to fundamental physics. The recent demonstration of quantum supremacy - the ability of a quantum computer to perform a task that is impossible for a traditional computer - promises to make the quantum ecosystem a production reality in the next decade.

- ***State of the art***. Different architectures are being pursued in academic and industrial fields worldwide: qubits based on superconductors, semiconductors, trapped ions, integrated photonics, topological qubits, molecular spin qubits and degenerate gases. The Italian system has extensive experimental, theoretical and technological expertise in several of these platforms: photonics quantum information processing, quantum simulation with atomic systems, superconducting systems, semiconductors and qubits based on magnetic molecules.

- ***Objective and impact***: to make Italy a key player in the field of QT for computers and simulators as a supplier of enabling technologies, as a developer of integrated platforms and algorithms, and as an industrial end user; to equip the Italian system with a quantum computing/simulation infrastructure at the forefront in Europe. The impact of this effort is enormous on enabling technologies in our country. The search for QT-based solutions fuels a transformative and cutting-edge industry, in terms of both small and medium-sized enterprises (SMEs) and large industries, in various fields - integrated electronic circuits for control and readout (TRL 8), integrated photonics (TRL 7), innovative materials (TRL 5-7), cutting-edge cryogenics (TRL 7), other components and control software (TRL 7) to manage the new hardware effectively.

- ***Strategy***: 1. Strengthen, from a theoretical and experimental point of view, the platforms for quantum computation and simulation in which Italy has extensive expertise (superconductors, semiconductors, magnetic molecules, integrated photonics, atomic systems), perfecting their technology; 2. Demonstrate and use the quantum advantage in the NISQ (Noisy, Intermediate-Scale Quantum) regime, based on the development of already available imperfect machines, integrating quantum computing techniques with those of High Performance Computing; 3. Achieve the full power of quantum computing, by implementing quantum error correction, with codes targeted on specific platforms; 4. Develop new quantum algorithms, for the solution of numerous highly complex problems and 5. Develop a transformative and cutting-edge industry, in the areas identified above, by creating advanced

- **Articulation 1. Quantum technologies for computers and simulators**

- Quantum computing represents a radical change in computational paradigms. Computers and quantum simulators have revolutionary potential in many areas, from the optimisation of production and social processes to the solution of complex problems, from chemistry to biology, from the development of innovative materials and new drugs to fundamental physics. The recent demonstration of quantum supremacy - the ability of a quantum computer to perform a task that is impossible for a traditional computer - promises to make the quantum ecosystem a production reality in the next decade.

- **Articulation 2. Quantum technologies for communications**

- **Articulation 3. Quantum technologies for sensors and metrology**

•

- **Articulation 4. Quantum technologies for energy efficiency and sustainability**

- **Articulation 5. Research infrastructures for quantum technologies**

- **Articulation 6. Training and human capital**.

2018: Phd in "Quantum Technologies": University of Napoli Federico II, CRN and University of Camerino 2022: Master Degree in "Quantum Science and Engineering", Univeristy of Napoli Federico II

PNR 2021-2027 Programma nazionale per la ricerca

MUR Ministero dell'Università e della Ricerca

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PNRR: nascono i 5 centri nazionali per la ricerca

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Naviga la sezione

Nome Centro Nazionale	Proponente	Sede Hub	Numero Soggetti Partecipanti Totali	Numero Università-enti pubblici di ricerca-organismi di ricerca	Numero Imprese	Finanziamento concesso (in euro)	% di finanziamento concesso destinato al Sud
National Centre for HPC, Big Data and Quantum Computing	Istituto Nazionale di Fisica Nucleare (INFN)	Casalecchio di Reno (BO)	49	34	15	319.938.979,26	41%
National Research Centre for Agricultural Technologies (Agritech)	Università degli Studi di Napoli Federico II	Napoli	46	32	14	320.070.095,50	45%
Sustainable Mobility Center (Centro Nazionale per la Mobilità Sostenibile – CNMS)	Politecnico di Milano	Milano	49	25	24	319.922.088,03	40%
National Biodiversity Future Center - NBFC	Consiglio Nazionale delle Ricerche (CNR)	Palermo	48	41	7	320.026.665,79	44%
National Center for Gene Therapy and Drugs based on RNA Technology	Università degli Studi di Padova	Padova	49	32	17	320.036.606,03	42%

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at WOLTE-16 2024, June 2024, Cagliari, Italy.

ICSC
Centro Nazionale di Ricerca in HPC,
Big Data and Quantum Computing

https://www.supercomputing-icsc.it/

Home | ICSC | Programmi di Ricerca | Bandi a Cascata | Osservatorio | Risultati | Media

In Evidenza:

Pubblicati i primi bandi a cascata di ICSC – Centro Nazionale di Ricerca in High Performance Computing, Big Data e Quantum Computing

INAUGURATO ALL'UNIVERSITA' FEDERICO II DI NAPOLI IL PRIMO COMPUTER QUANTISTICO SUPERCONDUTTIVO ITALIANO

da Matteo Massicci | 29 Maggio 2024 | Comunicati Stampa | Commenti 0

È stato inaugurato e presentato oggi, mercoledì 29 maggio, presso il nuovo centro di computazione quantistica superconduttiva del Dipartimento di Fisica 'E. Pancini' dell'Università degli Studi di Napoli Federico II il primo computer quantistico superconduttivo...

Leggi di più

Ultime News

INAUGURATO ALL'UNIVERSITA' FEDERICO II DI NAPOLI IL PRIMO COMPUTER QUANTISTICO SUPERCONDUTTIVO ITALIANO

29 Mag 2024

APERTE LE ISCRIZIONI PER IL CORSO IN BIOMEDICAL COMPUTING RE-TRAIN-ME

27 Mag 2024

L' UNIVERSITA' DI CATANIA BANDISCE TRE NUOVE BORSE DI RICERCA NELL'AMBITO DEI PROGETTI ICSC

24 Mag 2024

DAL 29 AL 31 MAGGIO, A BRESCIA, LA CONFERENZA GARR 2024

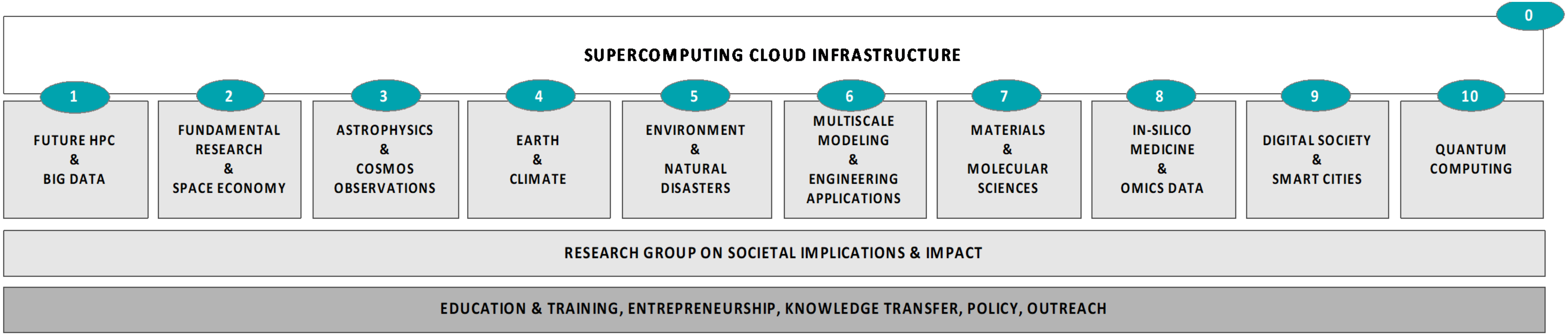
15 Mag 2024

ONLINE LA PRIMA VERSIONE DELLE RACCOMANDAZIONI PER UN USO RESPONSABILE ED ETICO DELL'IA NELLA PUBBLICA AMMINISTRAZIONE

13 Mag 2024

Rivedi il consenso

https://www.supercomputing-icsc.it/2024/05/27/aperte-le-iscrizioni-per-il-corso-in-biomedical-computing-re-train-me/



Spoke 1 - Future HPC & Big Data

According to the EU vision, High-Performance Computing rests on five pillars: skills, applications, infrastructure, technology, and federation of resources. All the pillars are represented in the Future HPC spoke. The main focus is on the technology pillar across all the layers of standard (i.e., non-Quantum) computing systems: Circuits, Architecture, Programming Model, and Execution Model up to just before the last tier, i.e., Applications, which are addressed in other spokes of the centre. In this focused strategy, the FutureHPC & BD spoke is tightly linked with the work program of the technological pillar of the EuroHPC Joint Undertaking, which is expected to contribute to the sustainability of the FutureHPC & BD spoke. The technological pillar is crucial for EU digital sovereignty and is paramount for engaging industry in achieving (by 2030) European leadership and autonomy in HPC infrastructure, data, and services and fueling innovation across the computing continuum.

Spoke 2 - Fundamental Research & Space Economy

Science, and in particular science at the frontier of knowledge, is becoming more and more a computing intensive discipline. Current and next-generation experiments show processing and data needs comparable with the top global players and need a stack of solutions which are not typical of the curriculum of scientists. The trend has indeed started more than 15 years ago, with the development of solutions needed to satisfy the science of Collider Physics; since then, similar needs have been documented in other scientific domains, with Astroparticle physics showing by the end of the 2020s similar if not larger resource deployments. The activities in Spoke 2 "Fundamental Research and Space Economy" focus on boosting the science capabilities of current and future science initiatives, using the opportunities that PNRR in general and the National Centre for Big Data, HPC and Quantum Computing (CN) in particular offer in the next three years.

Spoke 9 - Digital Society & Smart Cities

HPC and big data - combined with suitable models, methodologies, and algorithms - offer new opportunities to solve key challenges in smart cities and in digital societies. Indeed, these are characterized by the confluence and interaction of different systems in the social, organizational and technological domains, thus impossible to solve through decomposition into easier problems, and requiring new approaches able to overcome this "complexity wall".

The spoke intends to face this complexity by investigating novel approaches that build upon - and extend - the concept of "digital twins". The aim is to create a faithful digital representation of social and organizational structures of cities and communities and of their citizens, and of the physical and virtual contexts where they operate and interact, by exploiting available "big data" digital tracks, powerful data analysis and Artificial Intelligence (AI) techniques and advanced simulation opportunities unlocked by HPC infrastructures.

Through digital twins, the spoke intends to improve our capability to (i) replicate and understand the functioning and behaviors of our cities and societies, (ii) forecast future evolutions, also in response to changes, and (iii) support the experimentation and the evaluation of the effects of policies, protocols and scenarios aiming to change the behavior of cities and communities.

Napoli involvement + spoke 10 (later)

Public Research Institutions Founding Members

Politecnico di Milano 1863
Università di Pavia
Università degli Studi di Milano Bicocca
FBK Fondazione Bruno Kessler – Future built on knowledge
Università di Trento
Politecnico di Torino
Università degli Studi di Torino
Università degli Studi di Padova
SISSA
Università degli Studi di Trieste
Università degli Studi di Ferrara
Alma Mater Studiorum Università di Bologna
IIT Istituto Italiano di Tecnologia
Scuola Normale Superiore
Università degli Studi Firenze
Università di Pisa
Università degli Studi dell'Aquila
Politecnico di Bari
Università degli Studi di Bari Aldo Moro
Sapienza Università di Roma
Tor Vergata Università degli Studi di Roma
Università degli Studi di Napoli Federico II
CMCC Centro Euro-Mediterraneo sui Cambiamenti Climatici
Università del Salento
CRS4 Ideas become life
Università della Calabria
Università di Catania

Private Founding Members: strategic players for digital transformation

National Institutions

INFN Istituto Nazionale di Fisica Nucleare
CINECA
ENEA
Consiglio Nazionale delle Ricerche
INGV
Consortium GARR
INAF Istituto Nazionale di Astrofisica

eni
LEONARDO
Terna Driving Energy
sogei
autostrade per l'italia
ENGINEERING The Digital Transformation Company
FINCANTIERI
HUMANITAS Research Hospital
UPMC Life Changing Medicine
Thales Alenia Space (a Thales / Leonardo company)
Ferrovie dello Stato Italiane
UnipolSai Assicurazioni
INTESA SANPAOLO

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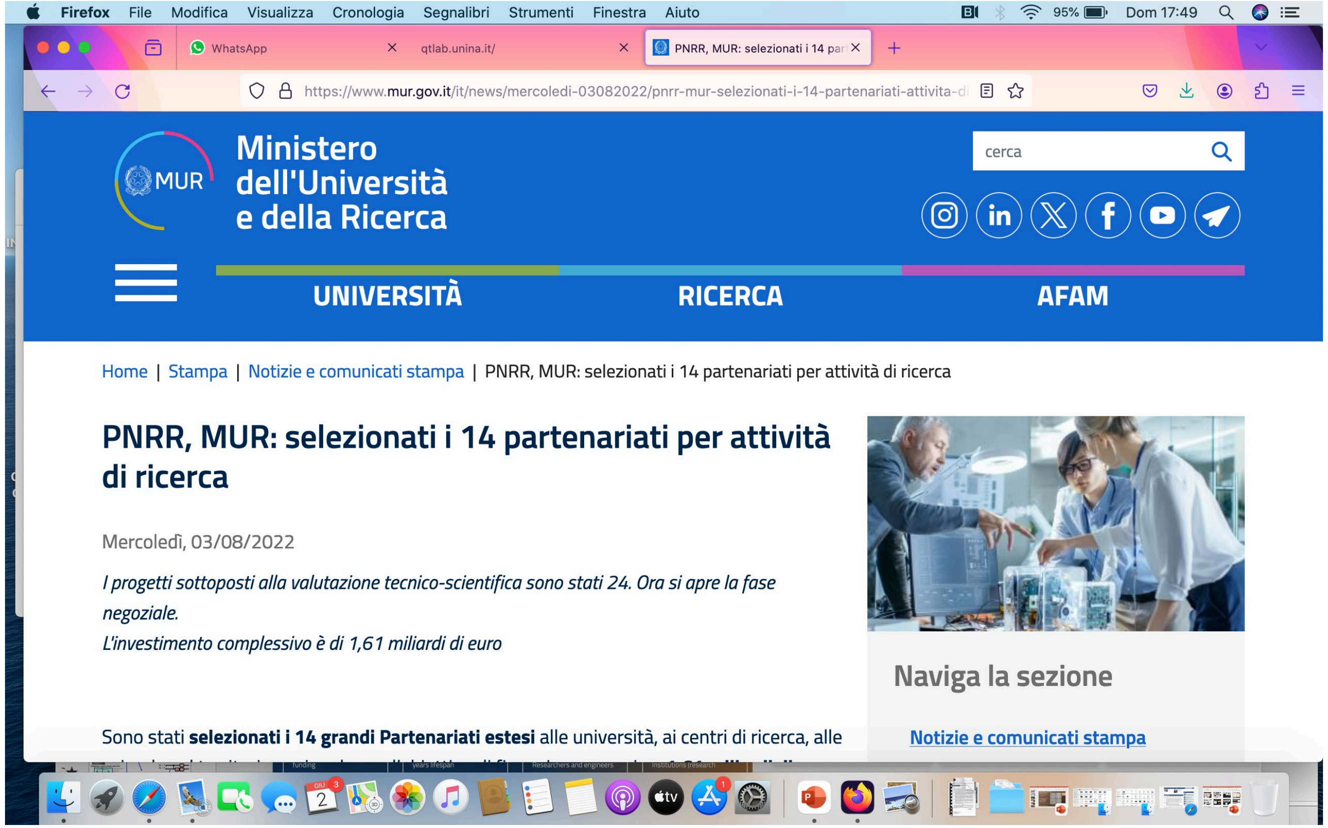
Tematica	Titolo	Proponente	Totale
1. Intelligenza artificiale: aspetti fondazionali	*Future Artificial Intelligence Research (hereafter FAIR)*	Consiglio Nazionale delle Ricerche - CNR	118
2. Scenari energetici del futuro	*NEST - Network 4 Energy Sustainable Transition*	BARI - Politecnico	122
3. Rischi ambientali, naturali e antropici	*RETURN*	NAPOLI - Federico II	124
4. Scienze e tecnologie quantistiche	*National Quantum Science and Technology Institute (NQSTI)*	CAMERINO - Università degli Studi	138
5. Cultura umanistica e patrimonio culturale come laboratori di innovazione e creatività	*CHANGES*	ROMA - Sapienza	134
6. Diagnostica e terapie innovative nella medicina di precisione	*HEAL ITALIA*	PALERMO - Università degli Studi	121
7. Cybersecurity, nuove tecnologie e tutela dei diritti	*SEcurity and RIghts in the CyberSpace (SERICS)*	SALERNO - Università degli Studi	120
8. Conseguenze e sfide dell'invecchiamento	*Age-It*	FIRENZE - Università degli Studi	125
9. Sostenibilità economico-finanziaria dei sistemi e dei territori	*GRINS – Growing Resilient, INclusive and Sustainable*	BOLOGNA - Università degli Studi	129
10. Modelli per un'alimentazione sostenibile	*ON Foods - Research and innovation network on food and nutrition Sustainability, Safety and Security – Working ON Foods*	PARMA - Università degli Studi	126
11. Made-in-Italy circolare e sostenibile	*3A-ITALY*	MILANO - Politecnico	121
12. Neuroscienze e neurofarmacologia	*A multiscale integrated approach to the study of the nervous system in healt and disease*	GENOVA - Università degli Studi	123
13. Malattie infettive emergenti	*One Health Basic and Translational Research Actions addressing Unmet Needs on Emerging Infectious Diseases*	PAVIA - Università degli Studi	106
14. Telecomunicazioni del futuro	*RESearch and innovation on future Telecommunications systems and networks, to make Italy more smART*	ROMA - Tor Vergata	135



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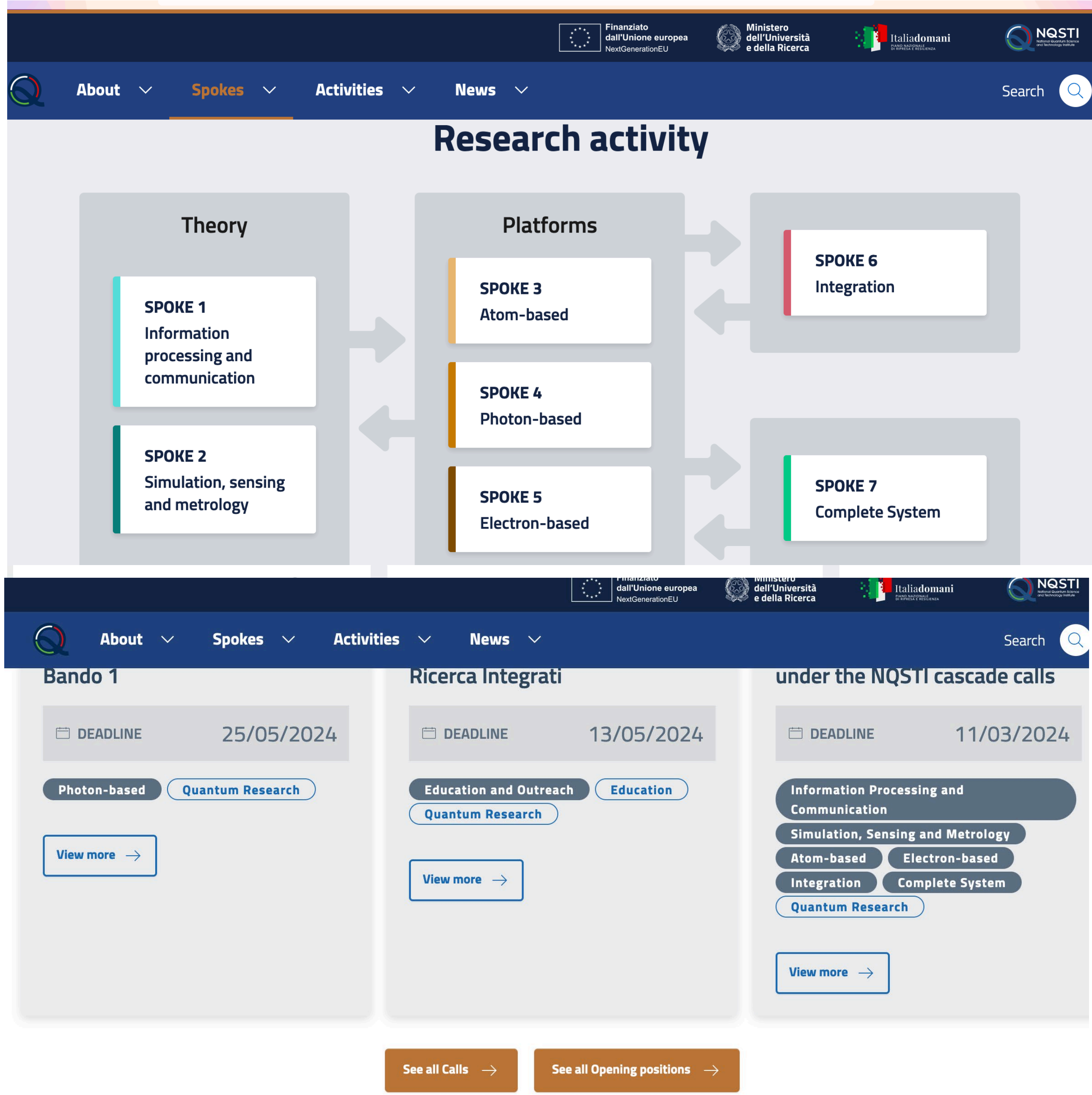

Main goals of the Spoke 10 of the ICSC center:

- creation of applications that use quantum calculators as accelerators to solve otherwise unresolvable problems;
- development of hardware and software tools that facilitate the planning of quantum calculators and their operational compatibility with traditional calculators;
- planning large and scalable quantum computers.

WP10.1. Software (Leader: INFN).
Development and application of high-level quantum software for algorithms solving general purpose problems, scientific and industrial applications.

- T1.1 New algorithms (Pavia, Bologna, IIT, Catania, CINECA, CNR, Pisa, Sapienza, Bari, PoliMI, Padova);
- T1.2 Applications and use cases (IIT, Bologna, CINECA, CNR, INAF, INFN, Pavia, Pisa, Bari, Bicocca, PoliMI, Padova)

WP10.2. Mapping, compilation and quantum computing emulation (Leader: CINECA).
Development of software toolchain for compilation, benchmarking, verification, emulation of quantum computers and algorithms.

- T2.1 Mapping and compilation (Bologna, CNR, Pisa, PoliMI);
- T2.2 Emulation (CINECA, INAF, Bari, Padova)

WP10.3. Firmware and hardware platforms (Leaders: CNR, Catania).
Development of low-level software for the physical operation of quantum computers. Development and support of the quantum computer hardware chain.

- T3.1 Photonic hardware (Sapienza, CNR, Bicocca, Pavia, Napoli);
- T3.2 Superconducting circuits (Napoli, INFN, Bicocca, CNR, Catania, Pisa);
- T3.3 Atomic hardware (CNR, Padova, Pisa);
- T3.4 Models and firmware (Catania, PoliMI, Bari, Padova, Bicocca, CNR, Pisa, Sapienza)

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing
1224 • 2024 Università degli Studi di Napoli Federico II

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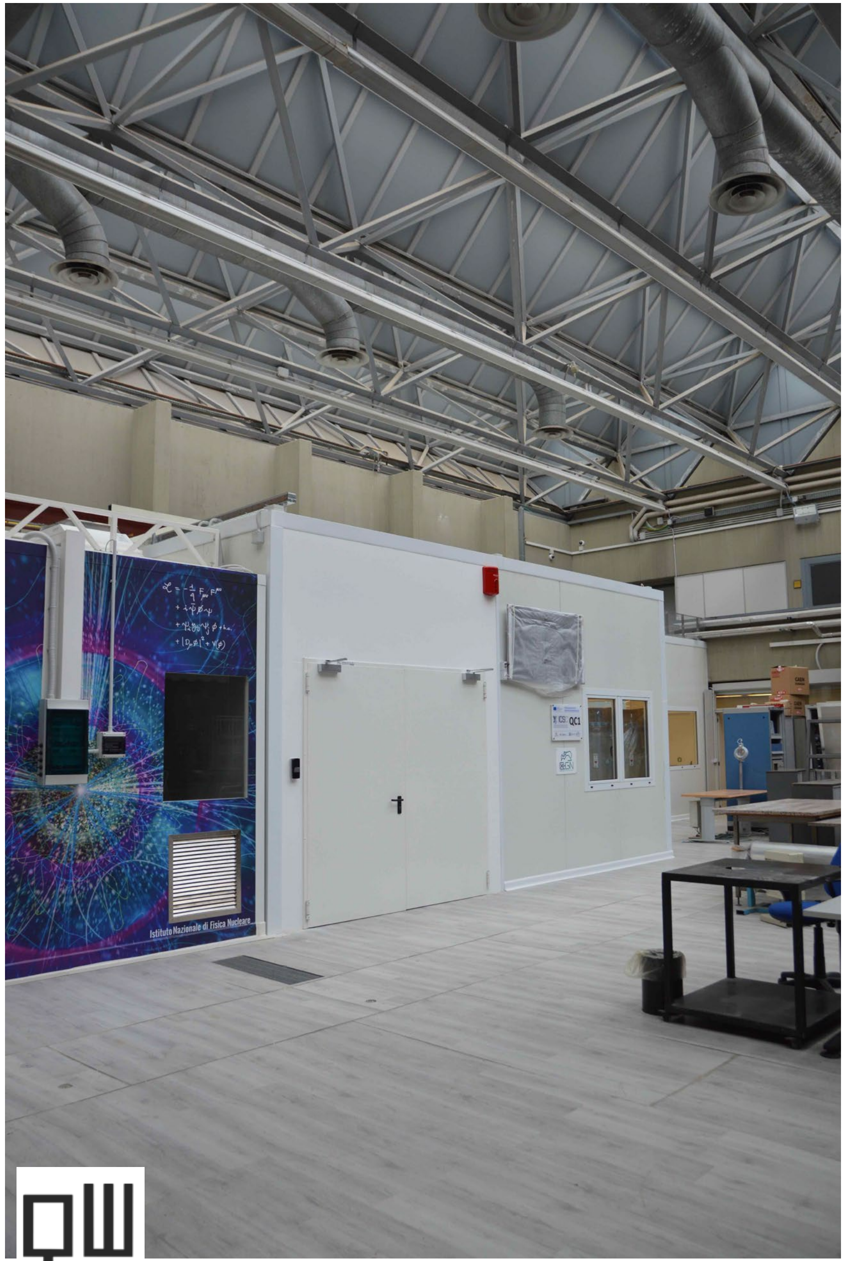
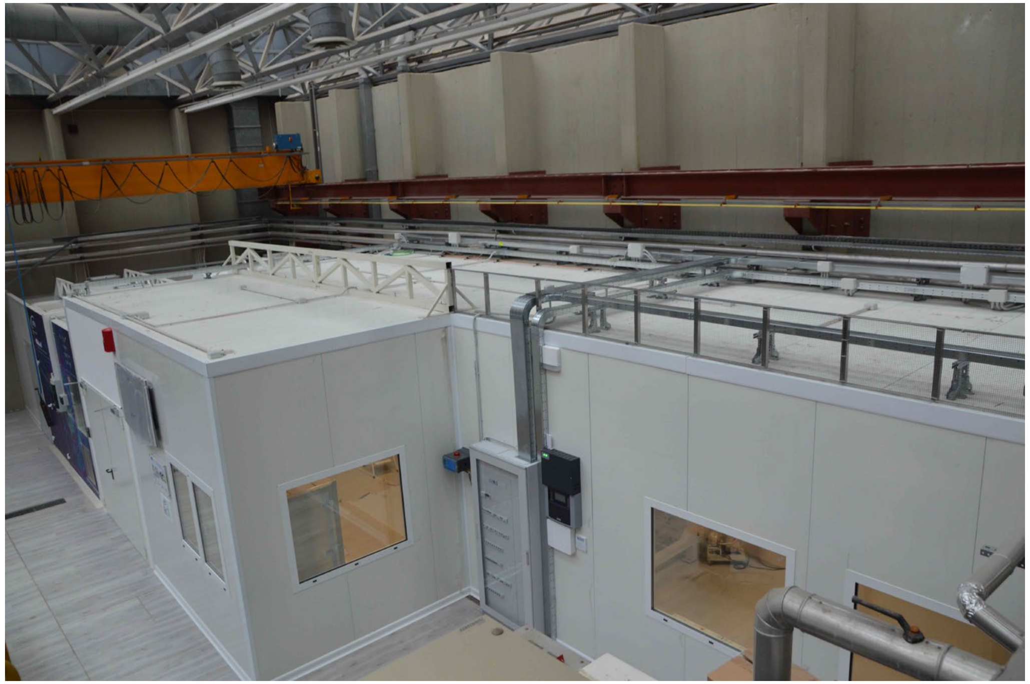
- creation of applications that use quantum calculators as accelerators to solve otherwise unresolvable problems;
- development of hardware and software tools that facilitate the planning of quantum calculators and their operational compatibility with traditional calculators;
- planning large and scalable quantum computers.

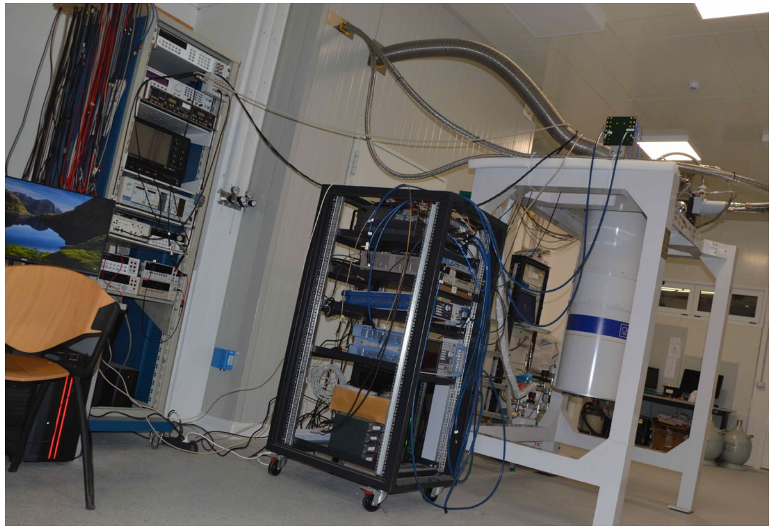
Milestones

- M9-M15: First Tender for Research Infrastructure
- M9-M15. Research activities on Software, Mapping, Compilation, Emulation, Firmware and Hardware at the end of Year 1: Design of quantum algorithms (SW); Classic emulator with 100+ qbits (MW); Report on architectural design of hardware platforms and tools (HW)
- M17-M22: Demonstrators: Use cases implementation and experimentation
- M17-M22: Second Tender for Research Infrastructure
- M22-M26: Research activities on Software, Mapping, Compilation, Emulation, Firmware and Hardware at the end of Year 2: Report on development and validation of quantum algorithms and applications (SW); Report on design of benchmarks for quantum computers and algorithms (MW); Report on design of quantum platforms (HW)
- M25-M36 Use cases: Report on use cases implementation and experimentation

- M25-M36 Research activities on Software, Mapping, Compilation, Emulation, Firmware and Hardware at the end of Year 3: Benchmarking quantum-accelerated applications against classical applications (SW); Test quantum supremacy in industrial setting (MW); Tools and methodologies for design automation and mapping (MW); One platform with 5+ qbits (HW); Photonic sampling machine with 5+ photons and 24+ modes (HW); Report on supporting tools for hardware platforms (HW)







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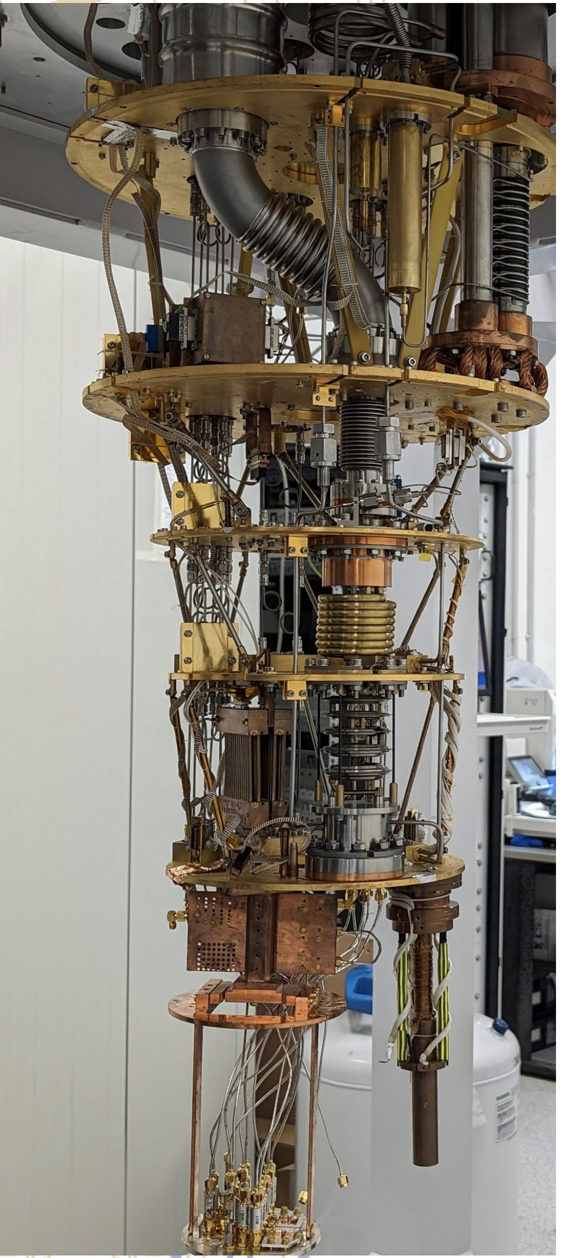

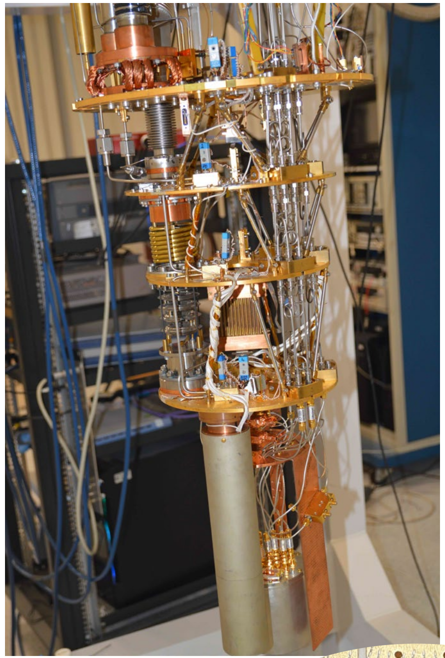

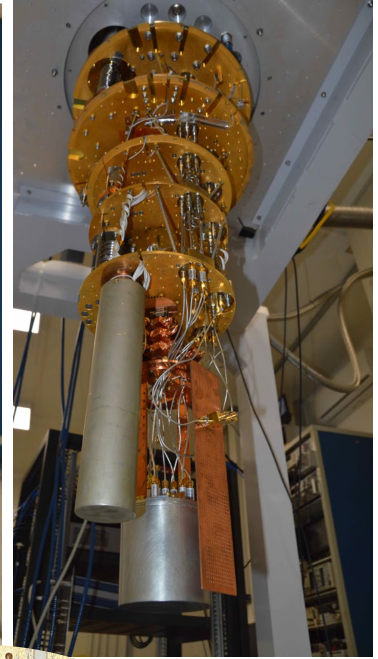

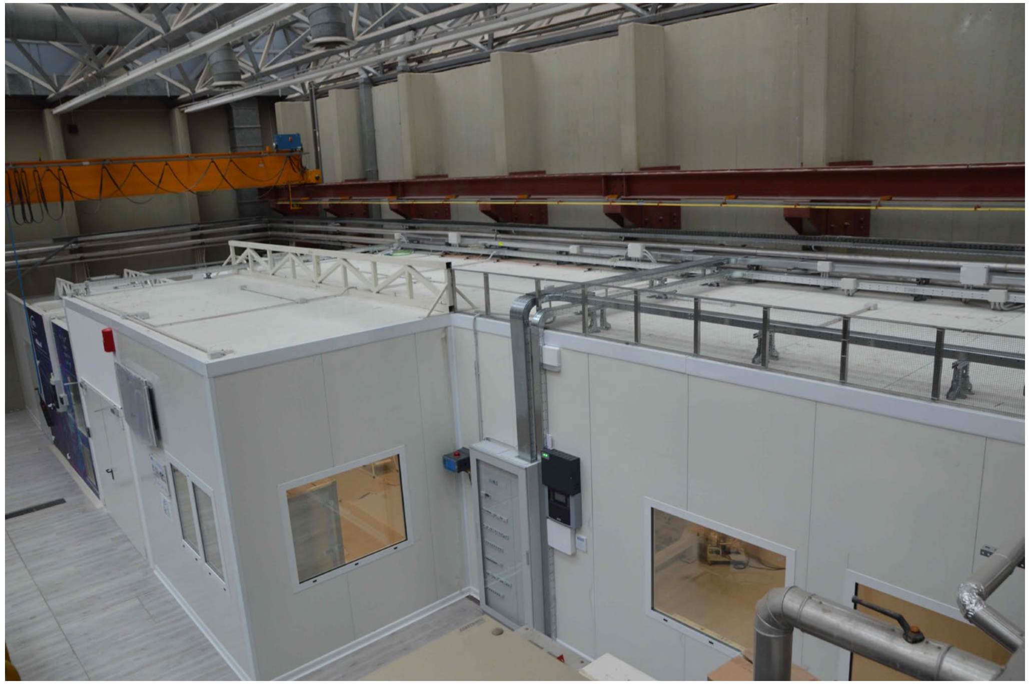

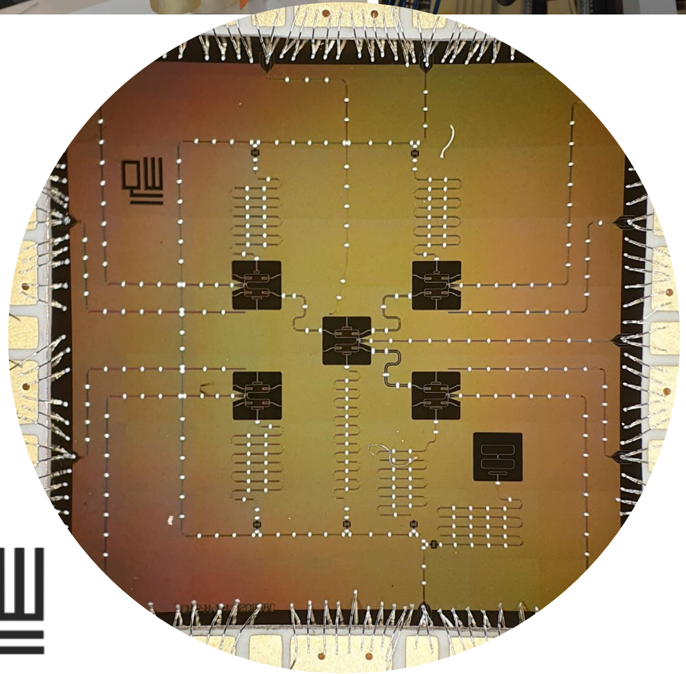

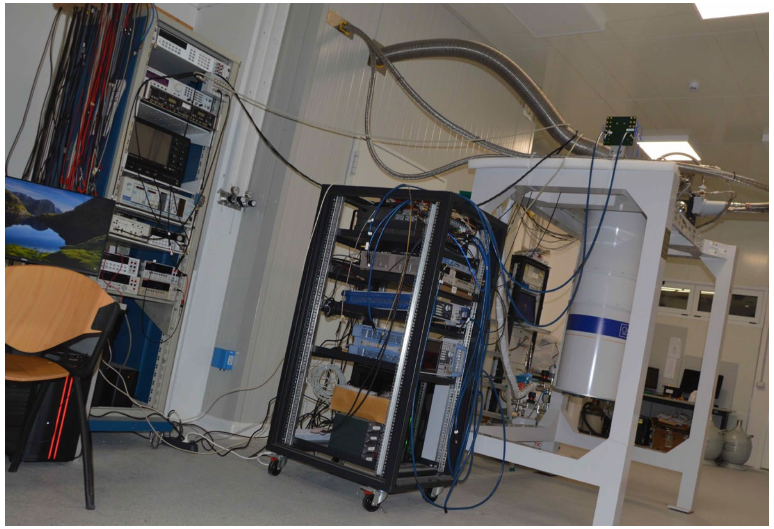

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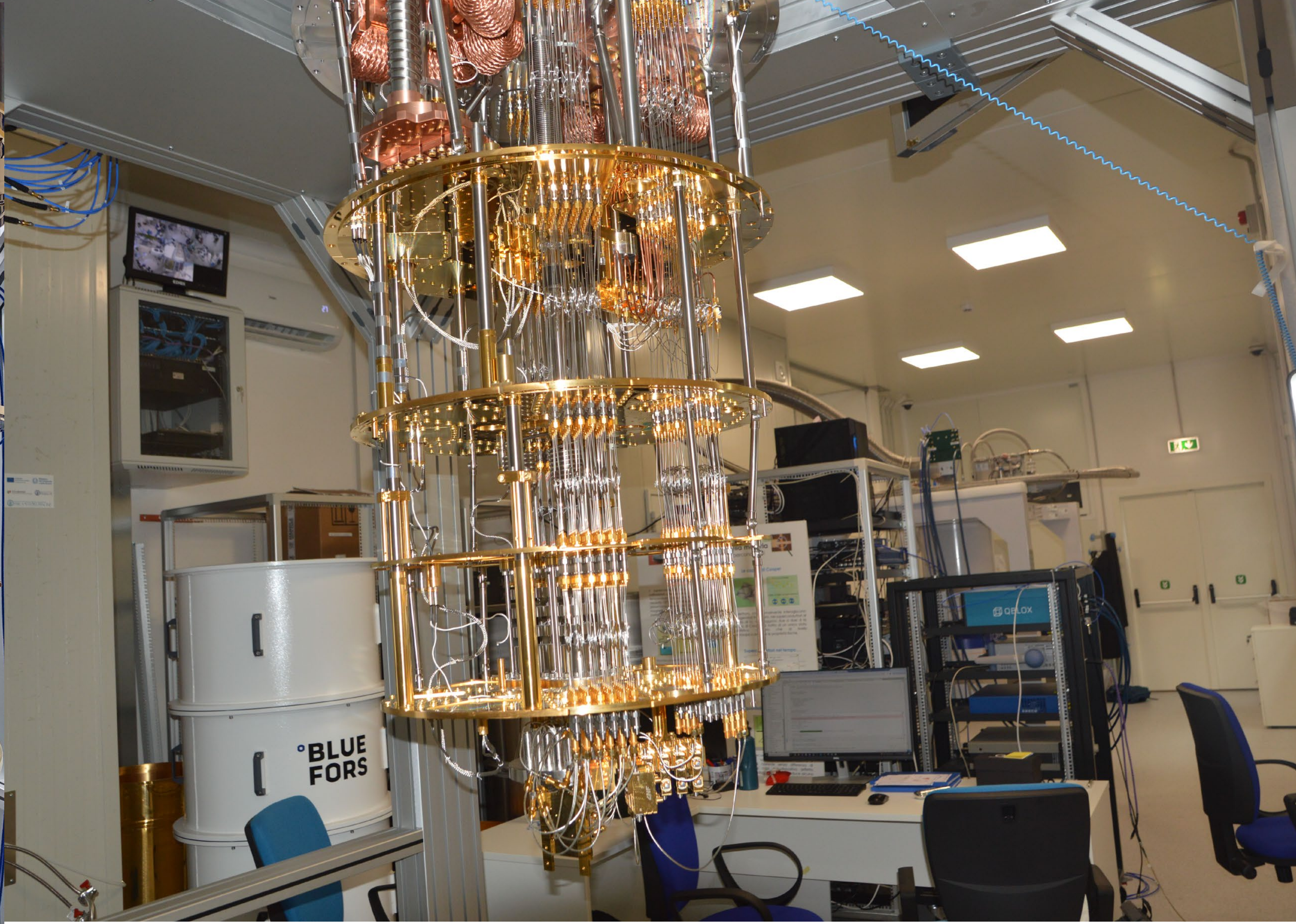

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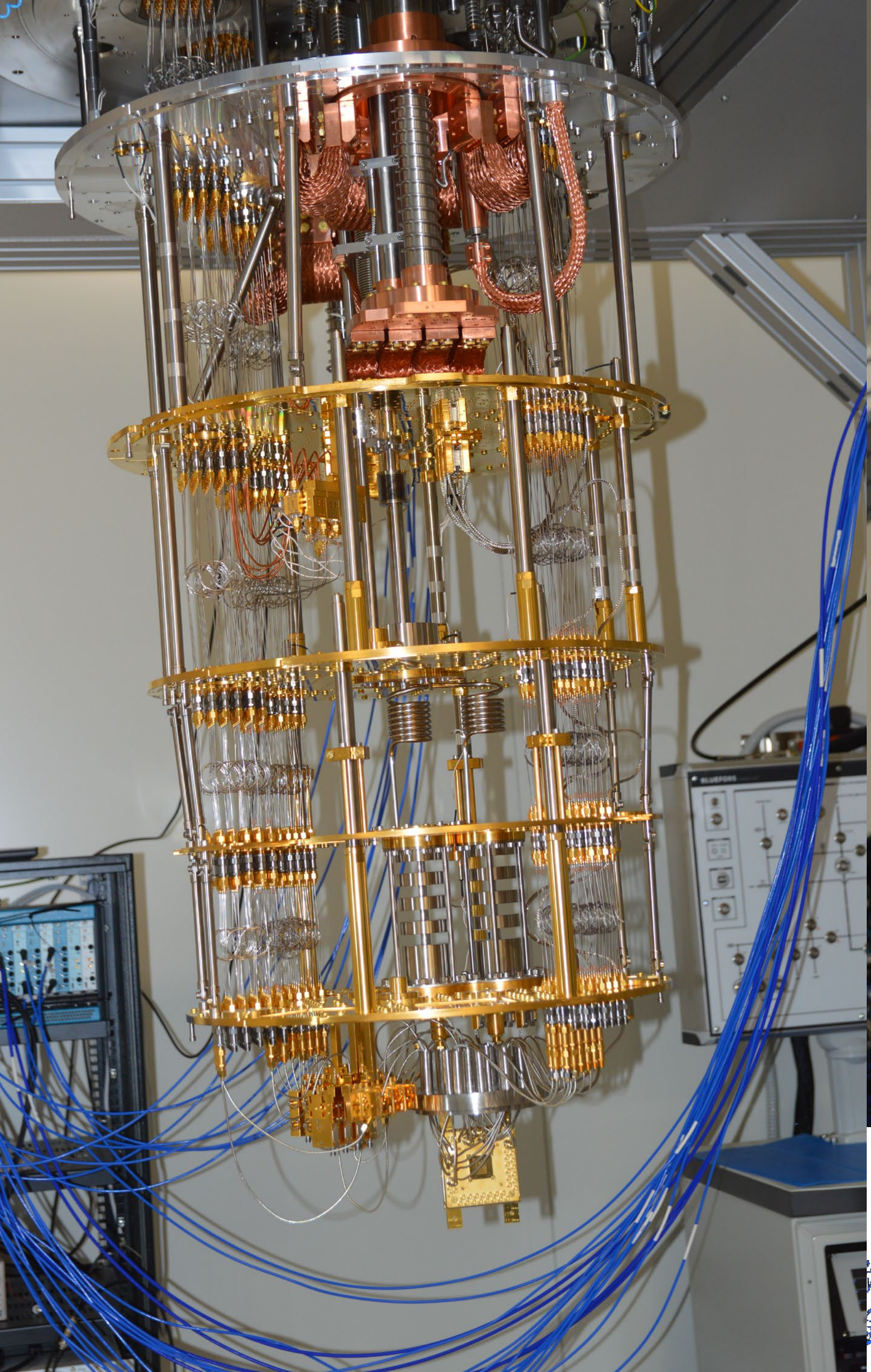

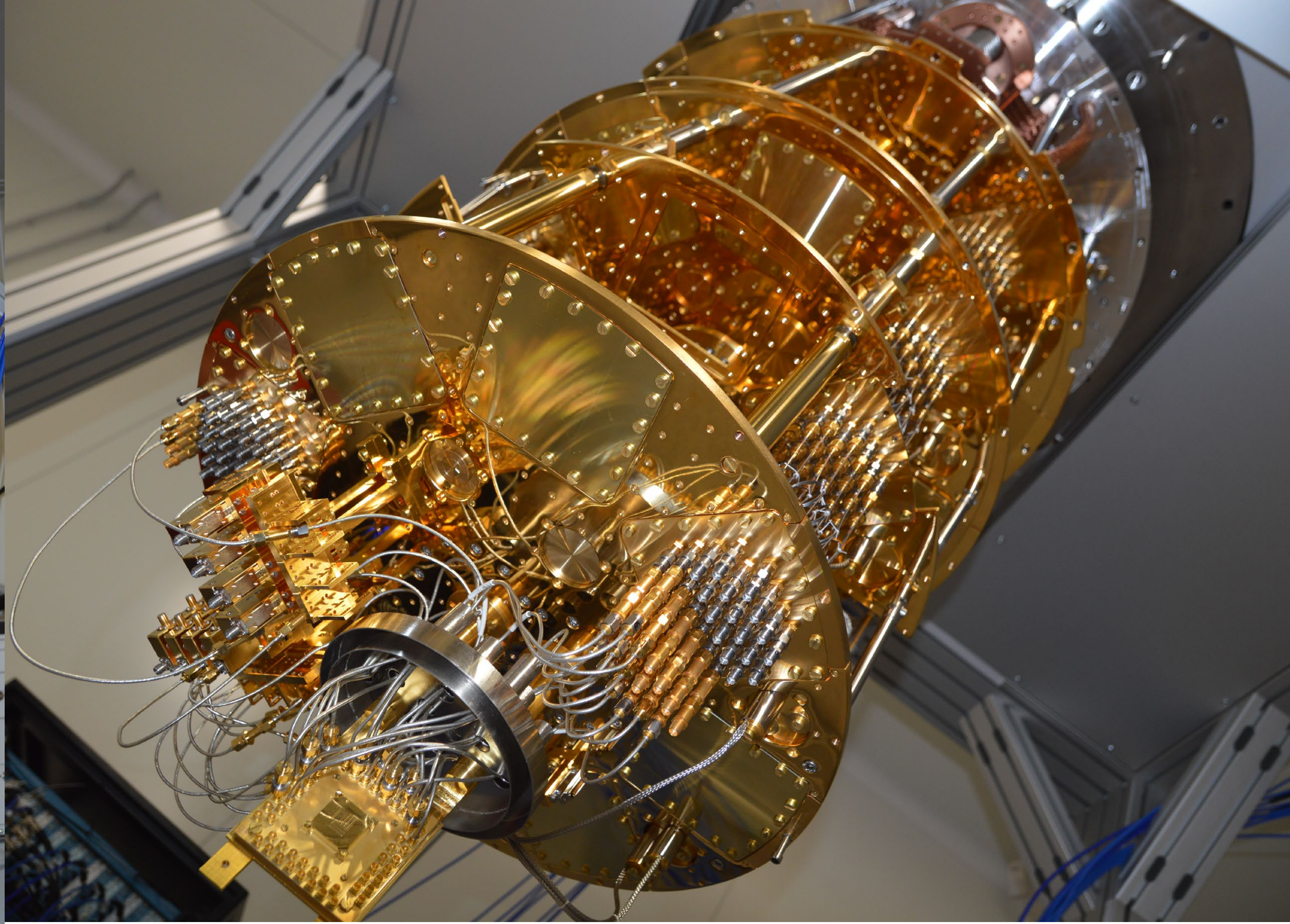

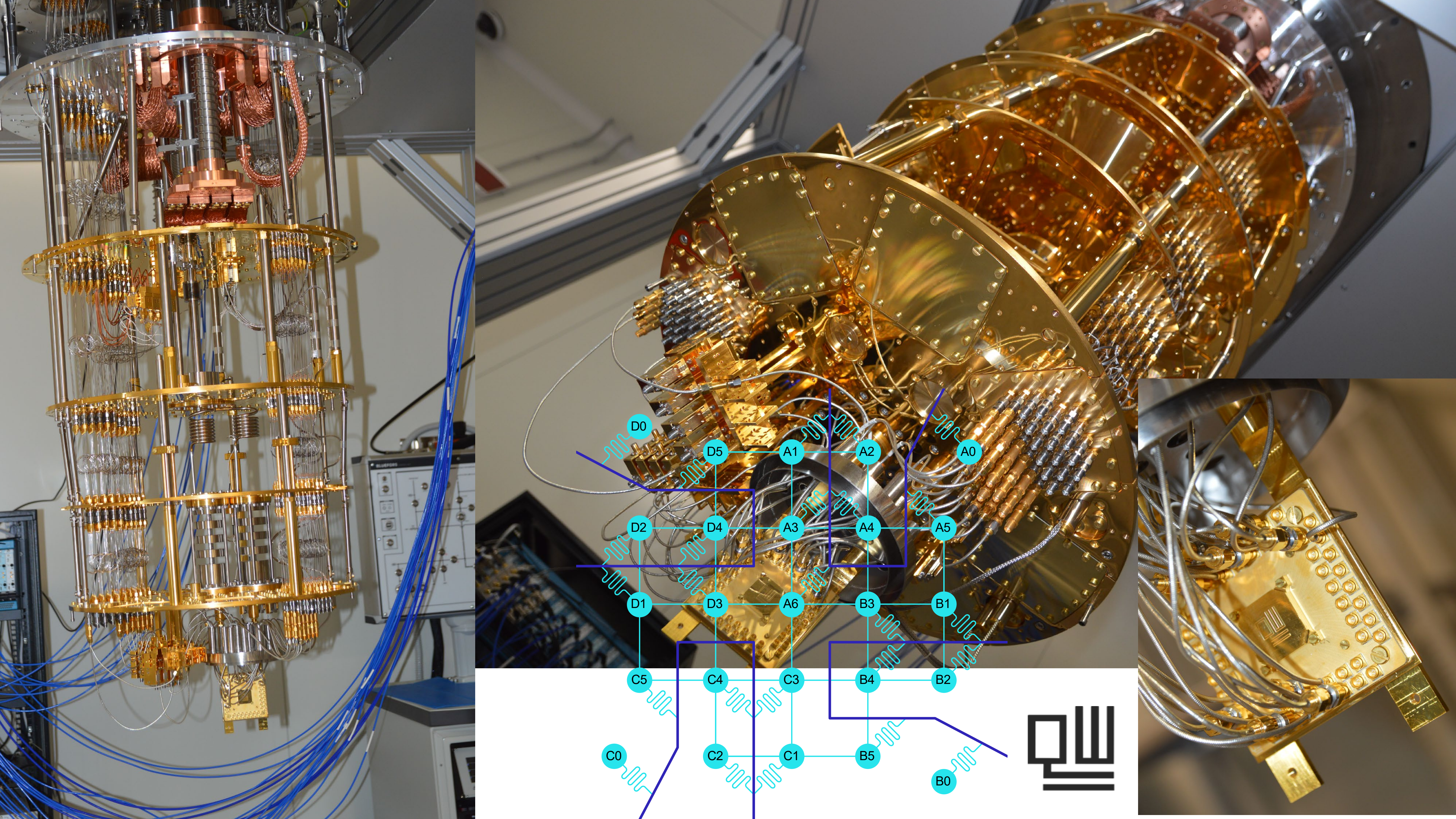
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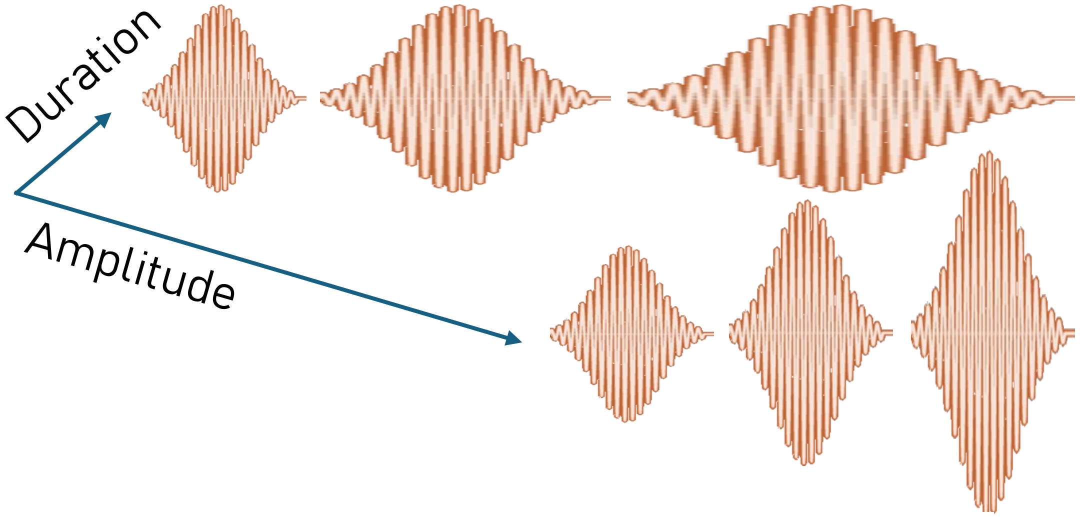
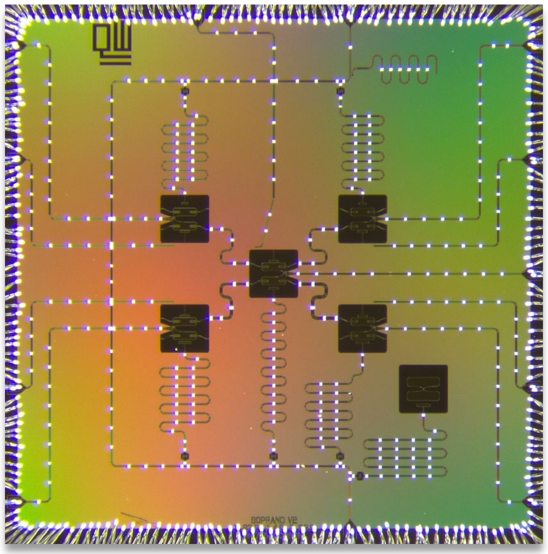
C4
C3
B4
B2
C0
C2
C1
B5
B0

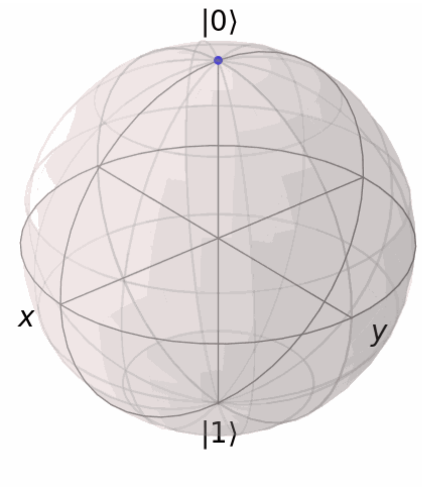
IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at WOLTE-16 2024, June 2024, Cagliari, Italy.

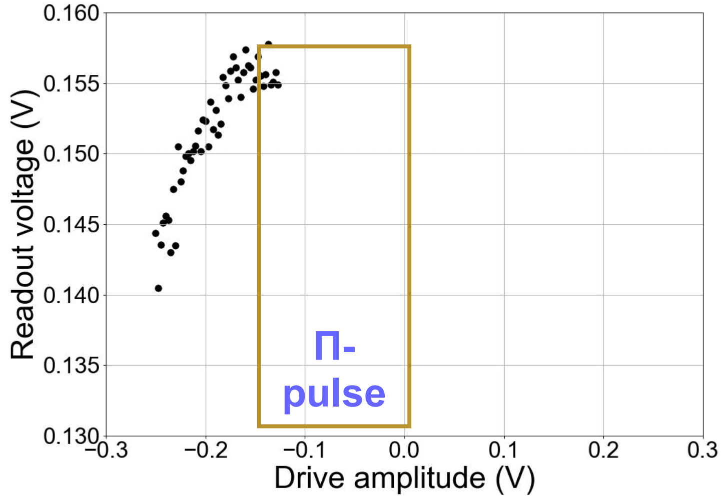
Hint of quantum coherent nature: Rabi oscillations

By continuosly changing the duration or amplitude of the control pulses, coherent oscillations between the $|0\rangle$ and $|1\rangle$ states of the qubit









We are moving coherently between the two states of the computational basis!

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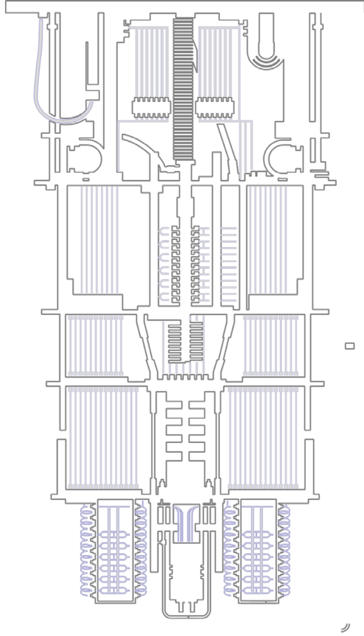
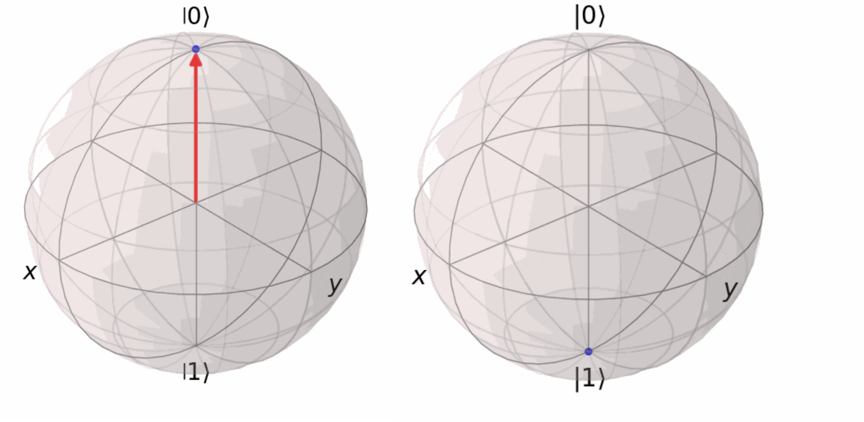
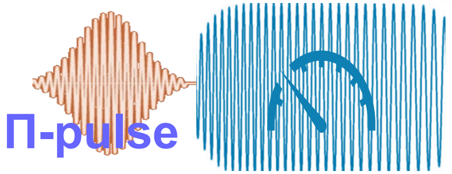
Note: the presentation slide contained animation

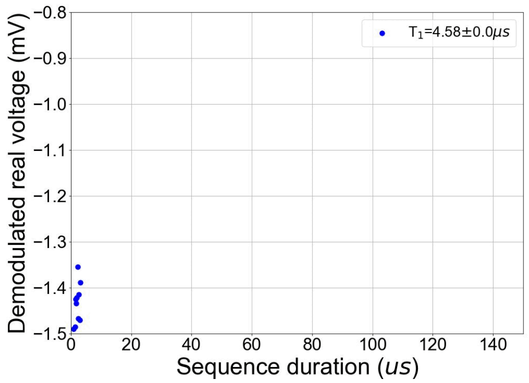
Coherence times and impact of noise



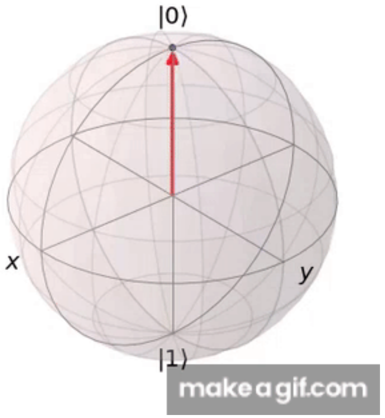
Relaxation time

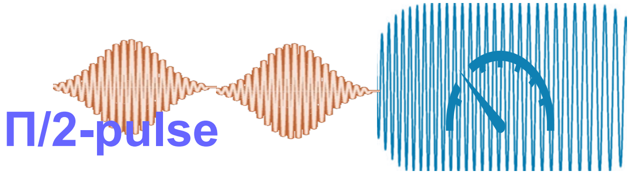


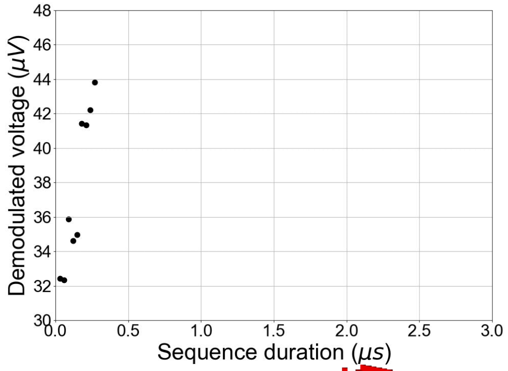




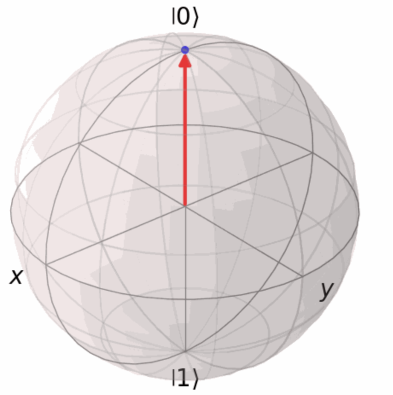
Ramsey coherence time

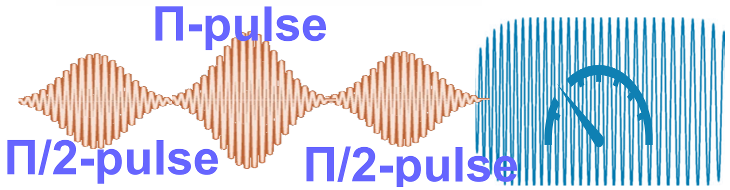


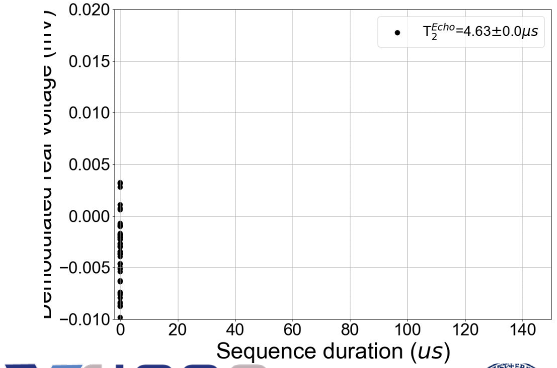




Echo coherence time







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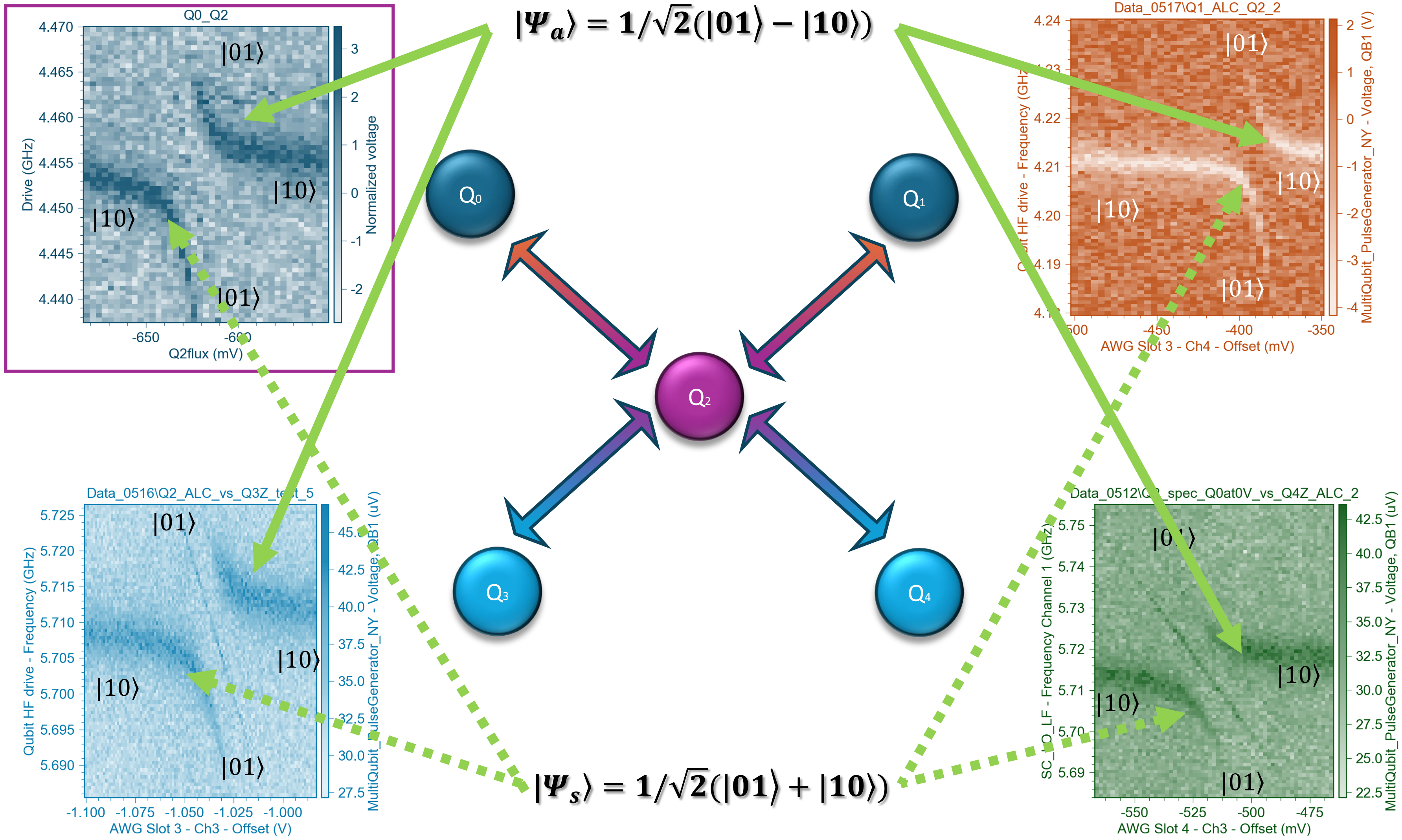
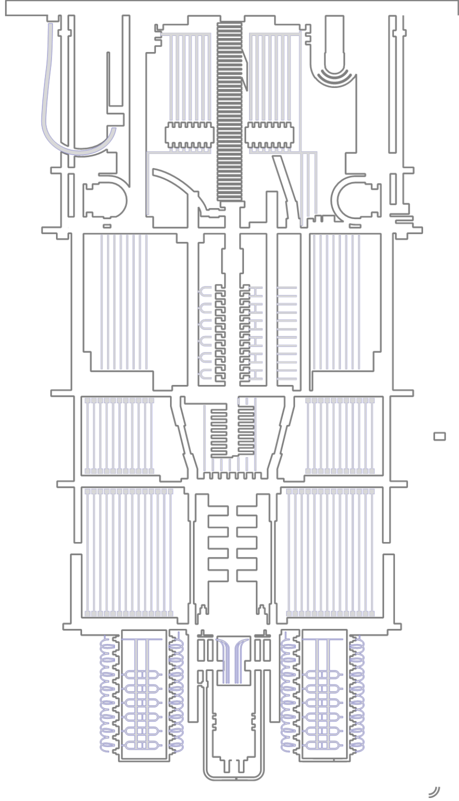
Note: the presentation slide contained animation

Systematic investigation on 2-qubits entanglement





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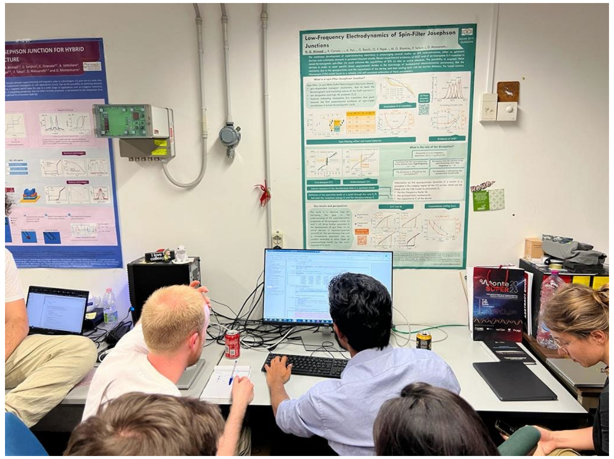
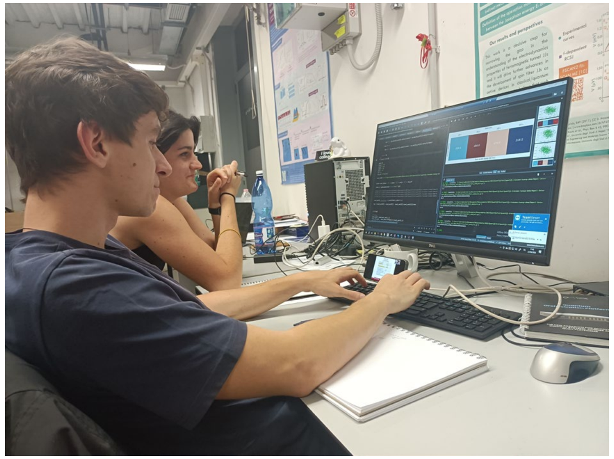
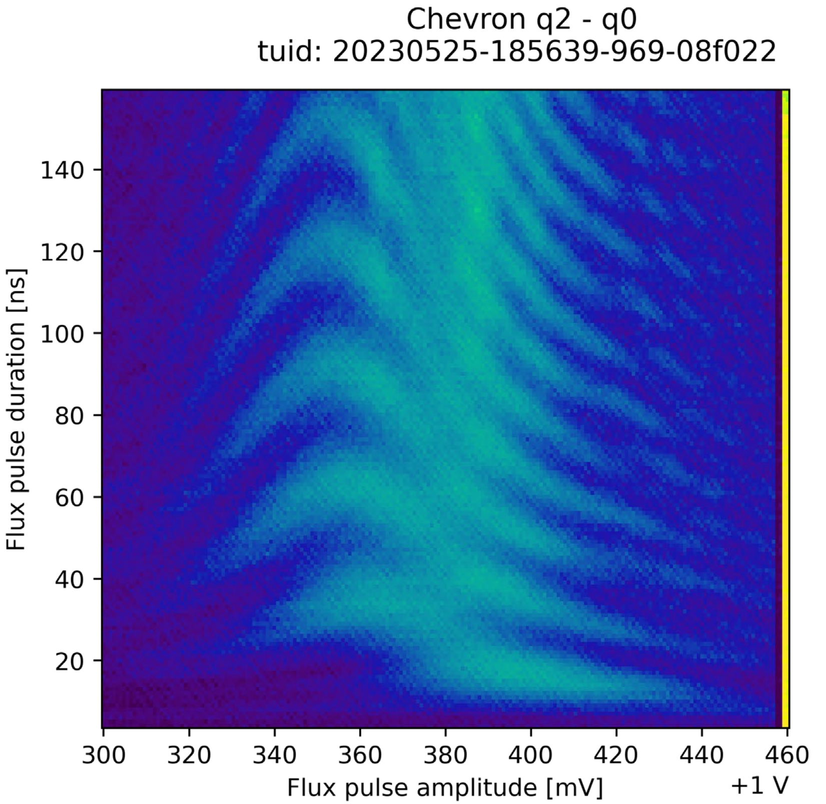
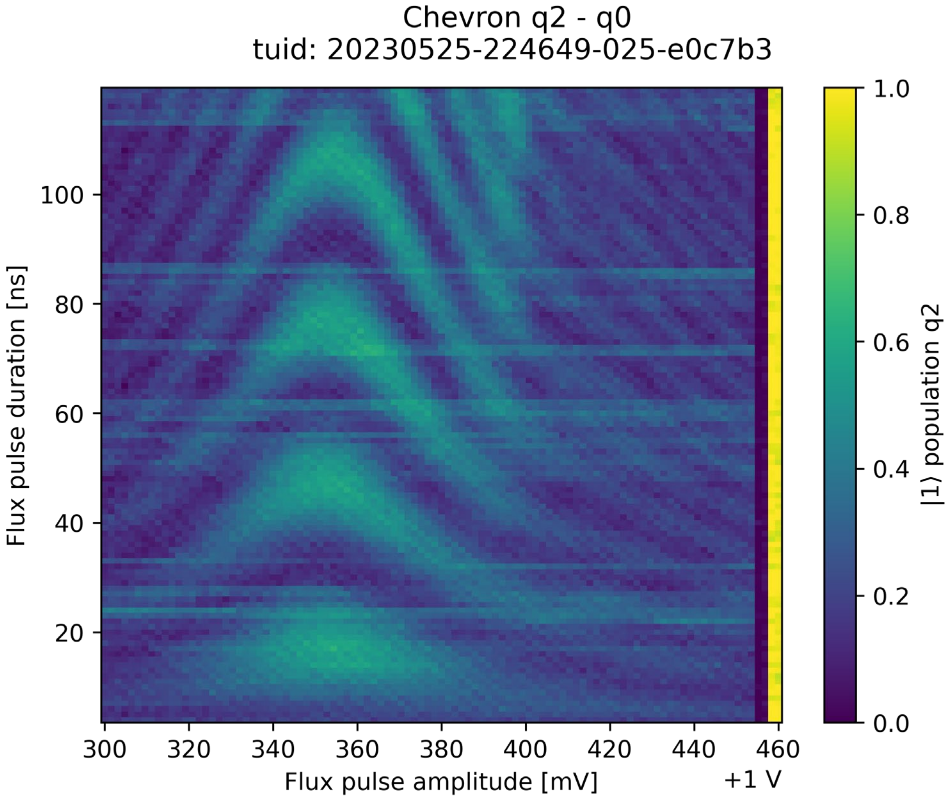
Controlled exchange of energy between two qubits: CZ gates optimization and calibration







Pre-calibration (distorted pattern)



After-calibration (symmetric pattern)

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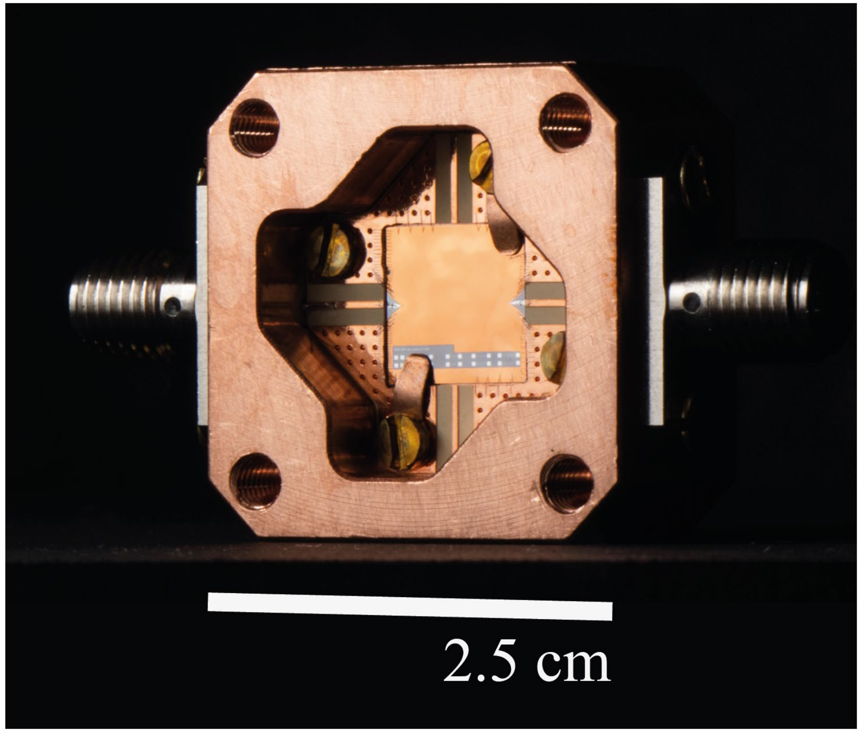
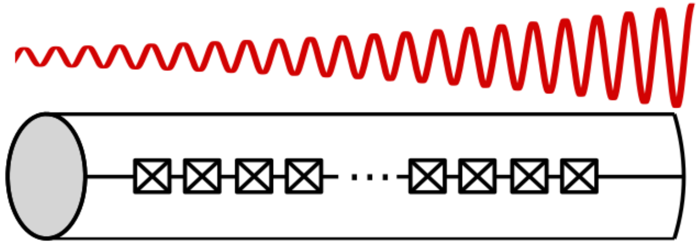
IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at WOLTE-16 2024, June 2024, Cagliari, Italy.

Improving readout fidelity: near-quantum limited noise travelling wave parametric cryogenic amplifiers (TWPA)

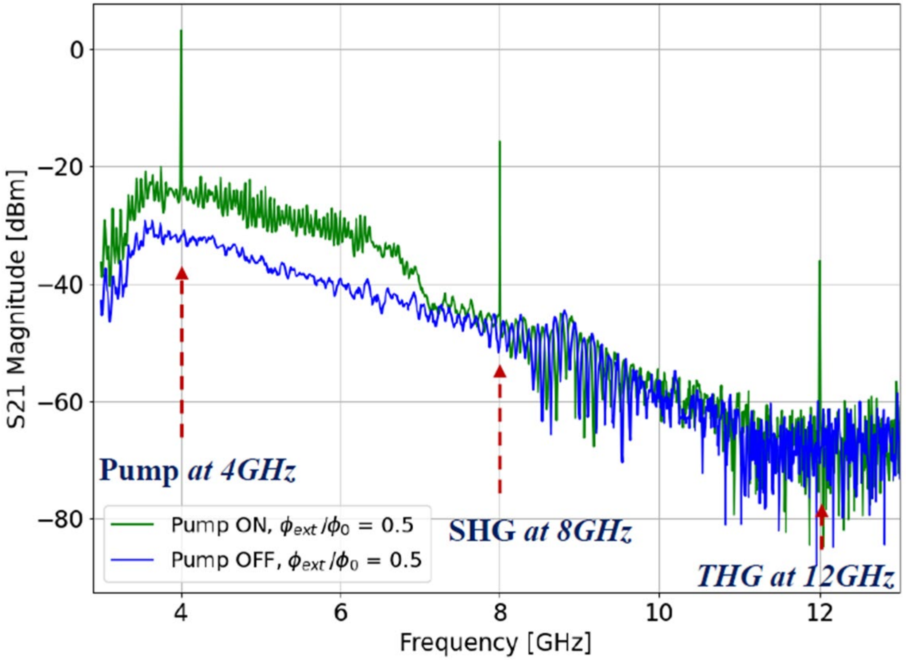


Leader: Martina Esposito, fabricated in collaboration with Nicolas Roch's Lab in Grenoble, France



Funded by the European Union

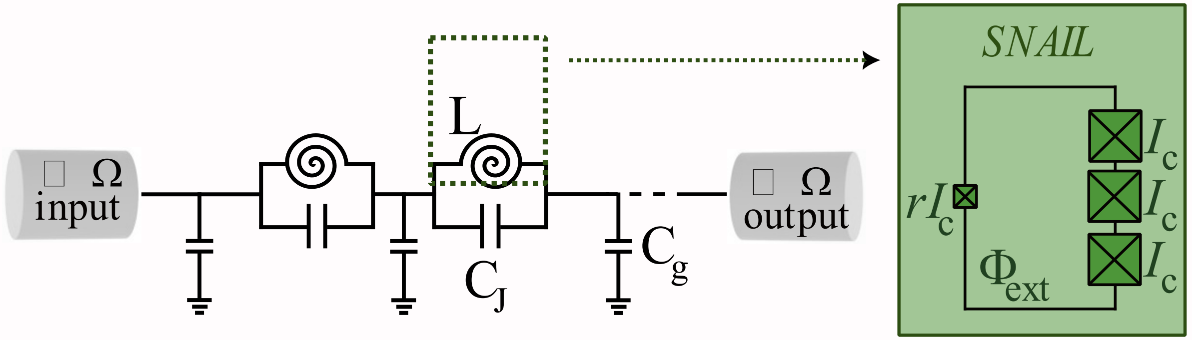
TruePA



Investigating pump harmonics generation in a SNAIL-based Traveling Wave Parametric Amplifier
A Yu. Levochkina, H G Ahmad, P. Mastrovito, I. Chantarjee, G Serpico, L Di Palma, R Ferroiudo, R Satariano, P. Darvehi, A Ranadive, G Cappelli, G Le Gal, L Planat, D Montemurro, D Massarotti, F. Tafuri, N Roch, G P. Pepe, and M Esposito, Arxive 2405.20096v1 (submitted

Investigating the generation of pump harmonics in a SNAIL-based Traveling Wave Parametric Amplifier

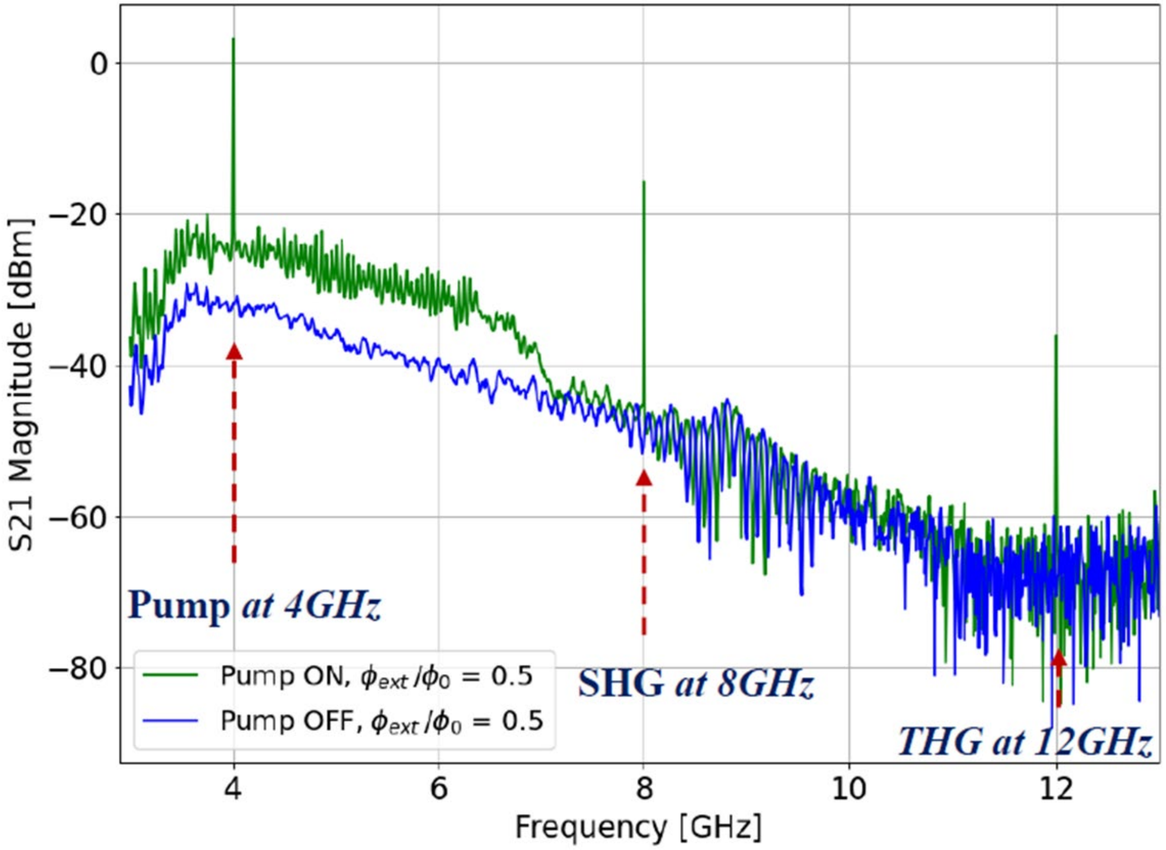
Thursday, June 6, 2024 @ 11.35



Fabricated in collaboration with Nicolas Roch's Lab in Grenoble, France

Anna Levochkina et al. , ArXive preprint (2024)

Supervisors G.P. Pepe and M. Esposito



Motivations:

Unveiling of generation spurious tones in TWPAs

Anna Levochkina

Isita Chattereje

Pegah Darvehi

TruePA

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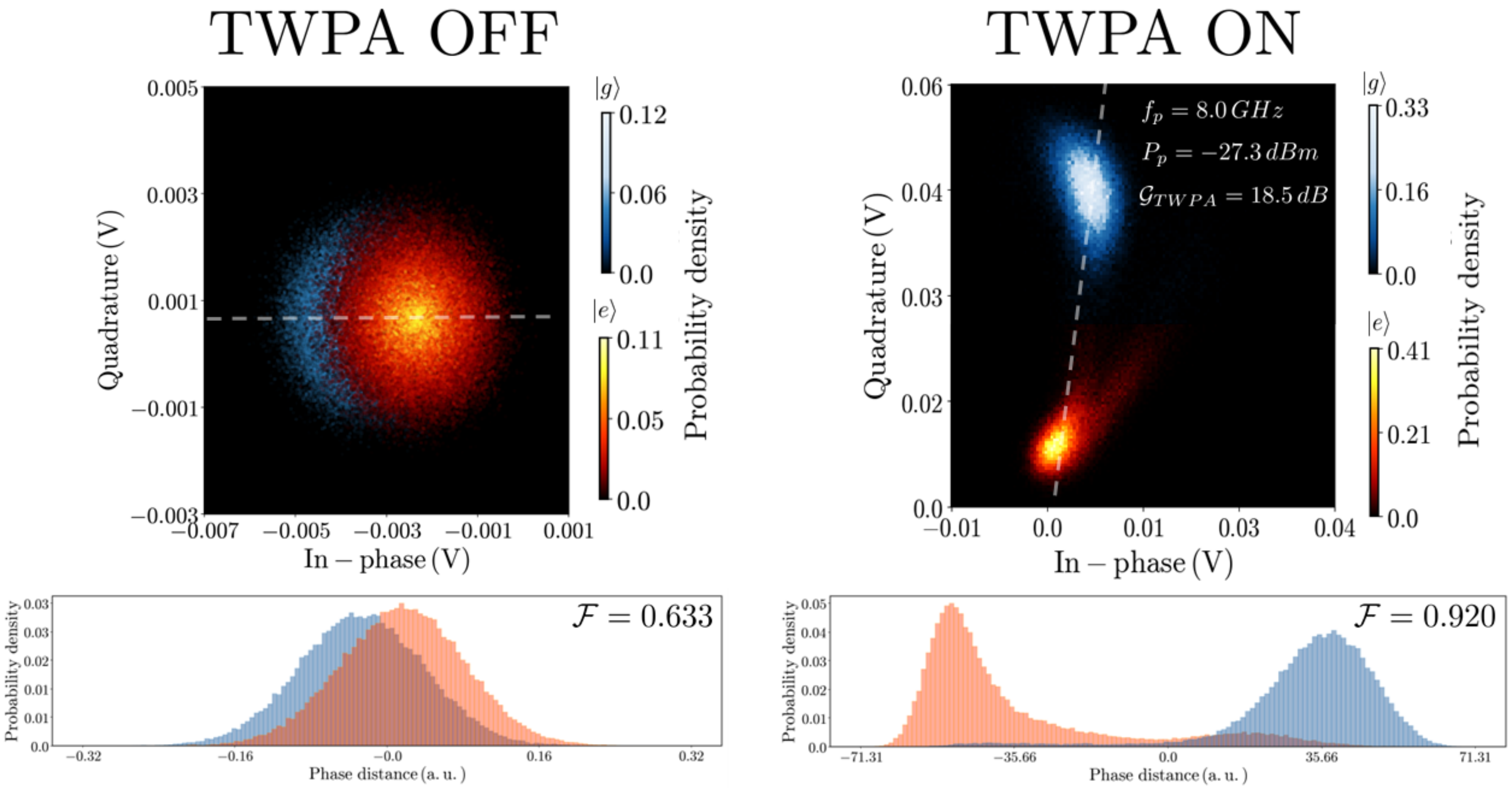
CNR SPIN

Funded by the European Union

Improving readout fidelity: near-quantum limited noise travelling wave parametric cryogenic amplifiers (TWPA)



Superlink project

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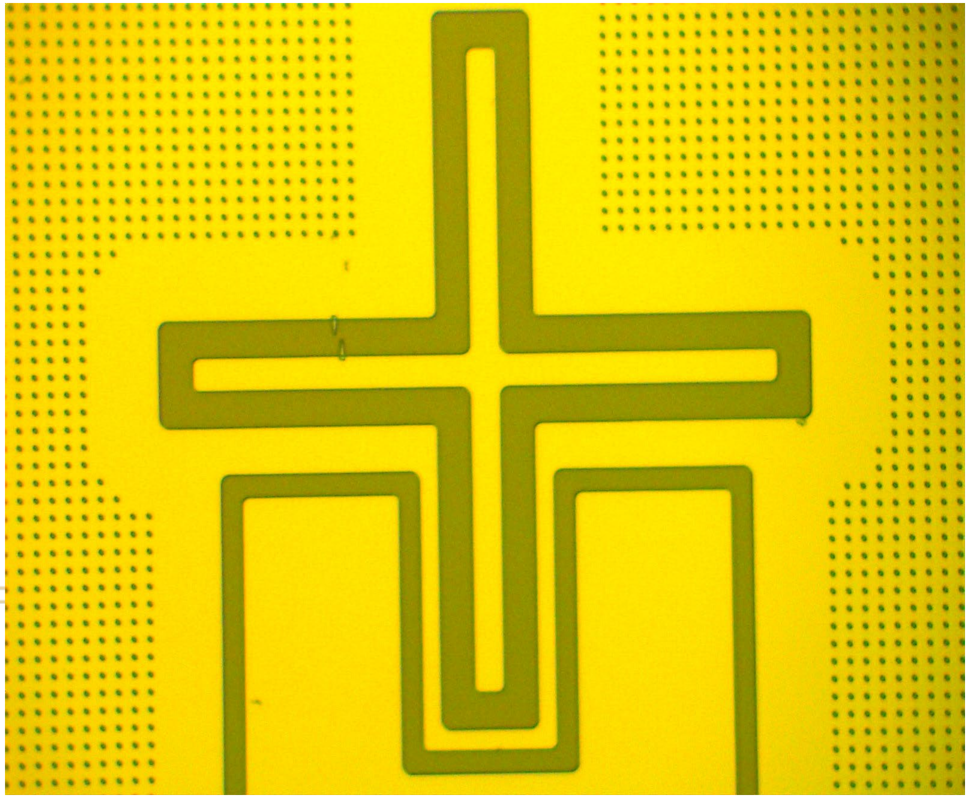
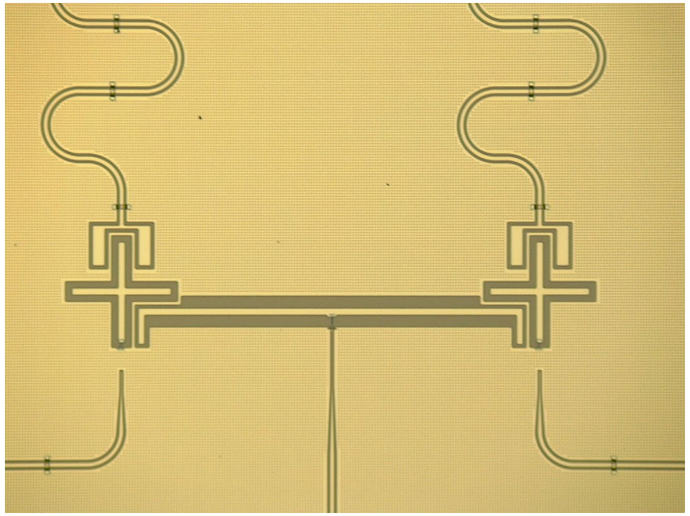
From single-qubits to multi-qubits architectures

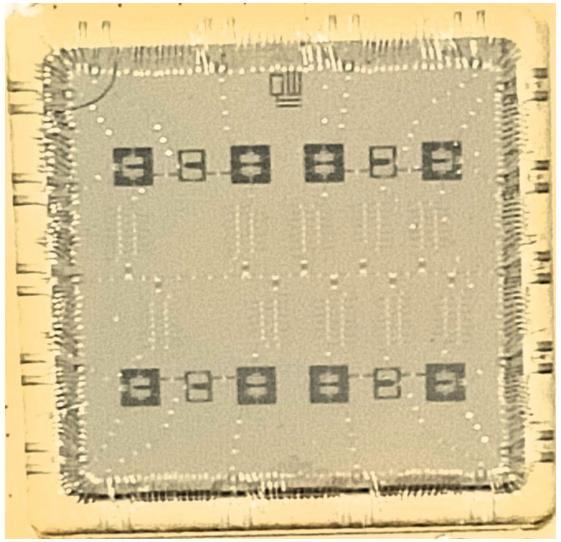


Design: Unina (Mastrovito P., Levochkina A.),
Fab: Chalmers University of Technology (Dr. Tancredi G.)

SuperLink QUANTERA



Superlink
Quantera Project



Eurostar SFQ4QPU

PARTNERS

Quantware, Seeqc-EU

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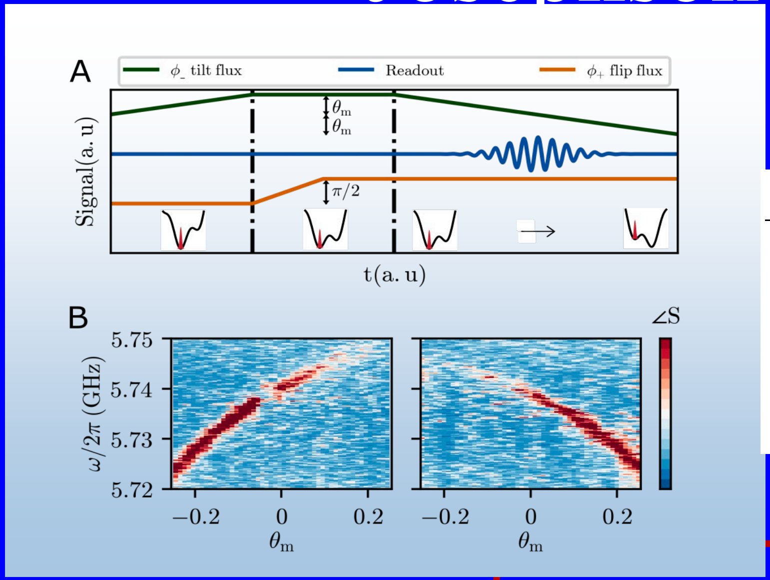
Josephson digital phase detector



PHYSICAL REVIEW APPLIED 19, 064025 (2023)

Discriminating the Phase of a Coherent Tone with a Flux-Switchable Superconducting Circuit

L. Di Palma,[1,2,*] A. Miano,[3] P. Mastrovito,[1] D. Massarotti,[4,5] M. Arzeo,[2] G.P. Pepe,[1] F. Tafuri,[1,6] and O. Mukhanov[7]

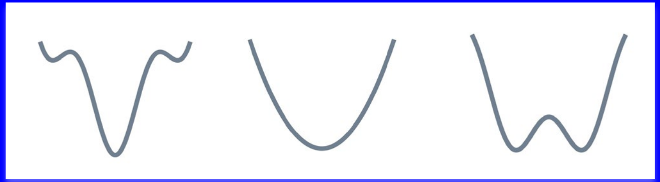
$$2E_j$$

$$U(\varphi) = \frac{E_l}{2}\varphi^2 - \frac{\Phi_0}{2\pi}\left[I_{c+}\cos(\phi_+)\cos(\varphi+\phi_-) + I_{c-}\sin(\phi_+)\sin(\varphi+\phi_-)\right]$$

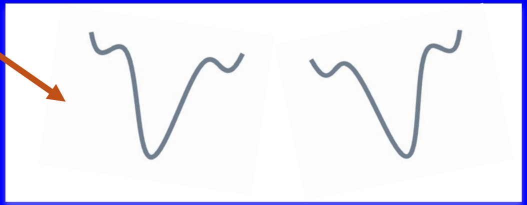
Two degrees of freedom given by Φ_1 and Φ_2

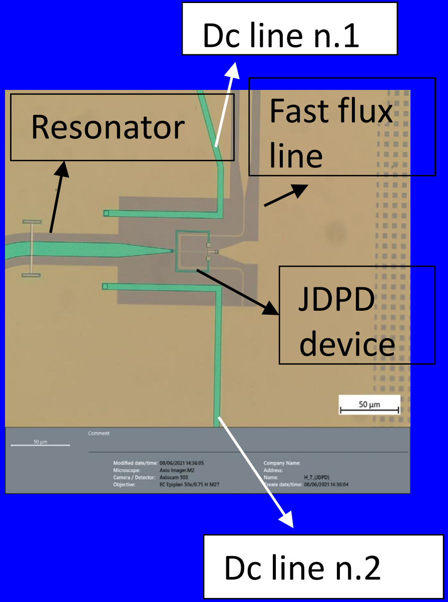
$$\Phi_+ = \Phi_1 + \Phi_2$$
$$\Phi_- = \Phi_1 - \Phi_2$$

Modifies the potential shape



Provides the tilt





Talk by Luigi Di Palma

Implementation of a hybrid classical/quantum algorithm for Quantum Error Mitigation on a 5-qubit superconducting device

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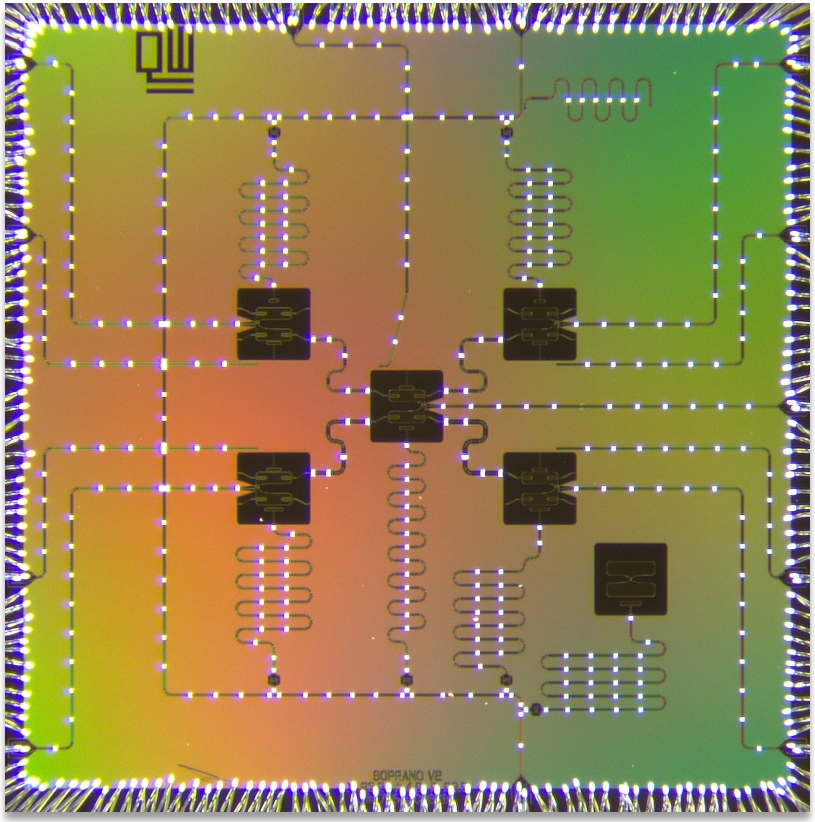
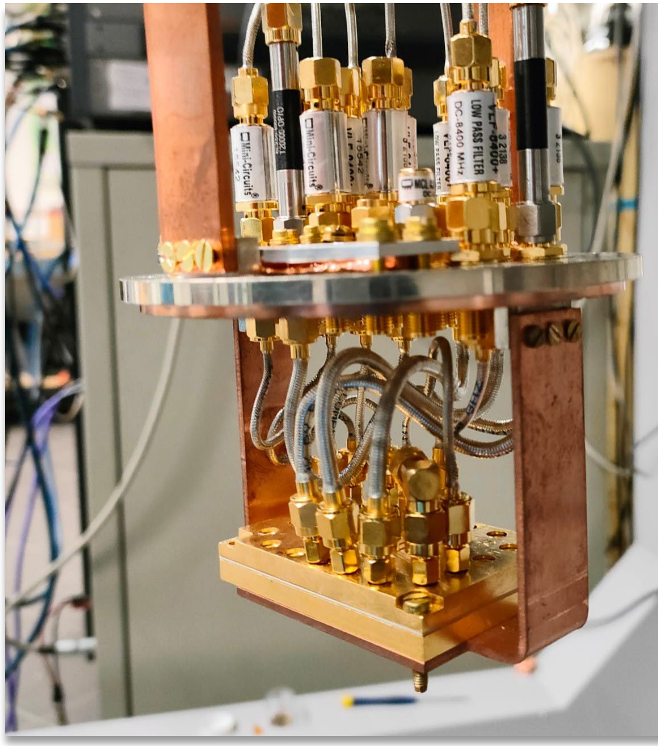


Courtesy of Quantware

MITIGATING ERRORS ON SUPERCONDUCTING QUANTUM PROCESSORS THROUGH FUZZY CLUSTERING

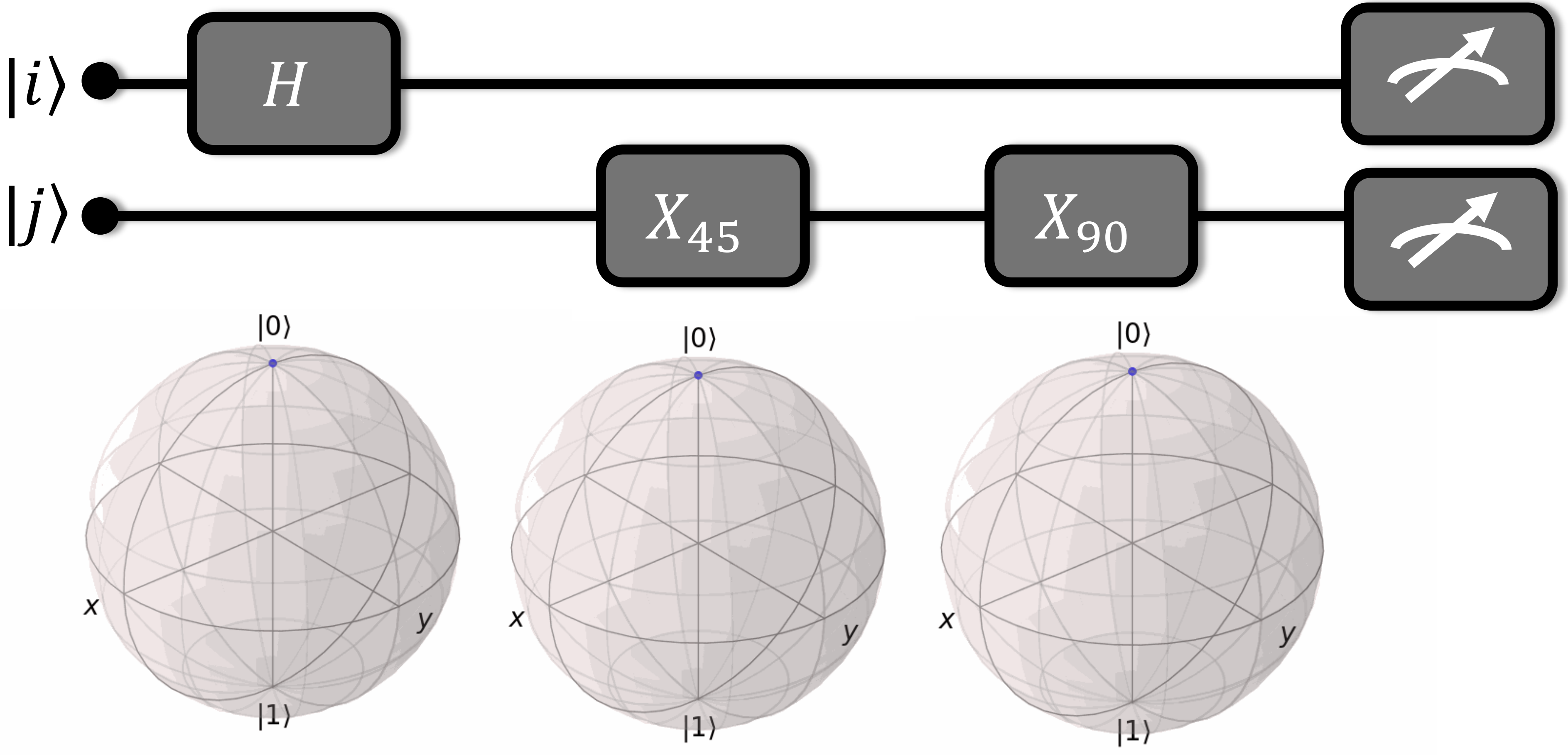
H. Ahmad, R. Schiattarella, P. Mastrovito, A. Chiatto, A. Levochkina, M. Esposito, D. Montemurro, G.P. Pepe, A. Bruno, F. Tafuri, A. Vitiello, G. Acampora & D. Massarotti, Advanced Quantum Technologies (2024)



IQuantum Error Mitigation technique that uses Fuzzy C-Means (FCM) clustering to specifically identify measurement error patterns: proof-of-principle validation of the technique on a 2-qubit register, obtained as a subset of a real NISQ 5-qubit superconducting quantum processor based on transmon qubits. We demonstrate that the FCM-based QEM technique allows for reasonable improvement of the expectation values of single- and two-qubit gates-based quantum circuits,

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at WOLTE-16 2024, June 2024, Cagliari, Italy.

Running random single- and two-qubit quantum circuits & algorithms



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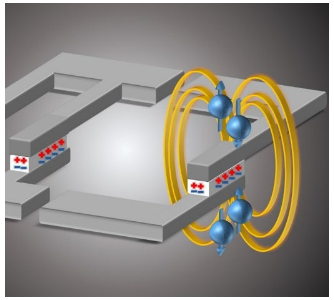
Note: the presentation slide contained animation

Currently running

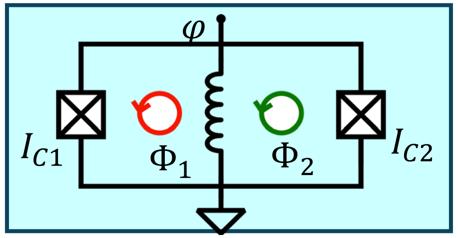
Hardware

Transmon qubit based on ferromagnetic JJs-ferrotransmon



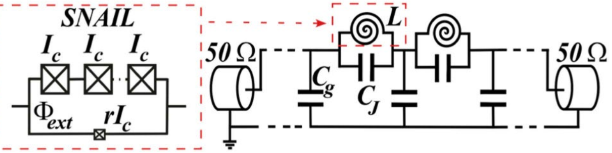
Credits: H: Ahmad, R. Satariano, R. Ferraiuolo, G. Serpico,

Josephson digital phase detector



Credits: L. Di Palma, A. Miano, P. Mastrovito

Josephson Travelling wave parametric amplifier (JTWPA)



Credits: M. Esposito, P. Darvehi, I. Chatterjee, A. Levochkina

On-chip microwave source of coherent states in superconducting quantum circuits

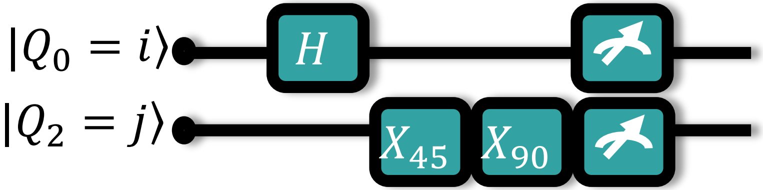
Running quantum measurements and protocols

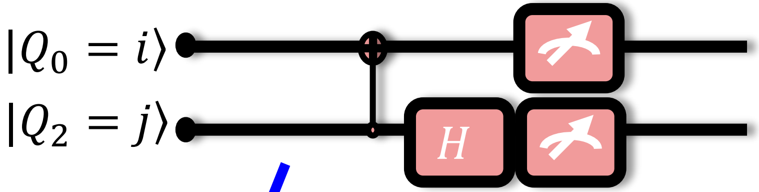
Flexibility in building Hamiltonians (Hamiltonian Engineering), Scaling the number of qubits for running algorithms, Coherence times and impact of noise, improving read out fidelity, novel gate optimization techniques, novel methods for identifying, correcting or mitigating errors on quantum measurements

Credits: P. Mastrovito, C. Cosenza, V. Stasino, H: Ahmad,

Software and Algorithms

Mitigating Errors on Superconducting Quantum Processors through Fuzzy Clustering





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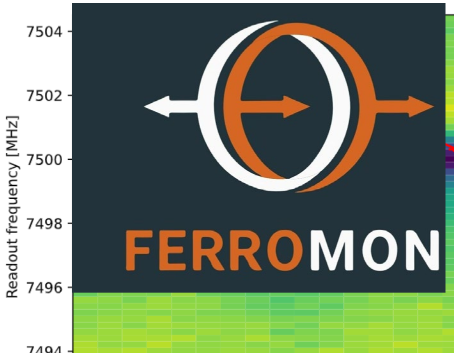
The ferrotransmon

The strong need for an increasing number of qubits in superconducting quantum processors for quantum computing requires novel solutions to improve scalability.

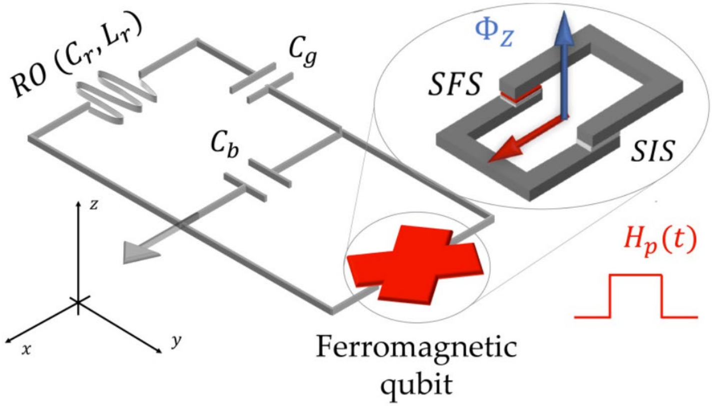
Tunability of qubit frequencies is essential for implementing two-qubit gates, and is achieved through the integration of Superconducting Quantum Interference Devices (SQUIDs)

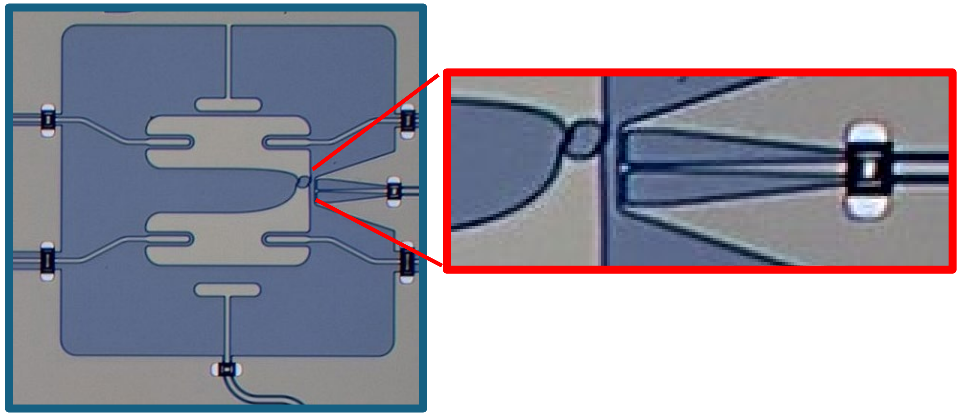


HORIZON-EIC-2022-PATHFINDERCHALLENGES-01

101115548

FERROMON





In the frame of the European EIC Pathfinder project Ferromon, we want to reduce the space occupied by tunability circuitry, by integrating unconventional ferromagnetic Josephson junctions in transmon qubits!

QBLOX

QuantrolOx

Finanziato dall'Unione europea NextGenerationEU

Ministero dell'Università e della Ricerca

Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

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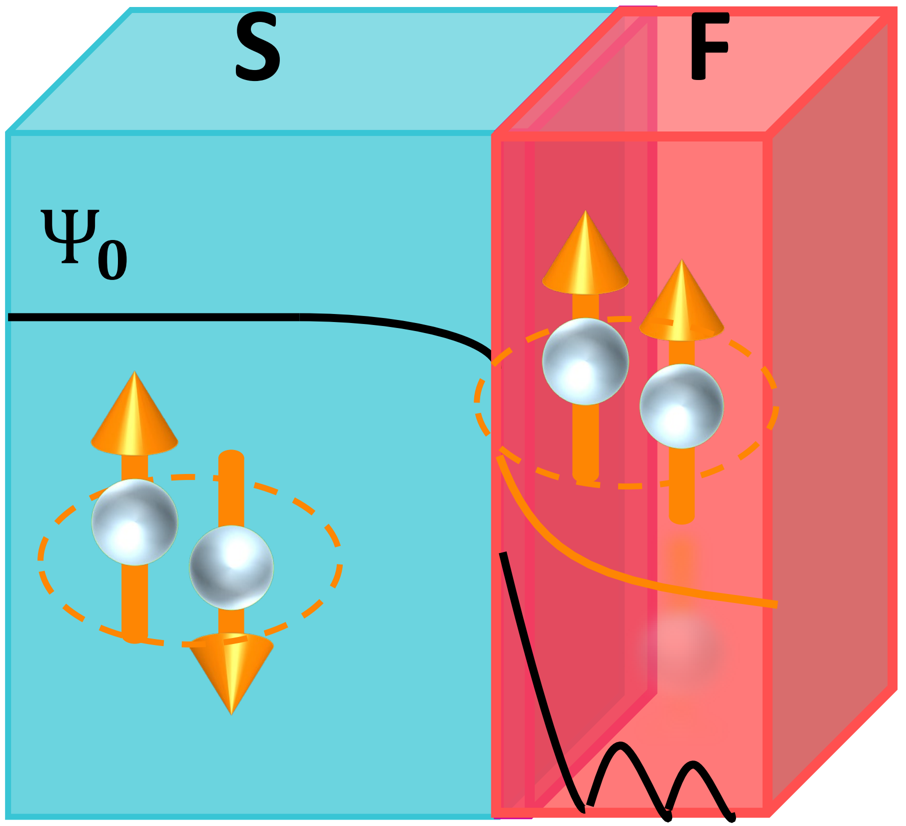
TUNNEL MAGNETIC JOSEPHSON JUNCTIONS TOWARDS HYBRID SUPERCONDUCTING QUANTUM ARCHITECTURES

TALK BY ROBERTA SATARIANO

Monday, June 3rd 16.45

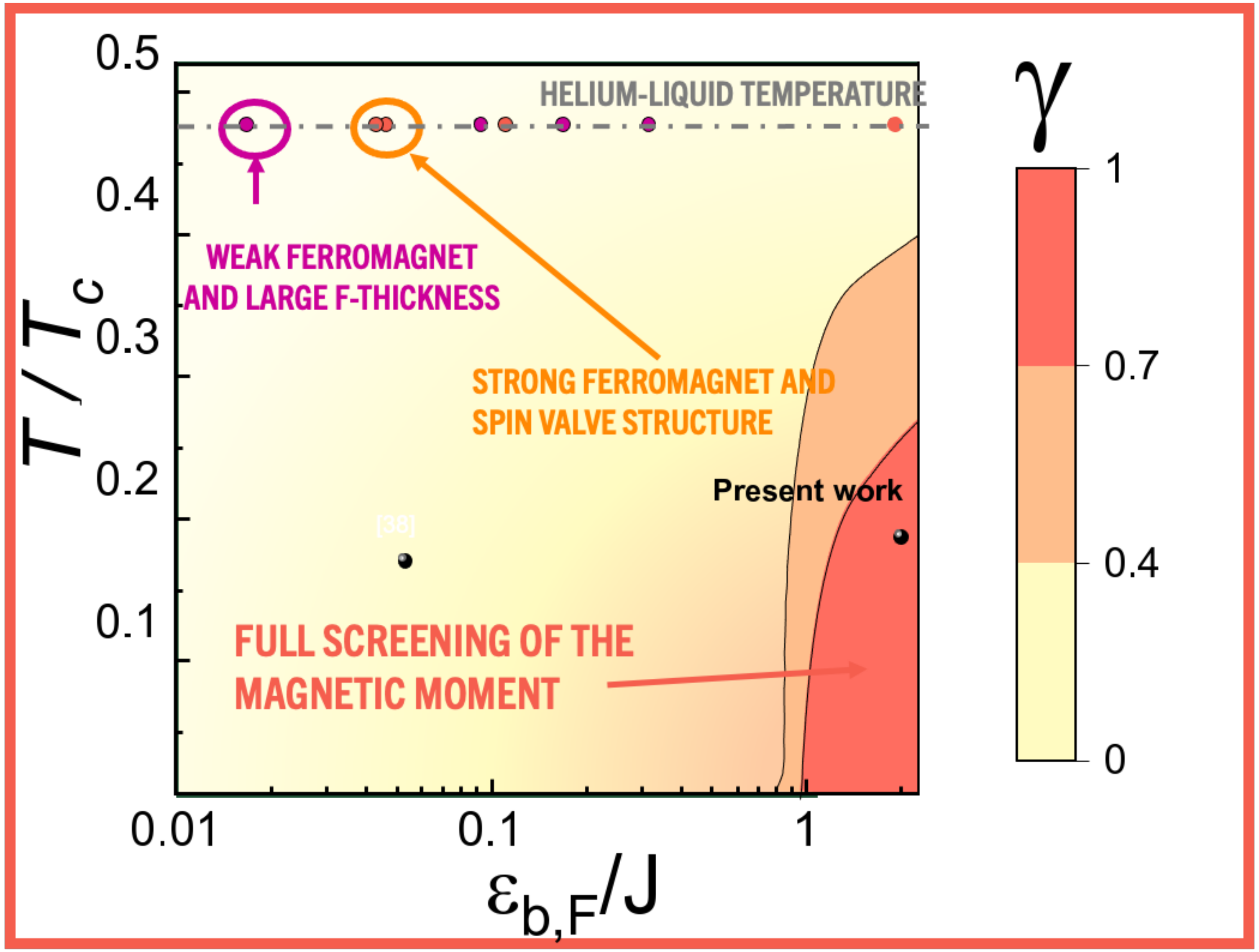
Magnetic non-collinearity



Spin-triplet superconductivity

0 - π phase transition

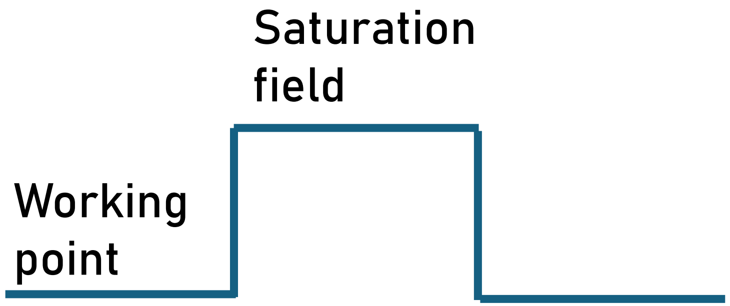
Spin screening at the S/F interface

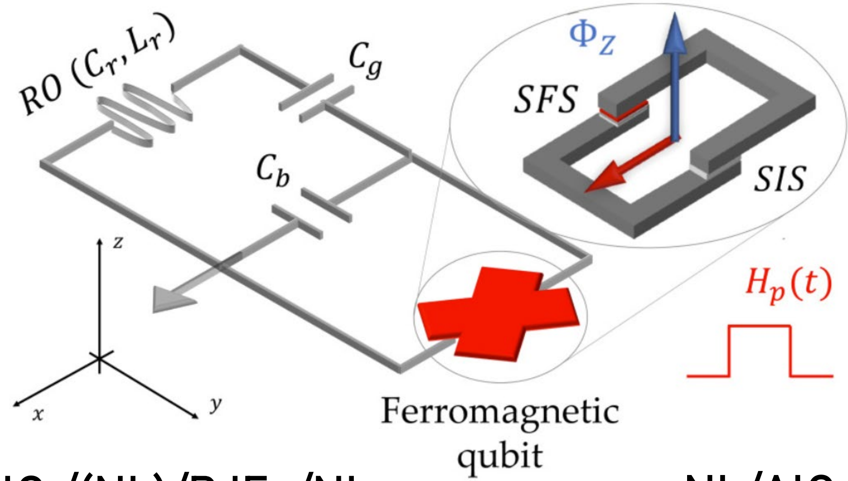


IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at WOLTE-16 2024, June 2024, Cagliari, Italy.

R. Satariano, A. F. Volkov, H. G. Ahmad, L. Di Palma, R. Ferraiuolo, A. Vettoliere, C. Granata, D. Montemurro, L. Parlato, G. P. Pepe F. Tafuri, G. Ausanio, and D. Massarotti, *Commun. Mater.* **5**, 67 (2024)

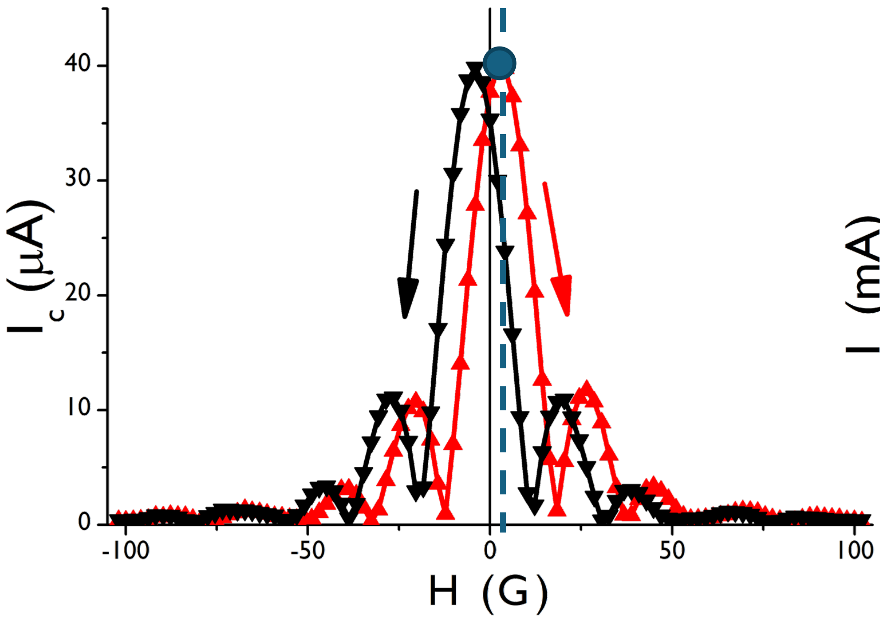
The ferrotransmon



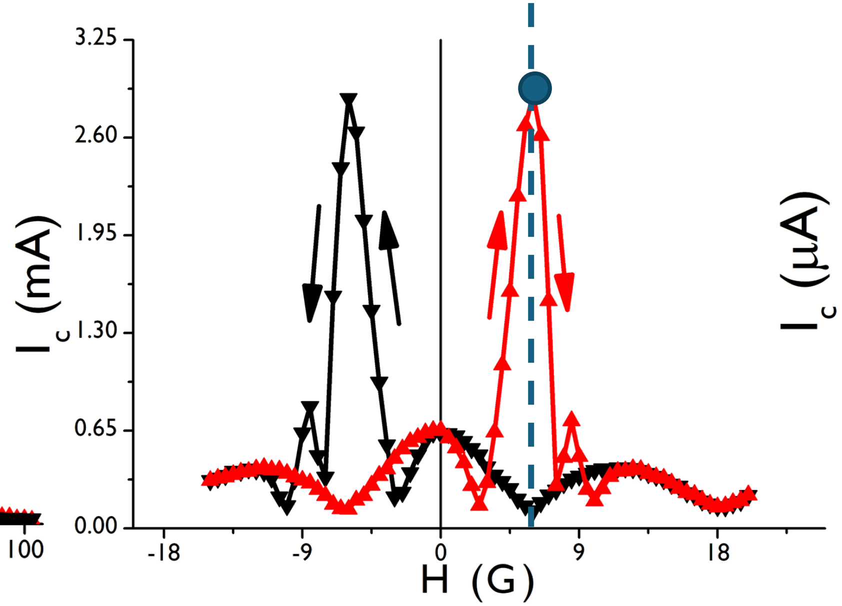


Ahmad et al., Hybrid ferromagnetic transmon qubit: Circuit design, feasibility, and detection protocols for magnetic fluctuations, PRB 2022

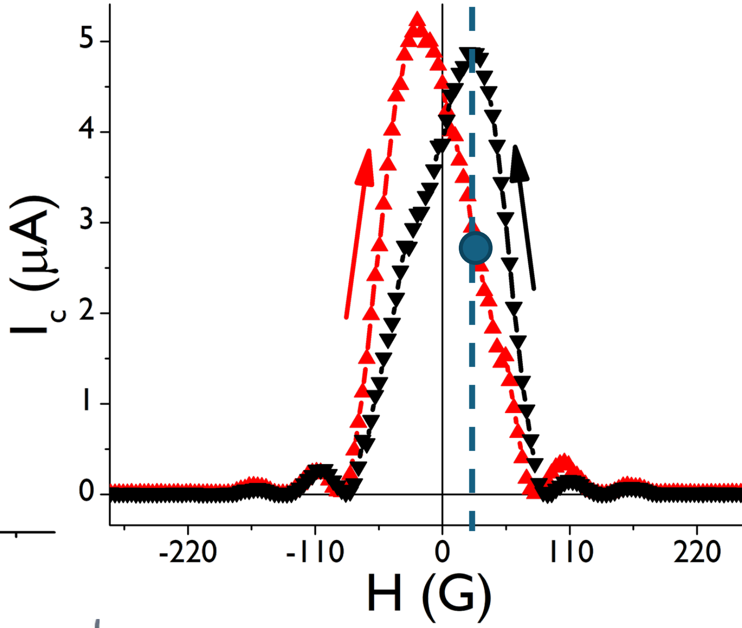
NbN/GdN/NbN



Nb/AlO$_x$/(Nb)/PdFe/Nb



Nb/AlO$_x$/(Nb)/Py/Nb



Received 12 Dec 2014 | Accepted 1 May 2015 | Published 9 Jun 2015 DOI: 10.1038/ncomms8376 OPEN

Macroscopic quantum tunnelling in spin filter ferromagnetic Josephson junctions

D. Massarotti[1,2], A. Pal[3], G. Rotoli[4], L. Longobardi[4,5], M.G. Blamire[3] & F. Tafuri[2,4]

JOURNAL OF APPLIED PHYSICS **123**, 133901 (2018)

RF assisted switching in magnetic Josephson junctions

R. Caruso,[1,2] D. Massarotti,[2,3] V. V. Bolginov,[4,5] A. Ben Hamida,[5,6] L. N. Karelina,[4] A. Miano,[1] I. V. Vernik,[7,8] F. Tafuri,[1,2] V. V. Ryazanov,[4,9] O. A. Mukhanov,[7,8] and G. P. Pepe[1,2]

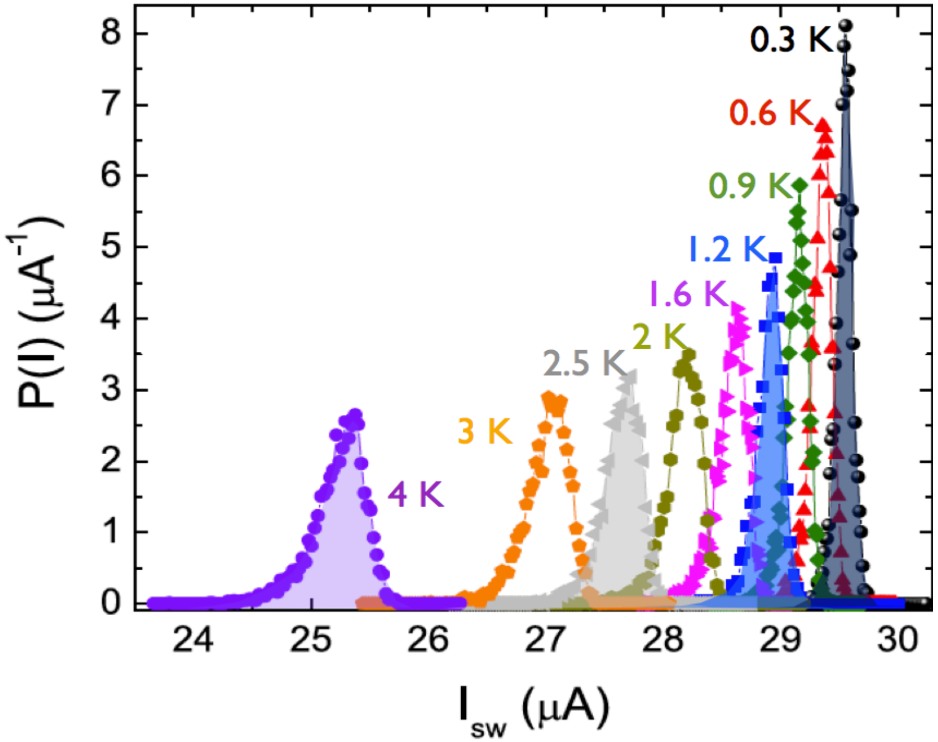
Characterization of scalable Josephson memory element containing a strong ferromagnet

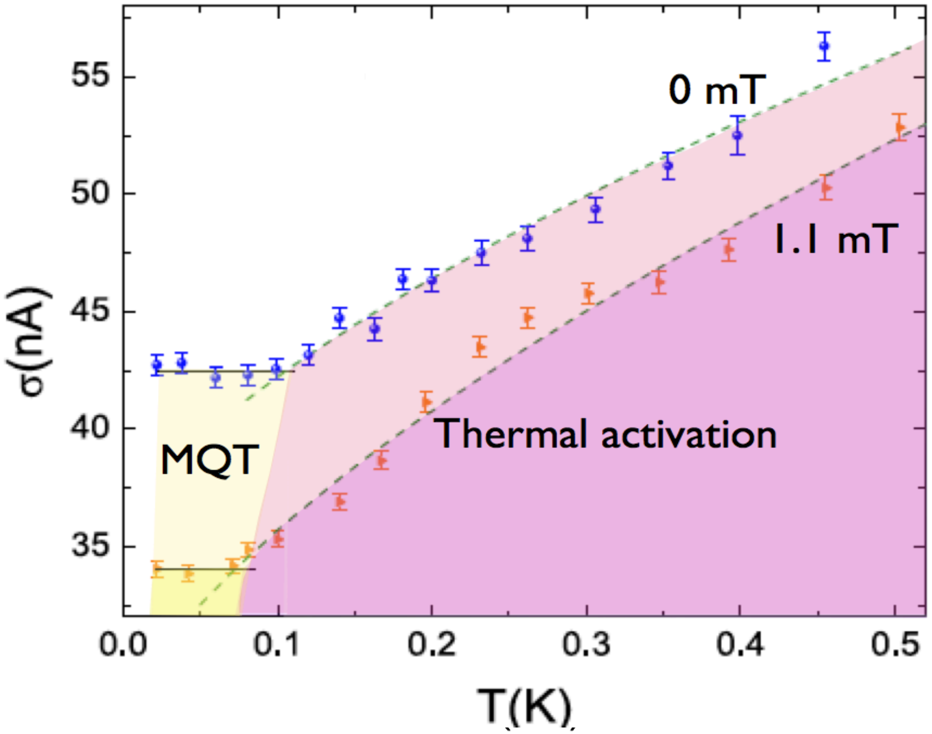
Cite as: J. Appl. Phys. **127**, 193901 (2020); doi: 10.1063/5.0004554

Received 12 Dec 2014 | Accepted 1 May 2015 | Published 9 Jun 2015
DOI: 10.1038/ncomms8376
OPEN
nature COMMUNICATIONS

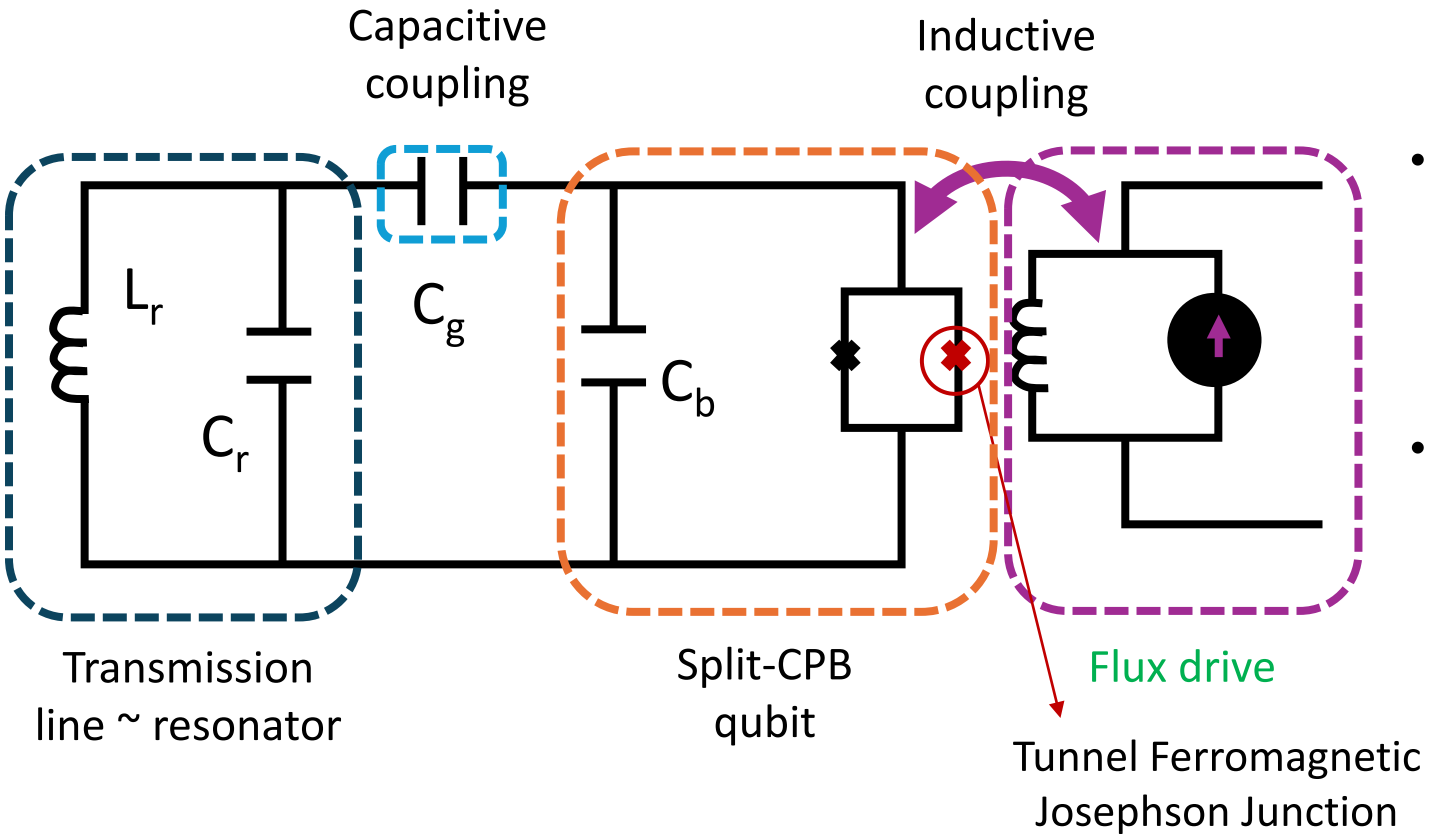
Macroscopic quantum tunnelling in spin filter ferromagnetic Josephson junctions

D. Massarotti[1,2], A. Pal[3], G. Rotoli[4], L. Longobardi[4,5], M.G. Blamire[3] & F. Tafuri[2,4]





Transmon qubit based on ferromagnetic JJs-ferrotransmon



- Spin-filter JJs based on GdN insulating ferromagnetic barriers
- SIFS-like Josephson junctions

- Tuning of E_J by using magnetic field pulses
- Qubit as quantum sensor

PHYSICAL REVIEW B **105**, 214522 (2022)

Hybrid ferromagnetic transmon qubit: Circuit design, feasibility, and detection protocols for magnetic fluctuations

Halima Giovanna Ahmad,[1,2,3,*] Valentina Brosco,[4,5] Alessandro Miano,[1,†] Luigi Di Palma,[1] Marco Arzeo,[2] Domenico Montemurro,[1,3] Procolo Lucignano,[1] Giovanni Piero Pepe,[1] Francesco Tafuri,[1,6] Rosario Fazio,[7,1] and Davide Massarotti[8,3]

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
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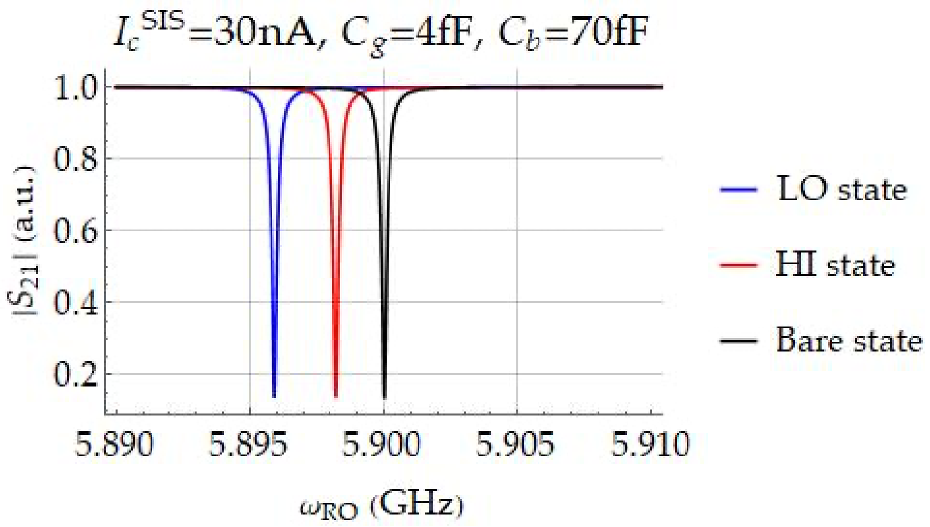
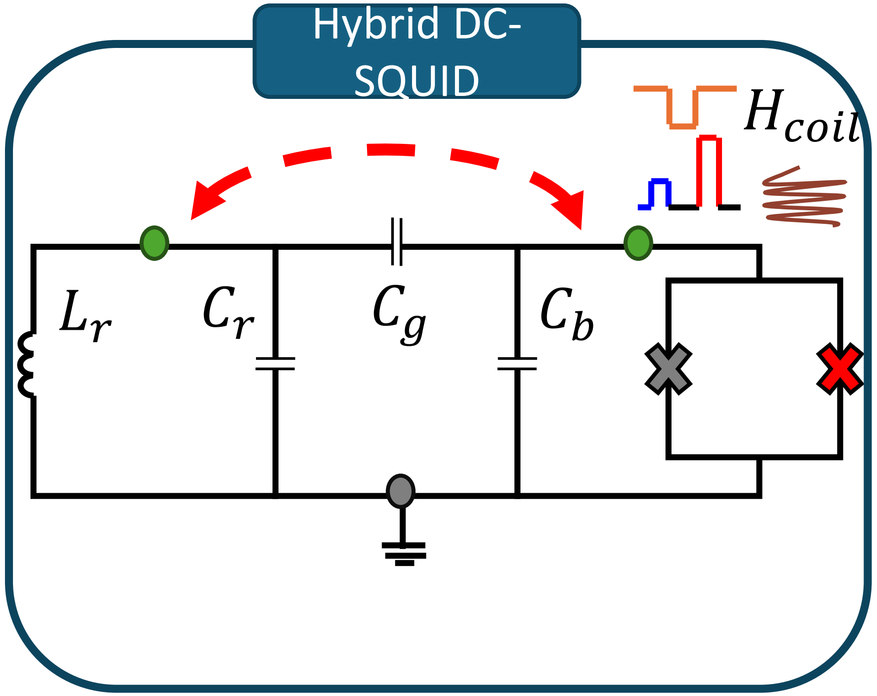
Transmon qubit based on ferromagnetic JJs-ferrotransmon





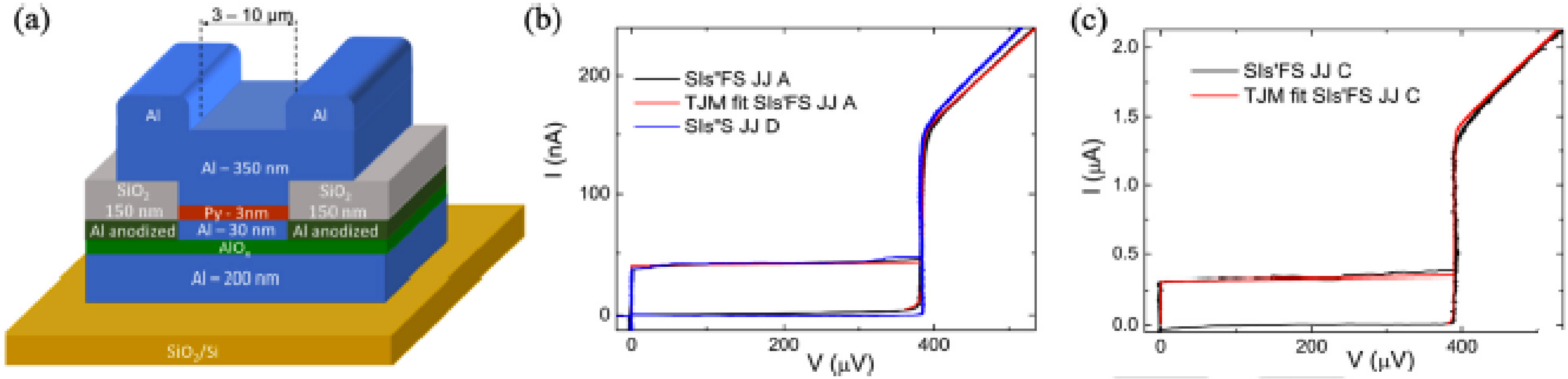
FERRO-TRANSMON CIRCUITAL DESIGN AND SIMULATIONS

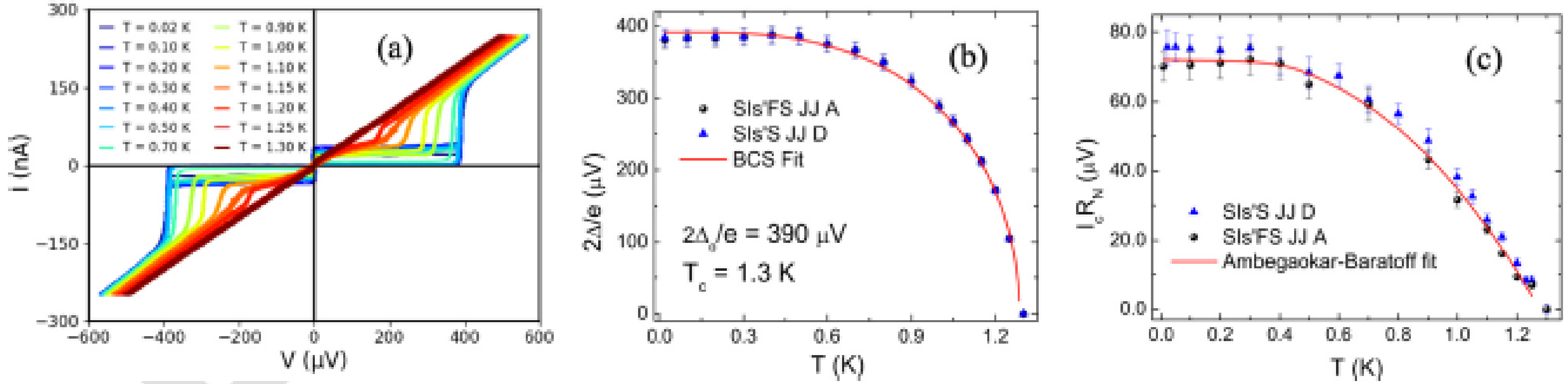
- Tuning of E_J by using magnetic field pulses
- Qubit as quantum sensor

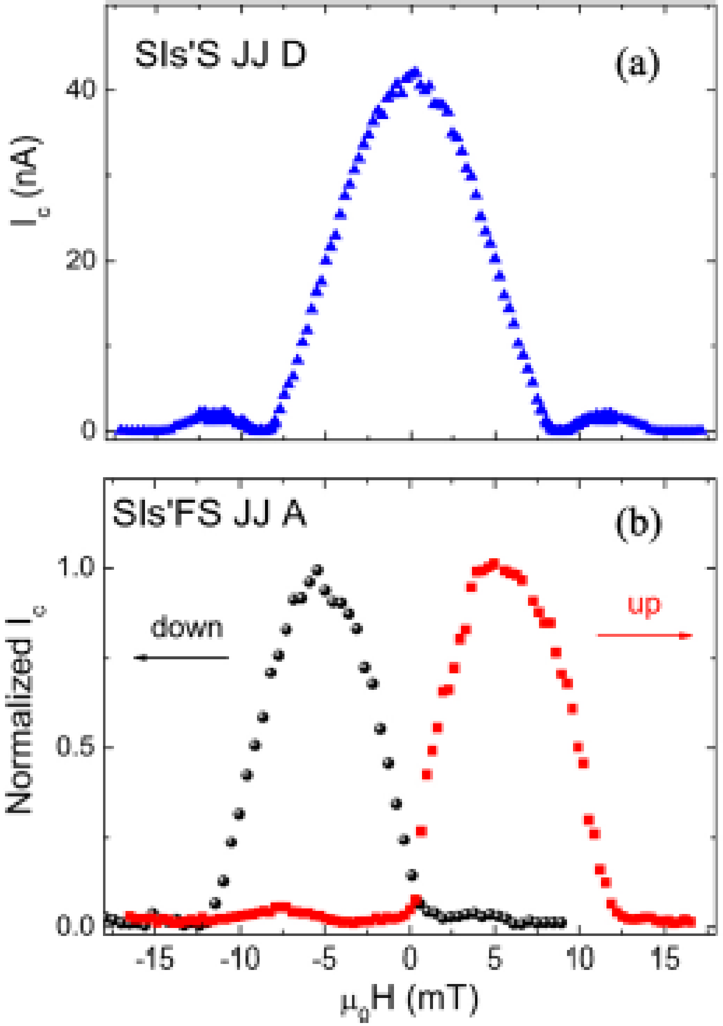
PHYSICAL REVIEW B **105**, 214522 (2022)

Hybrid ferromagnetic transmon qubit: Circuit design, feasibility, and detection protocols for magnetic fluctuations

Halima Giovanna Ahmad,[1,2,3,*] Valentina Brosco,[4,5] Alessandro Miano,[1,†] Luigi Di Palma,[1] Marco Arzeo,[2] Domenico Montemurro,[1,3] Procolo Lucignano,[1] Giovanni Piero Pepe,[1] Francesco Tafuri,[1,6] Rosario Fazio,[7,1] and Davide Massarotti[8,3]







Aluminum-ferromagnetic Josephson tunnel junctions for high quality magnetic switching devices

Cite as: Appl. Phys. Lett. **120**, 262601 (2022); doi: 10.1063/5.0101686
Submitted: 2 June 2022 · Accepted: 12 June 2022 ·
Published Online: 30 June 2022

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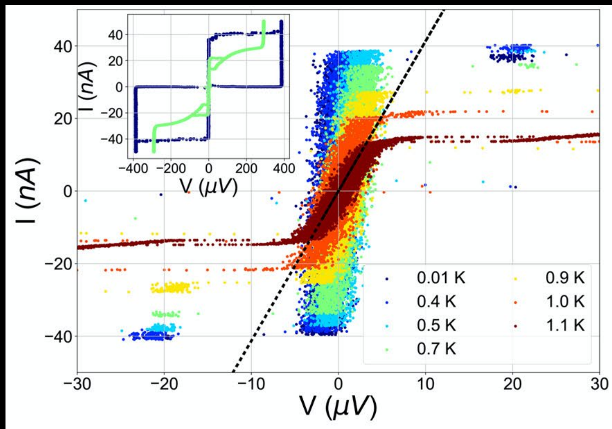
A. Vettoliere,[1] R. Satariano,[2] R. Ferraiuolo,[2] L. Di Palma,[2] H. G. Ahmad,[3] G. Ausanio,[2,4] G. P. Pepe,[2,4] F. Tafuri,[2,5] D. Montemurro,[2,4] C. Granata,[1] L. Parlato,[2,4,a)] and D. Massarotti[3,4,a)]

Phase dynamics of tunnel Al-based ferromagnetic Josephson junctions

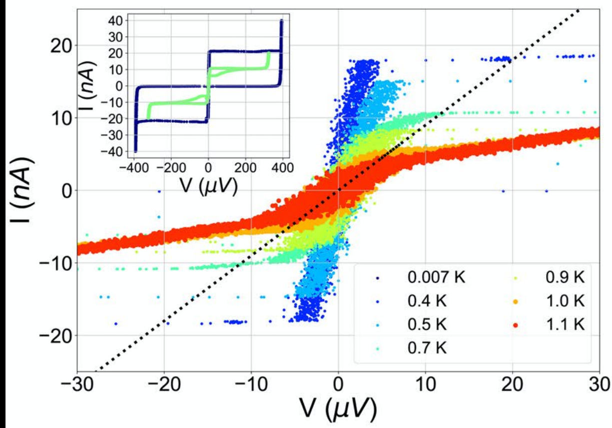
Cite as: Appl. Phys. Lett. **124**, 000000 (2024); doi: 10.1063/5.0211006
Submitted: 28 March 2024 · Accepted: 27 May 2024 ·
Published Online: 0 Month 0000
View Online

ABSTRACT

By measuring the current–voltage characteristics and the switching current distributions as a function of temperature, we have investigated the phase dynamics of Al tunnel ferromagnetic Josephson junctions (JJs), designed to fall in the typical range of parameters of state-of-the-art transmons, providing evidence of phase diffusion processes. The comparison with the experimental outcomes on non-magnetic JJs with nominally the same electrodynamical parameters demonstrates that the introduction of ferromagnetic barriers does not cause any sizeable detrimental effect and supports the notion of including tunnel ferromagnetic JJs in qubit architectures.



(a)



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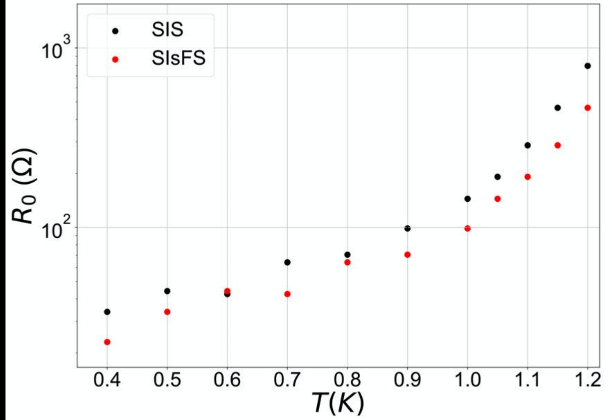
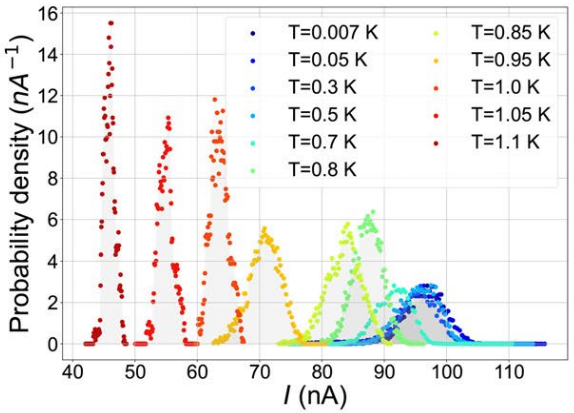
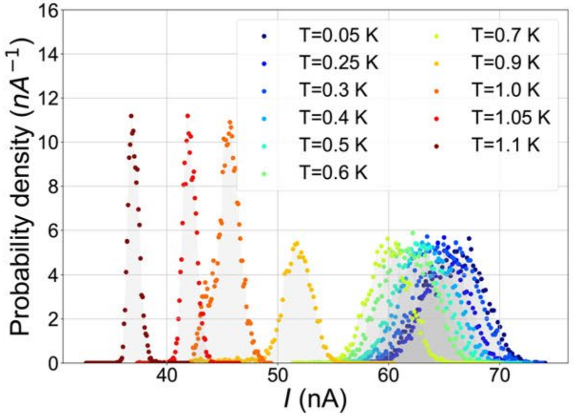




(a)



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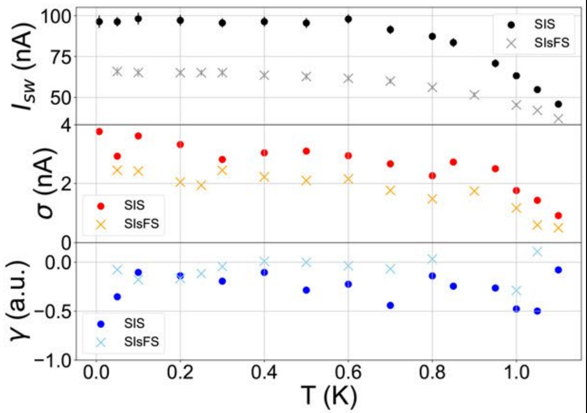
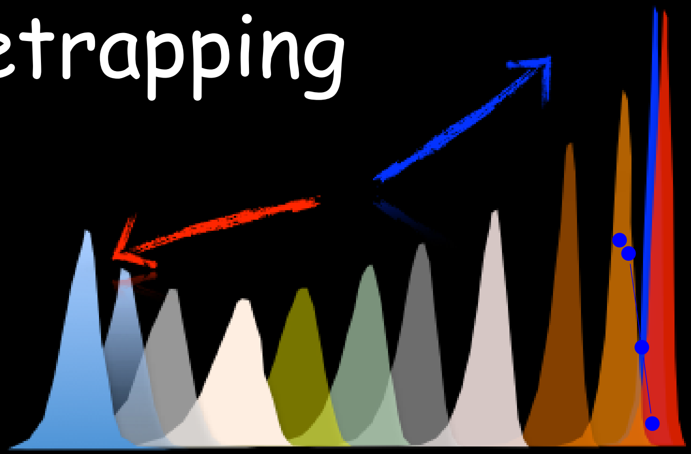


(c)

Multiple Escape and Retrapping

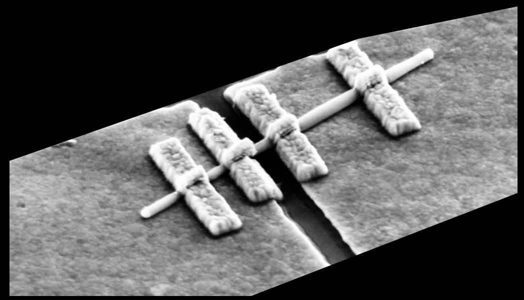


TA

MQT

Moderately damped JJs (1<Q<5)

Iansiti, Tinkham et al. PRB 39 (1989)
Kautz & Martinis, PRB 42 (1990)
Vion,Joyez, Esteve, Devoret PRL 77(1996)
Kivioja, Pekola et al. PRL 94 (2005)
Mannik, Lukens et al. PRB 71 (2005)
Krasnov et al. PRB 76 (2007); PRL 95 (2005)
Longobardi et al. PRB 84 (2011); PRL 109 (2012)
Massarotti et al PRB 92 (2015)



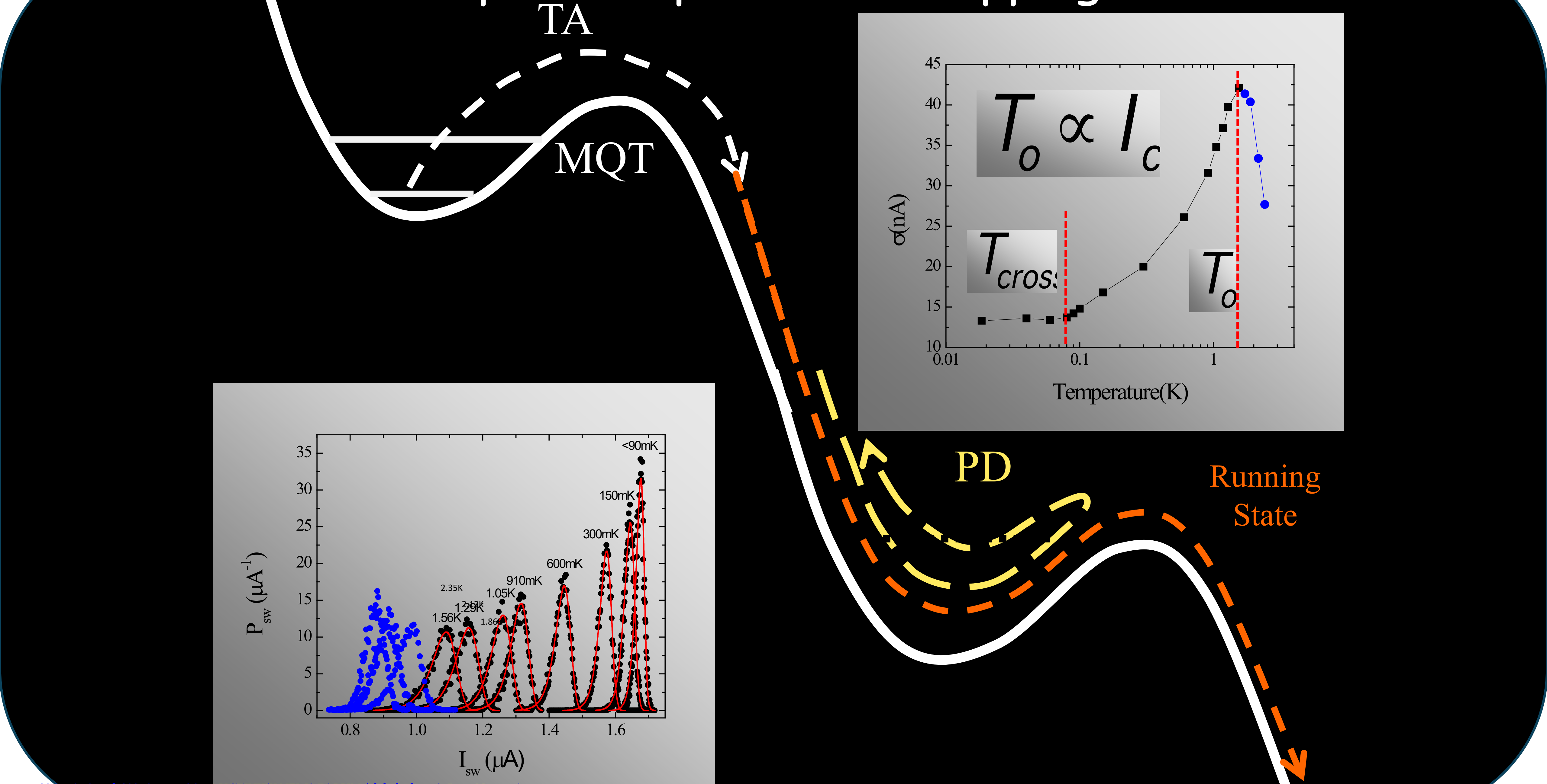
PD

Running State

Reduction of I_c unavoidably leads to a reduction of Q (increase in dissipation) and of the ratio $E_J/E_C=(I_C\Phi_O/2\pi)/(e^2/C)$

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at WOLTE-16 2024, June 2024, Cagliari, Italy.

Multiple Escape and Retrapping



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PHYSICAL REVIEW B VOLUME 42, NUMBER 16 1 DECEMBER 1990

Noise-affected *I-V* curves in small hysteretic Josephson junctions

R. L. Kautz and John M. Martinis
National Institute of Standards and Technology, 325 Broadway, Boulder, Colorado 80303-3328
(Received 11 June 1990)

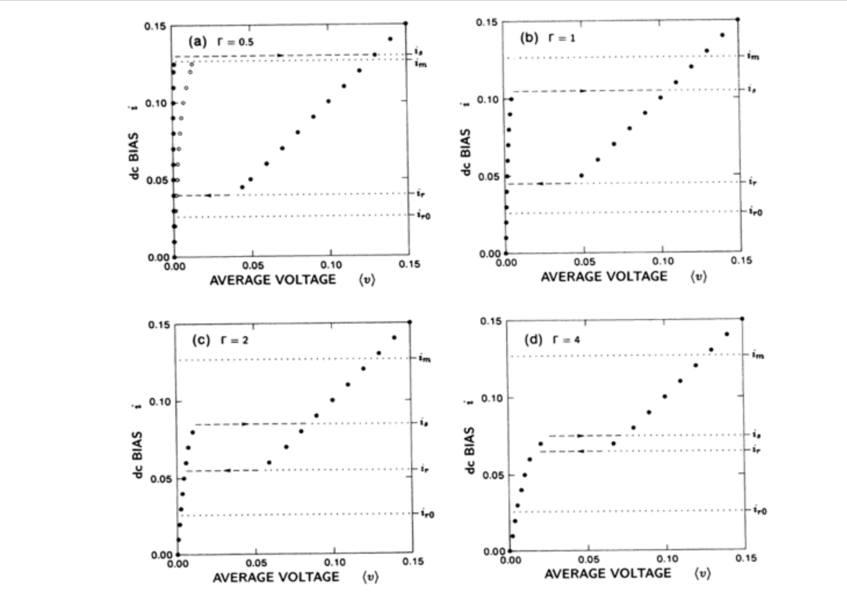
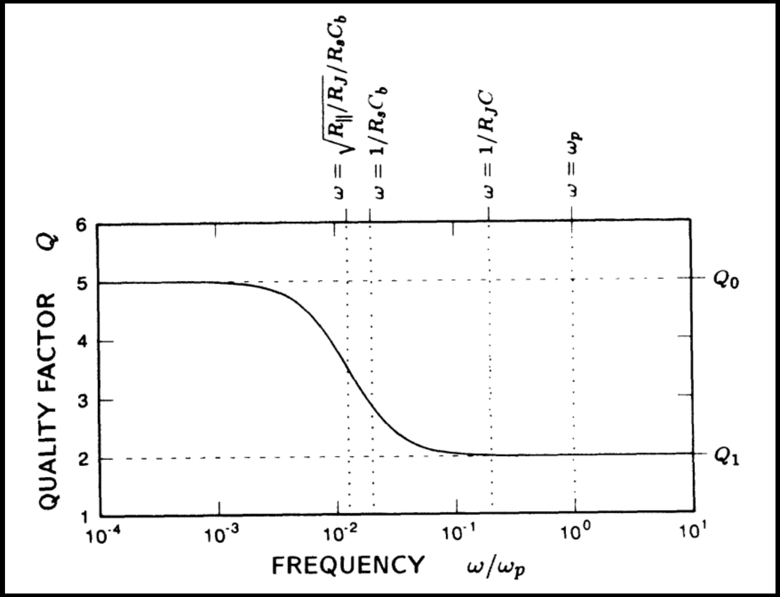
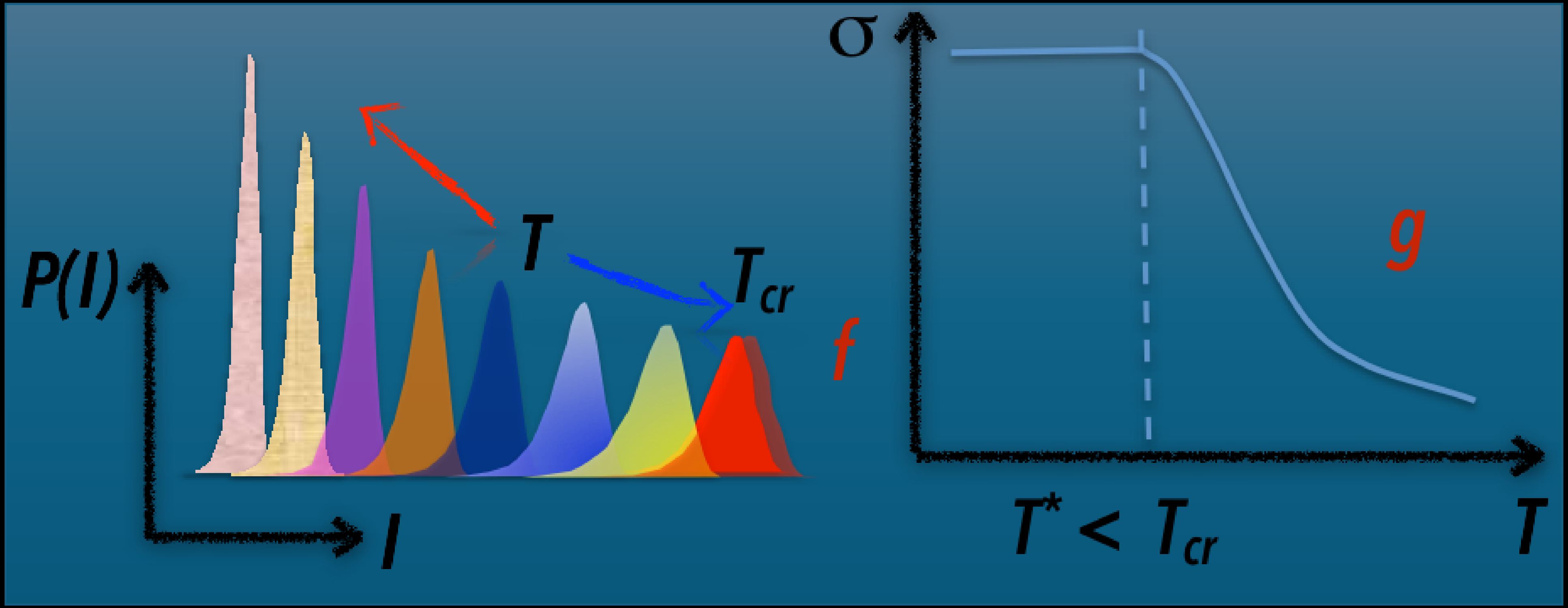


FIG. 16. Noise-affected *I-V* curves for the case $Q_0=100$, $Q_1=10$, and $\rho=0.1$ at the temperatures (a) $\Gamma=0.5$, (b) $\Gamma=1$, (c) $\Gamma=2$,

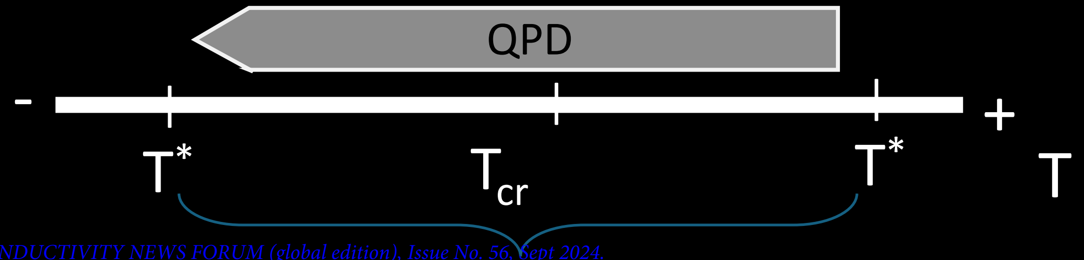




L. Longobardi, D. Massarotti, D. Stornaiuolo,
L. Galletti, G. Rotoli, F. Lombardi & F. Tafuri
Phys. Rev. Lett. . 109, 050601 (2012)

$$T^{*} \propto I_c$$

$$T_{cr} \propto \sqrt{I_c / C}$$



IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
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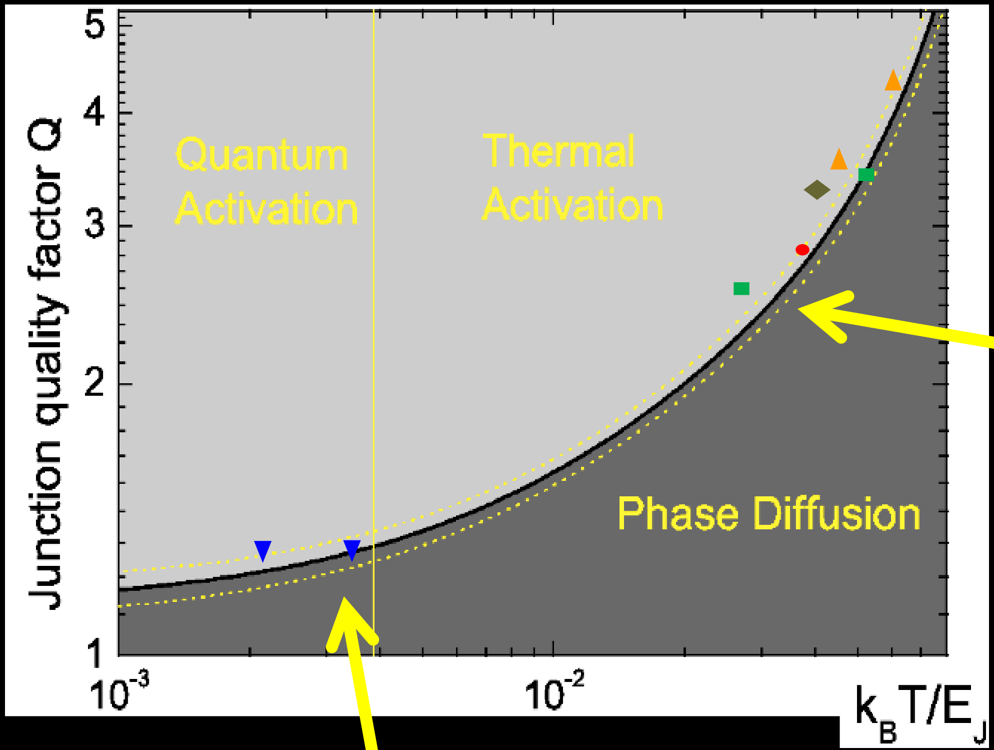
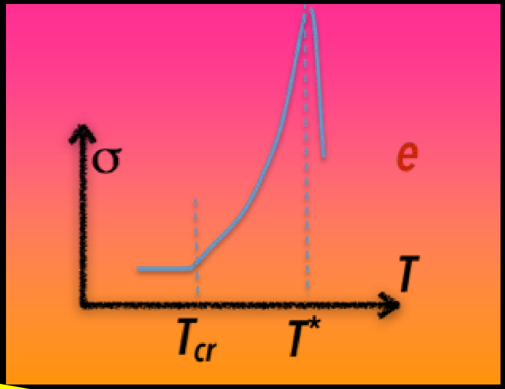
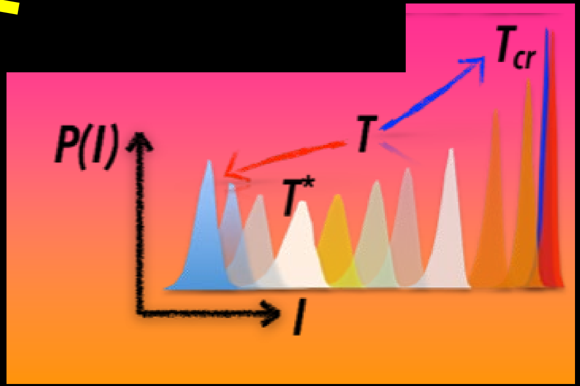
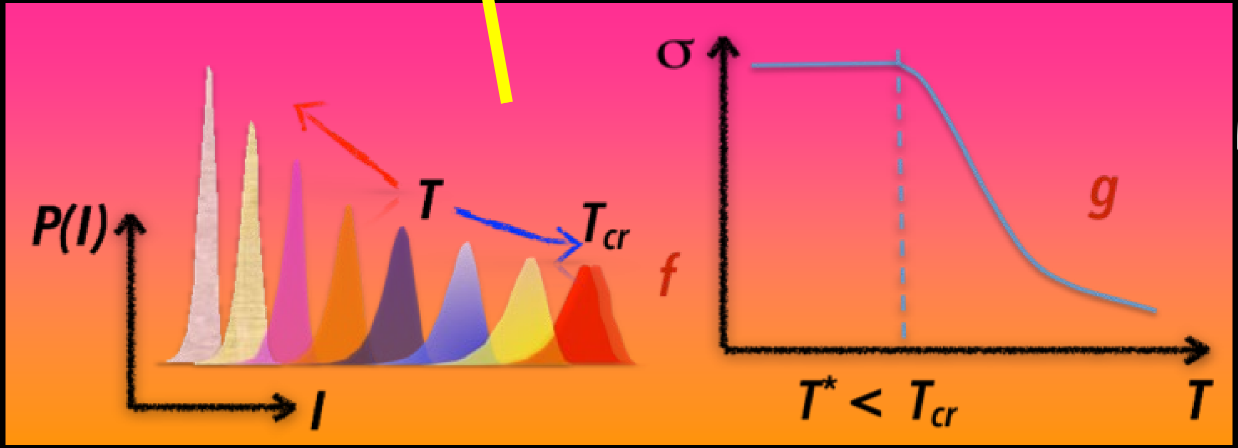






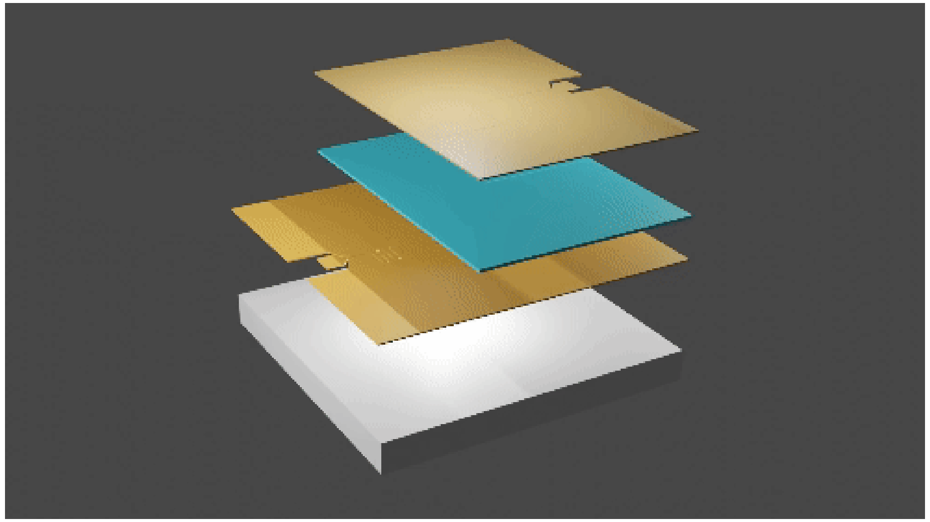


Phase diagram (E_J,T): the direct PD/MQT transition & the high-Jc limit

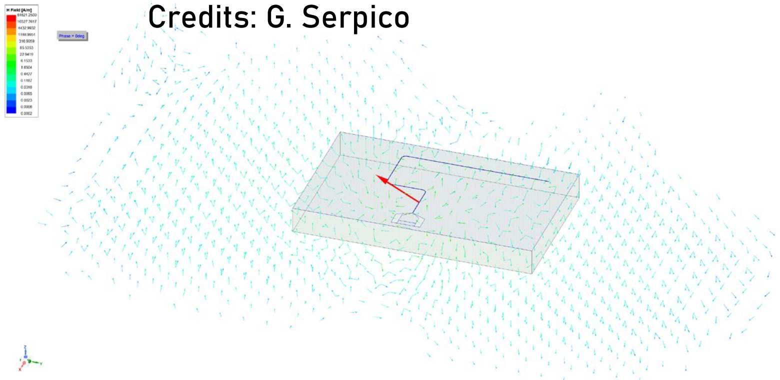
Longobardi et al. PRL 109 (2012); PRB 84 (2011)

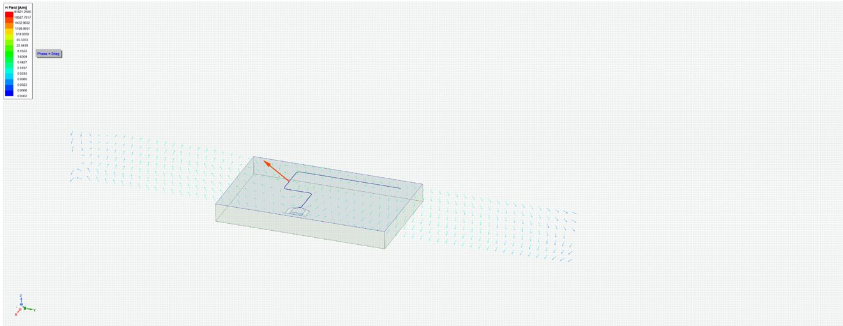
The ferrotransmon

We are working on circuit design of the ferrotransmon in order to increase the scalability of transmon qubits.



Credits: G. Serpico





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Note: the presentation slide contained animation

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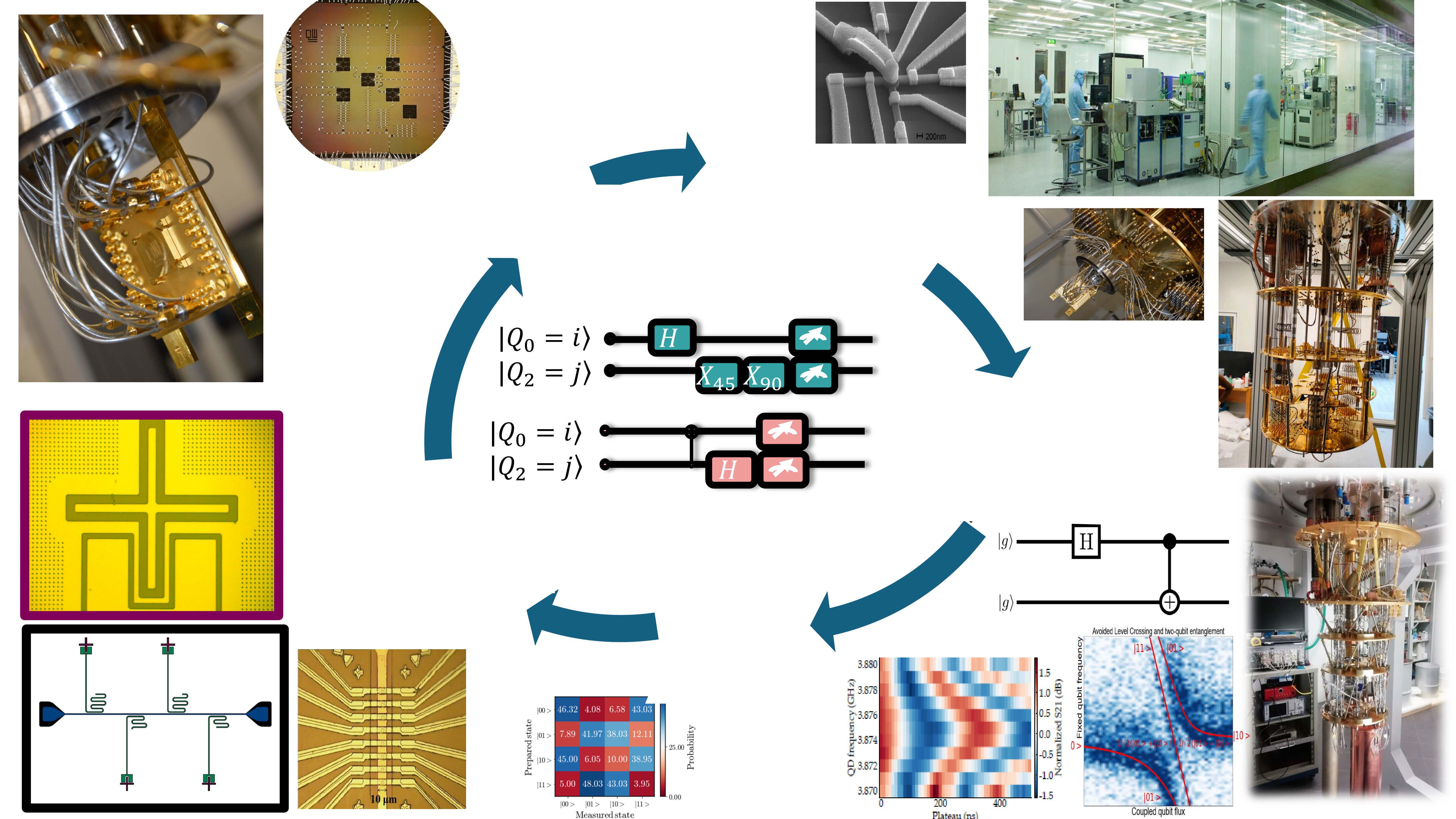
200nm
$|Q_0 = i\rangle$
$|Q_2 = j\rangle$
H
X_{45} X_{90}
$|Q_0 = i\rangle$
$|Q_2 = j\rangle$
H
$|g\rangle$
$|g\rangle$
H
10 µm
Prepared state
Measured state
Probability
|00 > |01 > |10 > |11 >
46.32 4.08 6.58 43.03
7.89 41.97 38.03 12.11
45.00 6.05 10.00 38.95
5.00 48.03 43.03 3.95
25.00
0.00
QD frequency (GHz)
3.880 3.878 3.876 3.874 3.872 3.870
Plateau (ns)
0 200 400
Normalized S21 (dB)
1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5
Avoided Level Crossing and two-qubit entanglement
Fixed qubit frequency
Coupled qubit flux
|11 >
|01 >
|10 >
|01 >

UniNAno: Nanotech facility

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
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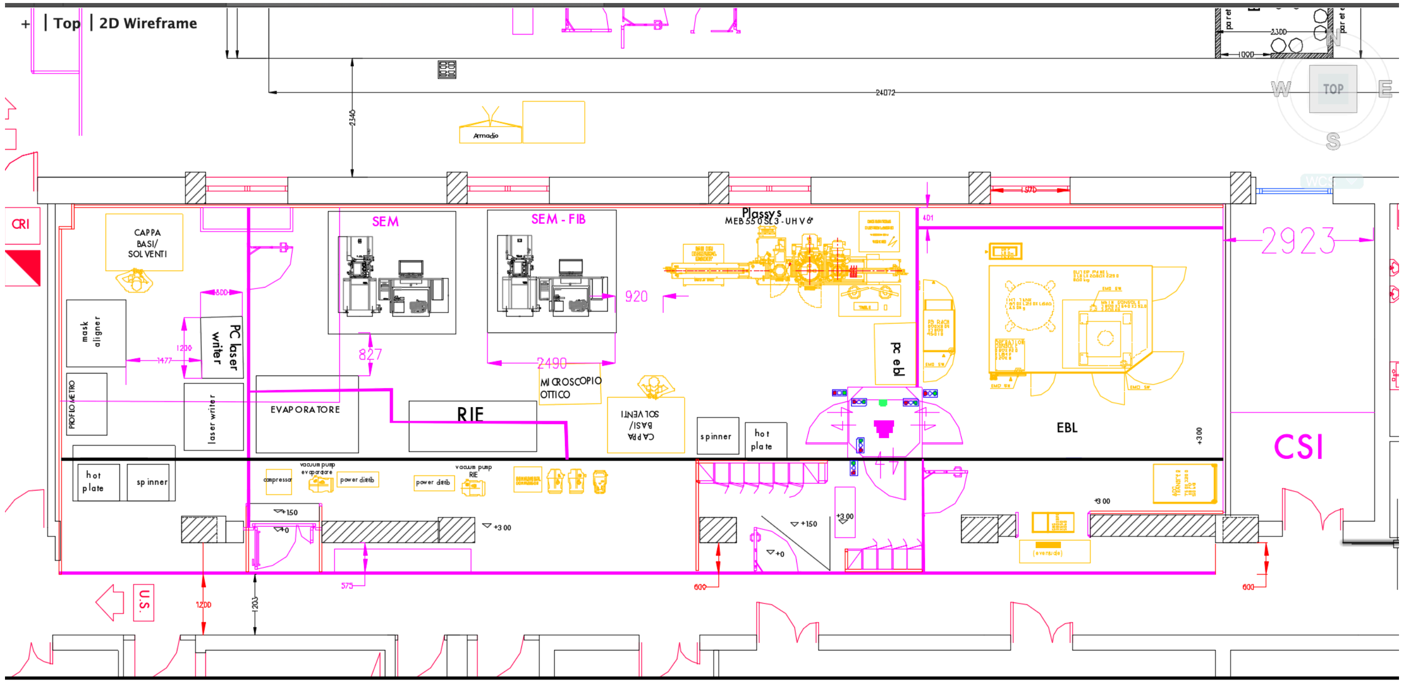
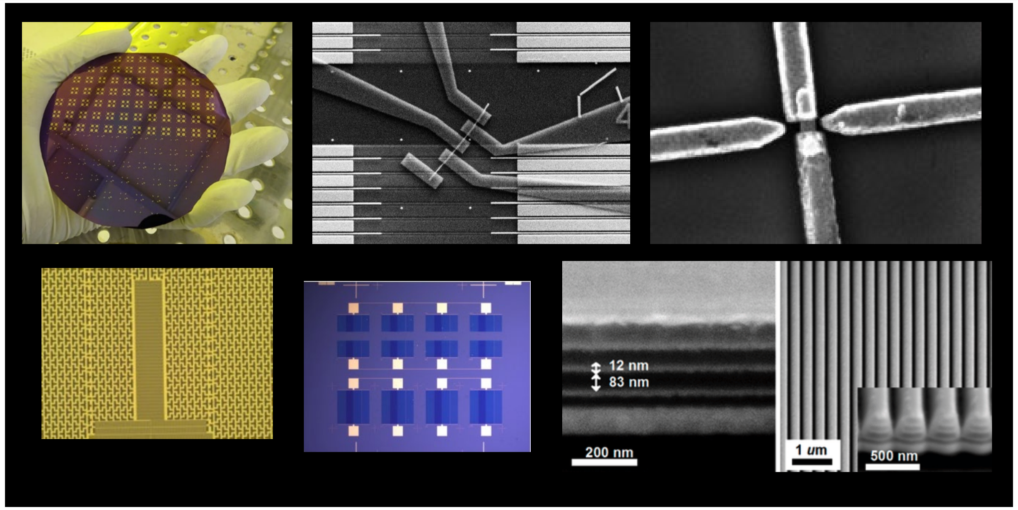


Credits: D. Montemurro



DIPARTIMENTO DI INGEGNERIA ELETTRICA E DELLE TECNOLOGIE DELL'INFORMAZIONE

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II - DIPARTIMENTO DI FISICA "ETTORE PANCINI"

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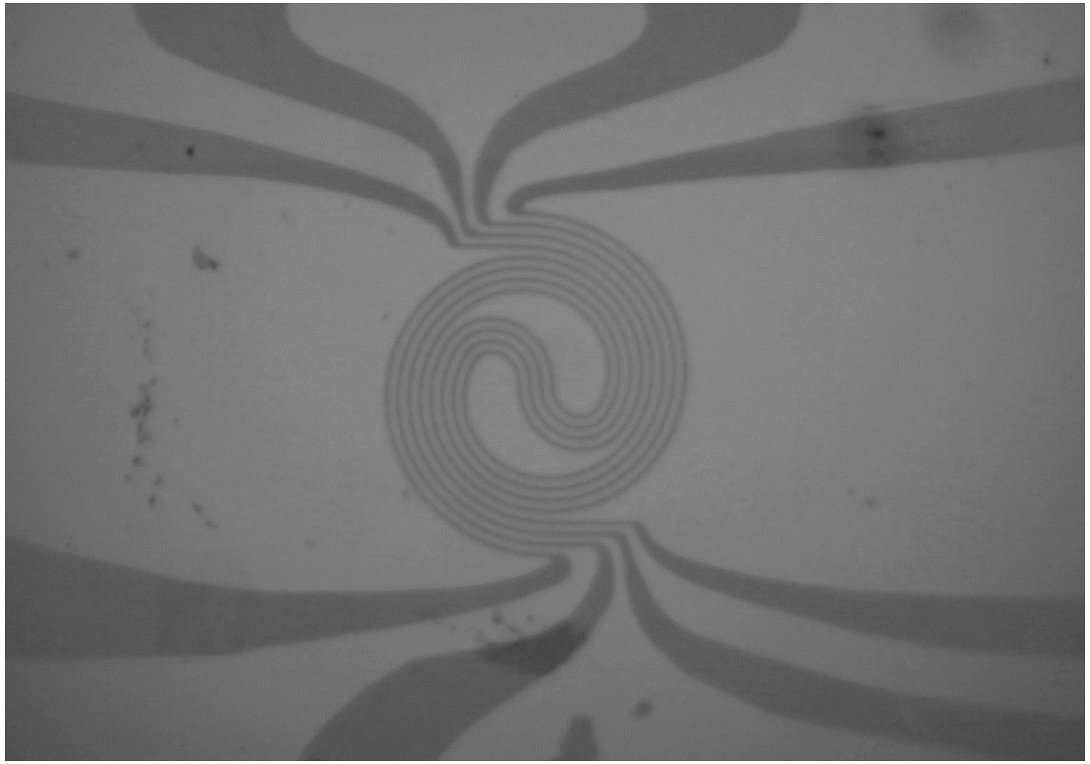
UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

Applications of very performing SNSPDs for Quantum Communication

- QKD experiments
- Characterization of photon sources
- Quantum Random Number Generation

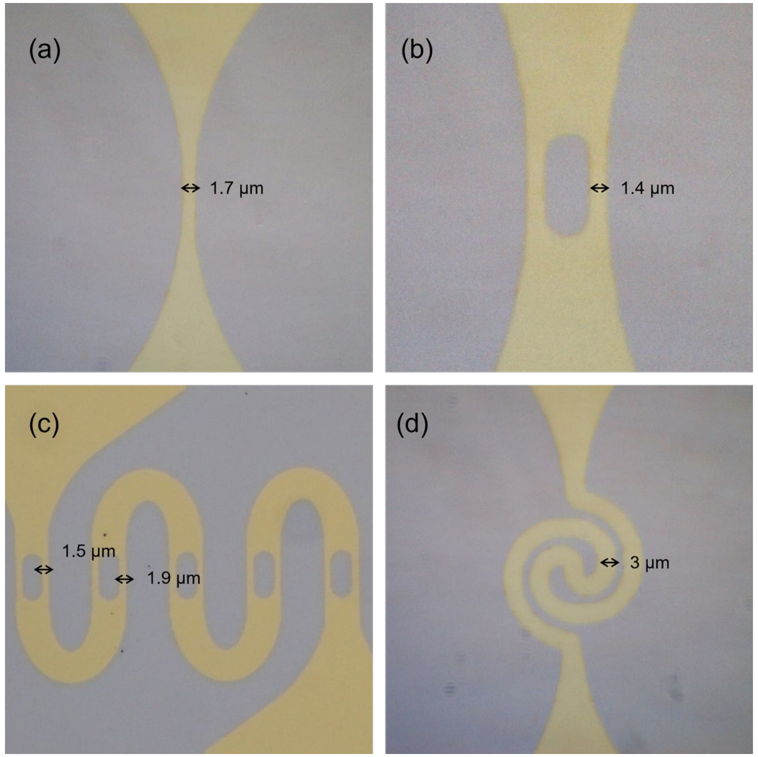


Leader and courtesy: Loredana Parlato and Giampiero Pepe

Development of new SNSPDs

- New materials
- New configurations

$Nb_{0.15}Re_{0.85}$ (4 nm)/Al (2 nm)



IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
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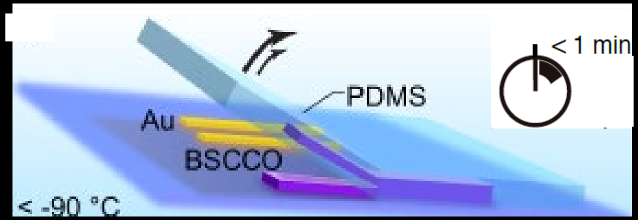
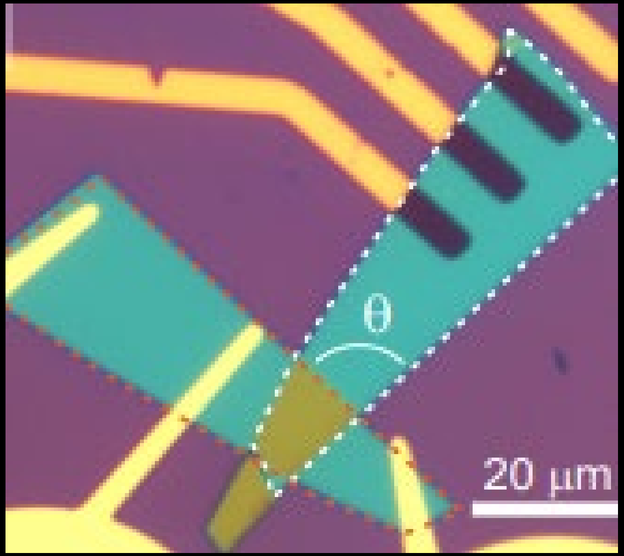
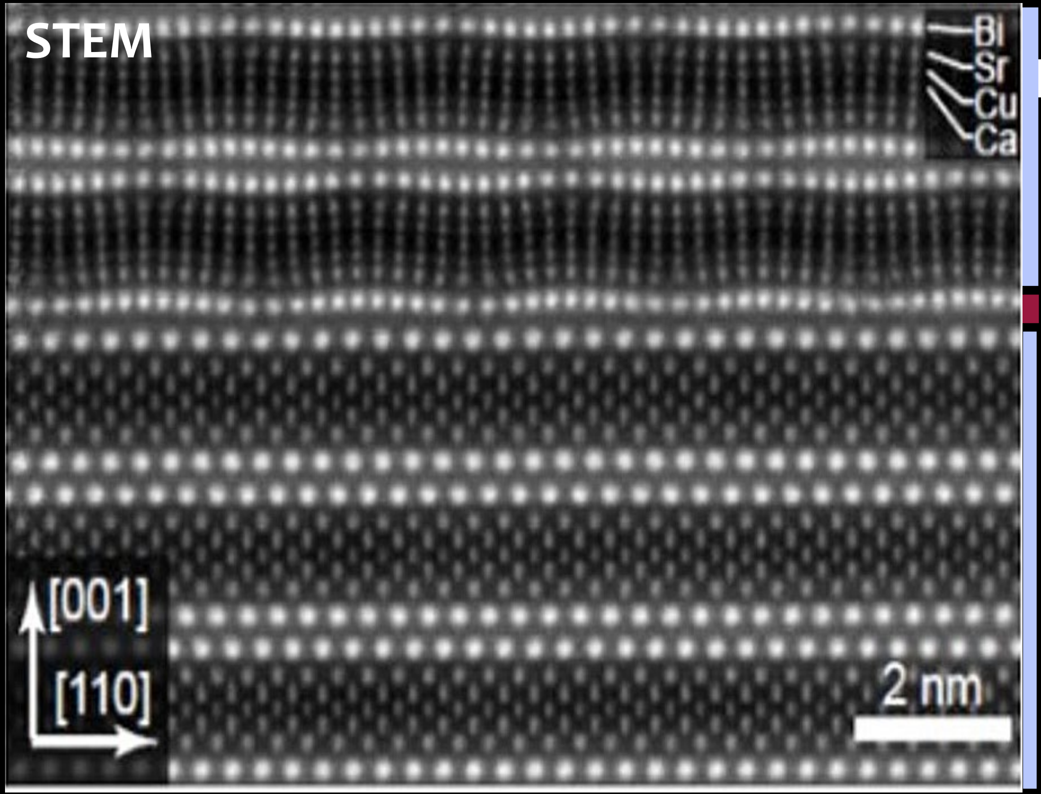
Ultra-clean twisted cuprate interfaces!







Top twisted layer

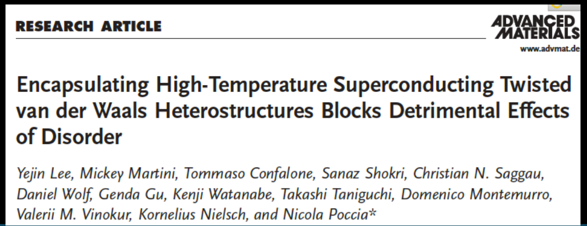
Interface

Bottom layer

Y. Lee, **N. Poccia** et al. *Advanced Materials* 35, 2209135 (2023)

M. Martini, **N. Poccia** et al. *Materials Today*, 67, 106-112 (2023)

Engineering **complexity, topological** and **strongly correlated physics** in one system and in a wide temperature range



RESEARCH ARTICLE

ADVANCED MATERIALS
www.advmat.de

Encapsulating High-Temperature Superconducting Twisted van der Waals Heterostructures Blocks Detrimental Effects of Disorder

*Yejin Lee, Mickey Martini, Tommaso Confalone, Sanaz Shokri, Christian N. Saggau, Daniel Wolf, Genda Gu, Kenji Watanabe, Takashi Taniguchi, Domenico Montemurro, Valerii M. Vinokur, Kornelius Nielsch, and Nicola Poccia**

Science

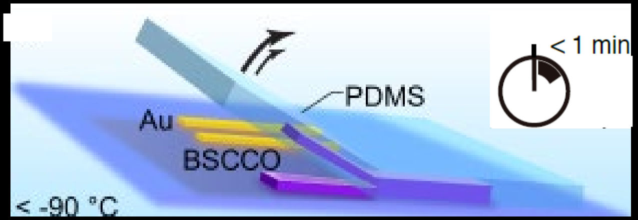
RESEARCH ARTI[...]

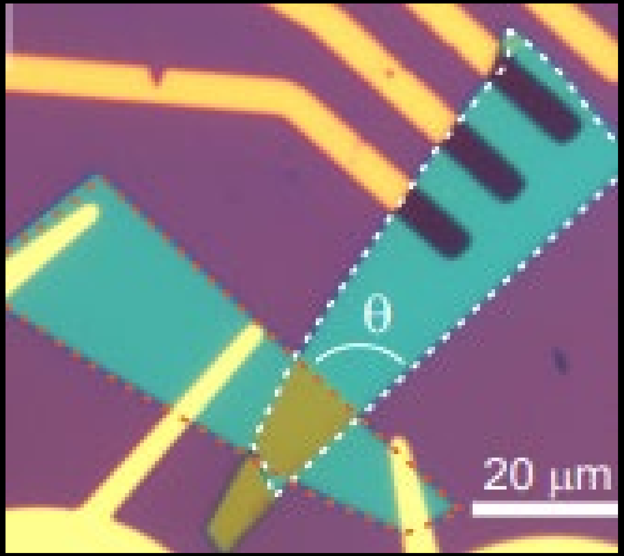
Cite as: S. Y. F. Zhao *et al.*, *Science* 10.1126/science.abl8371 (2023).

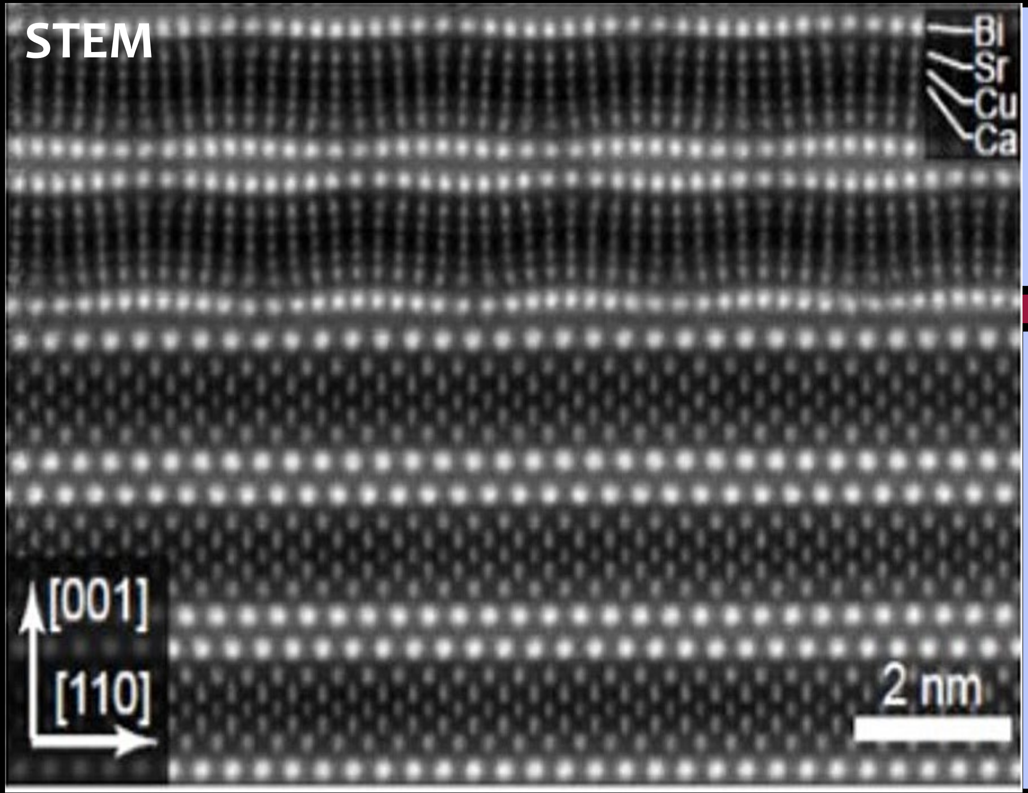
Time-reversal symmetry breaking superconductivity between twisted cuprate superconductors

S. Y. Frank Zhao[1]†, Xiaomeng Cui[1]†, Pavel A. Volkov[2], Hyobin Yoo[3], Sangmin Lee[4], Jules A. Gardener[5], Austin J. Akey[5], Rebecca Engelke[1], Yuval Ronen[1], Ruidan Zhong[6]‡, Genda Gu[6], Stephan Plugge[7], Tarun Tummuru[7], Miyoung Kim[4], Marcel Franz[7], Jedediah H. Pixley[2], Nicola Poccia[8,1]*, Philip Kim[1]*

Ultra-clean twisted cuprate interfaces!

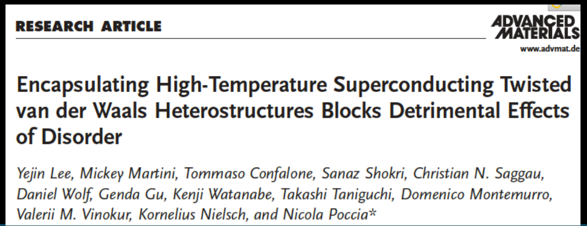






Vision for a cuprate twistronics for quantum hardware

- Integrating **novel circuits** as part of a **twisted cuprate interface**
- **Controlling increasing complexity**
- **Fabricate innovative qubit based on cuprates**



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PRL 94, 087003 (2005) PHYSICAL REVIEW LETTERS week ending 4 MARCH 2005

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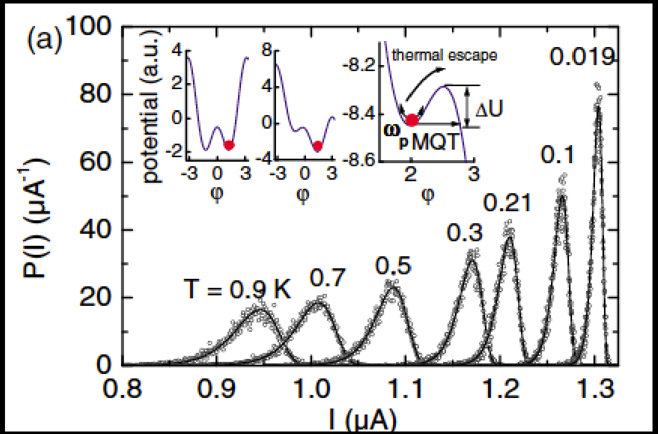

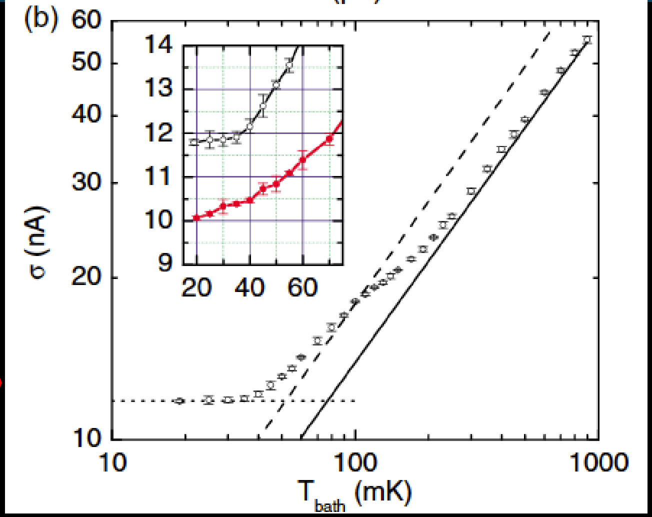

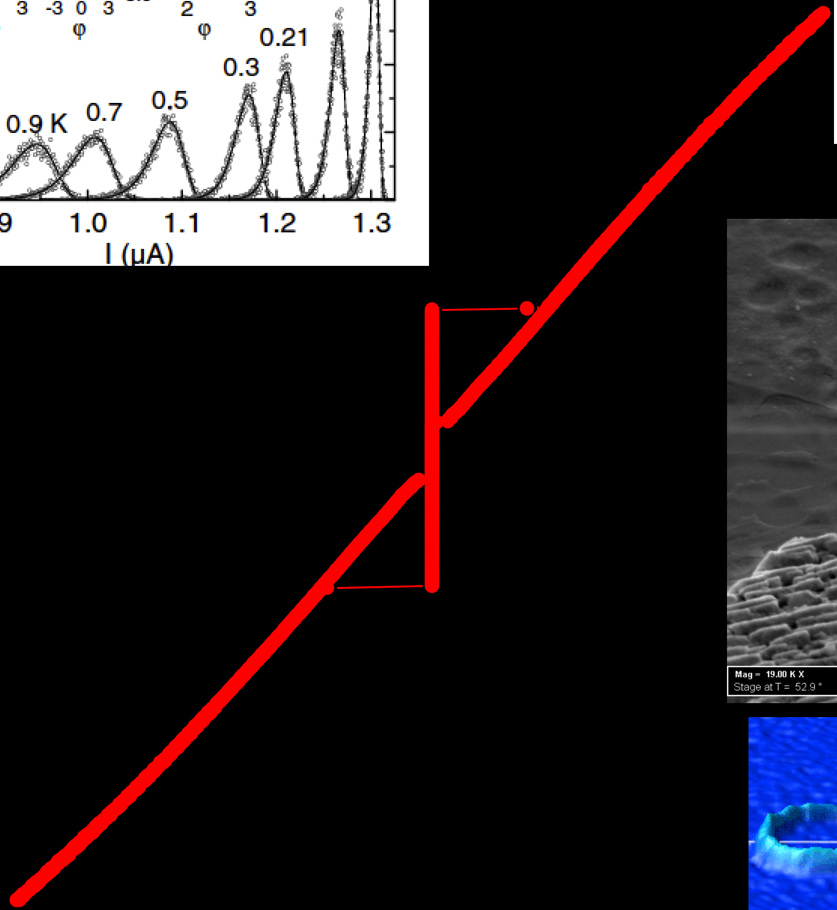

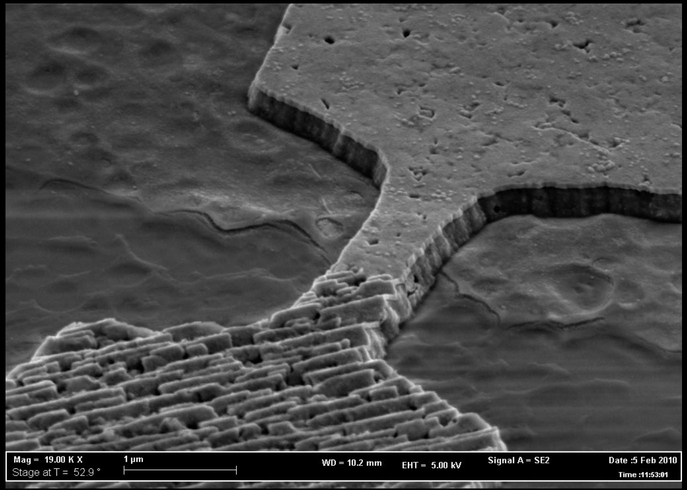

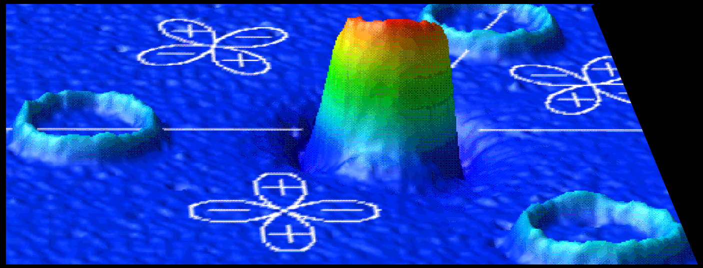

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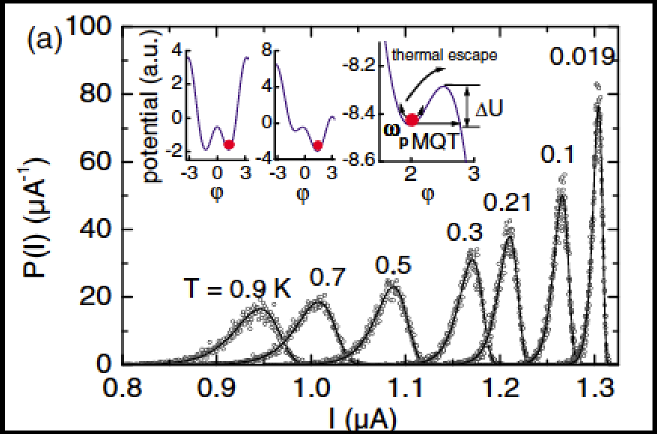
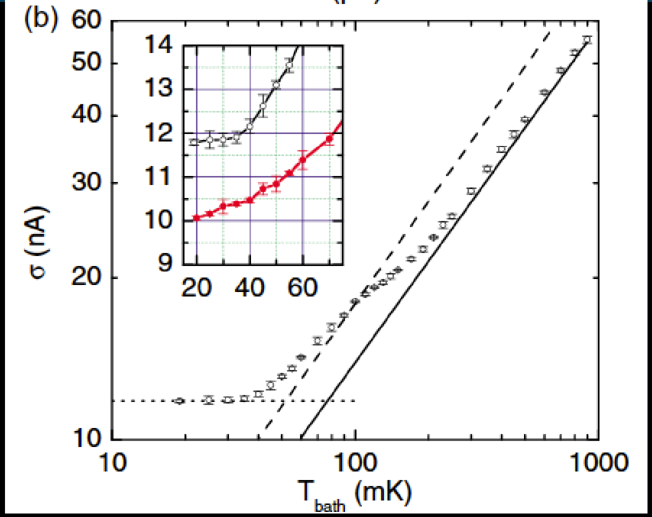
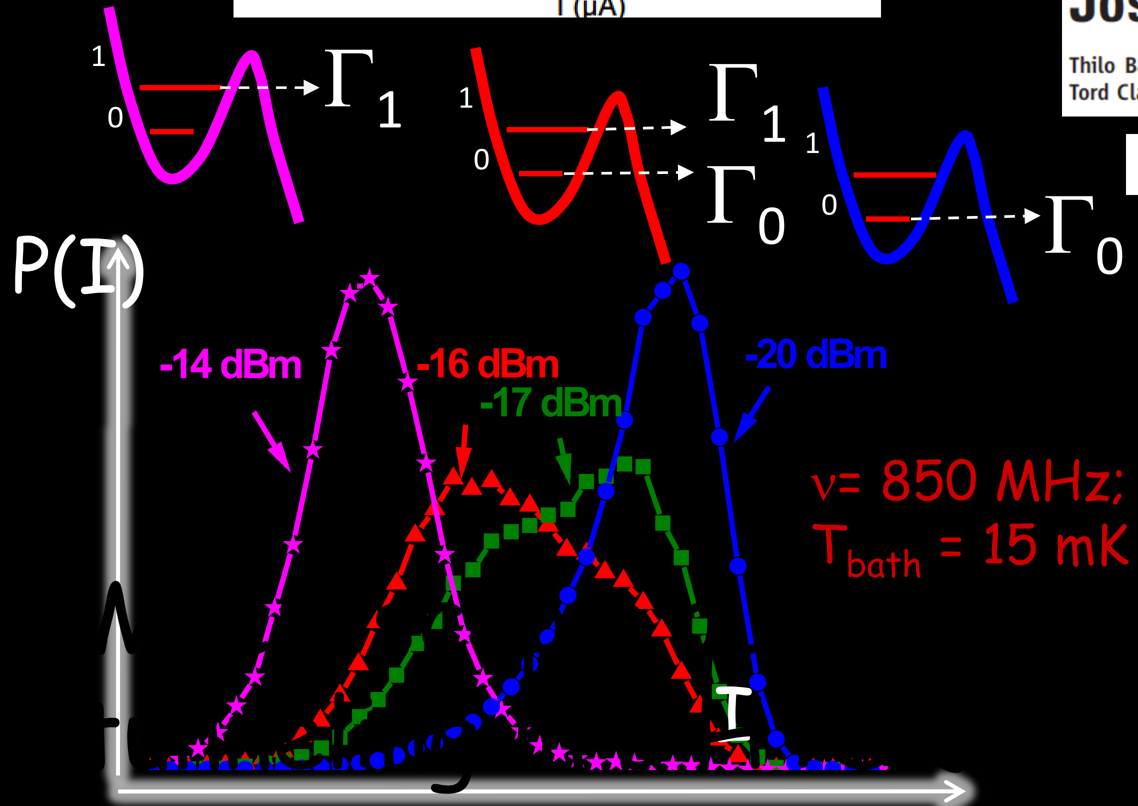


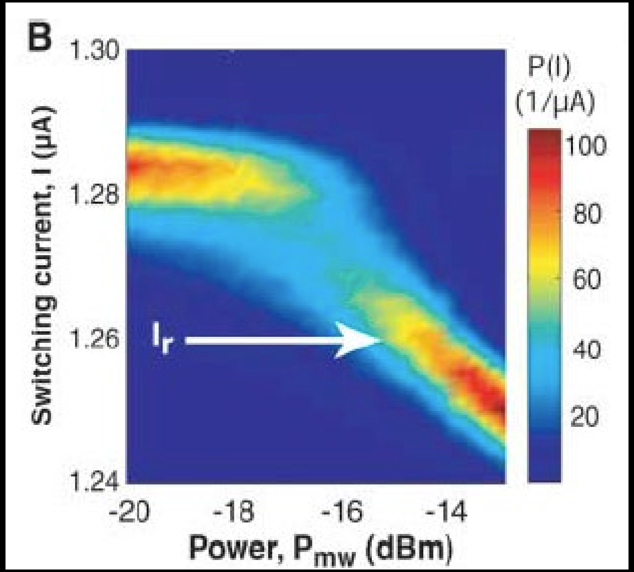


Quantum Dynamics of a d-Wave Josephson Junction

Thilo Bauch,[1] Tobias Lindström,[1] Francesco Tafuri,[2] Giacomo Rotoli,[3] Per Delsing,[1] Tord Claeson,[1] Floriana Lombardi[1]*

SCIENCE VOL 311 6 JANUARY 2006



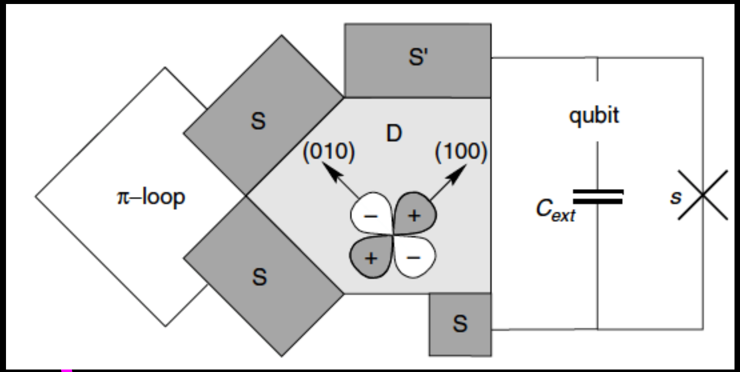


IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at WOLTE-16 2024, June 2024, Cagliari, Italy.

Environmentally decoupled *sds*-wave Josephson junctions for quantum computing

Lev B. Ioffe*‡, Vadim B. Geshkenbein†‡, Mikhail V. Feigel'man‡, Alban L. Fauchère† & Gianni Blatter†

NATURE | VOL 398 | 22 APRIL 1999 | www.nature.com



d-wave order parameter symmetry promotes the notion of a quiet qubit

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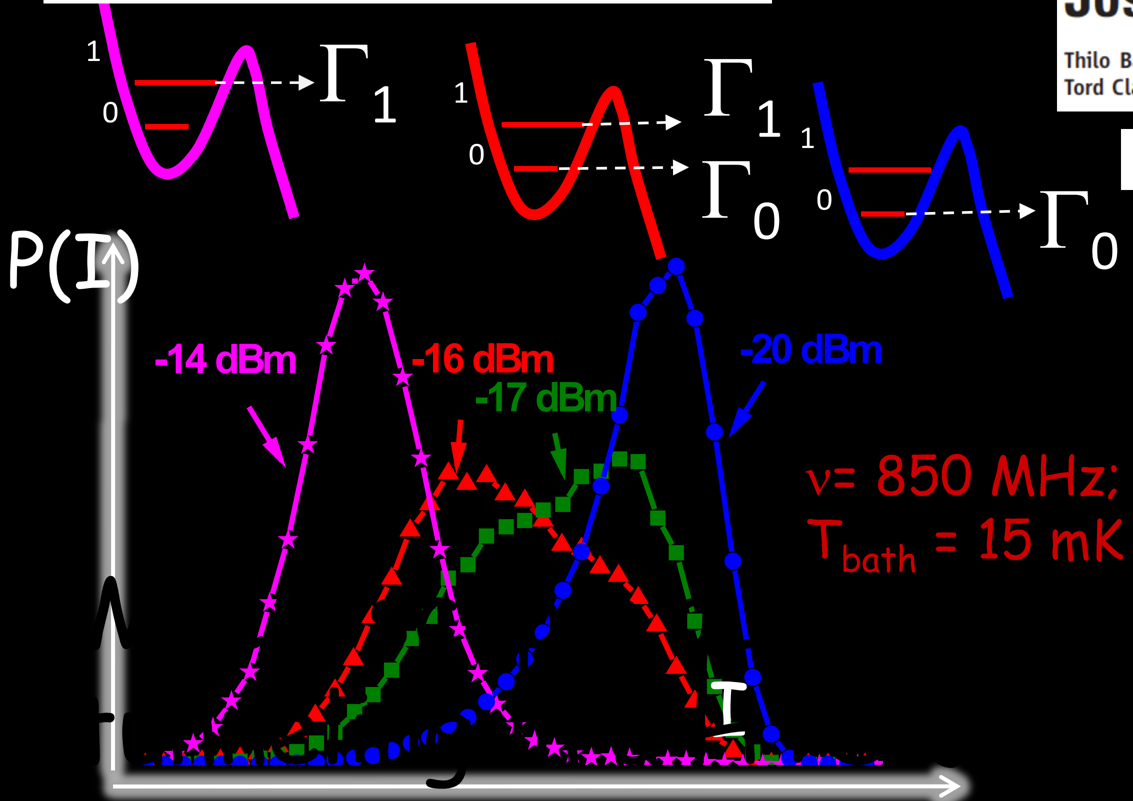
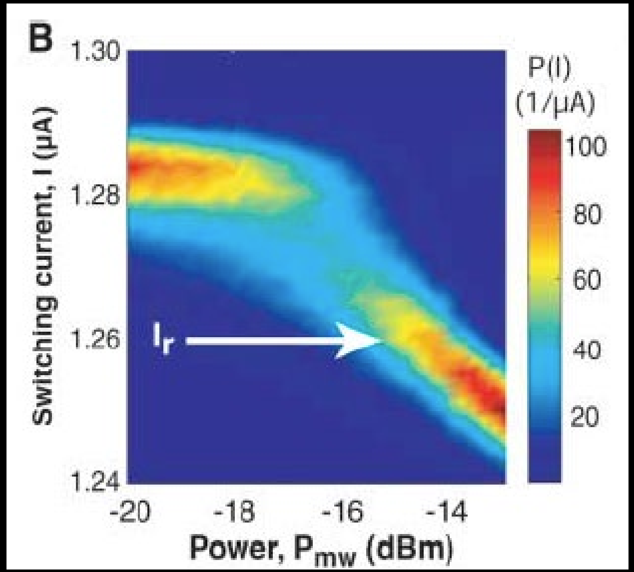
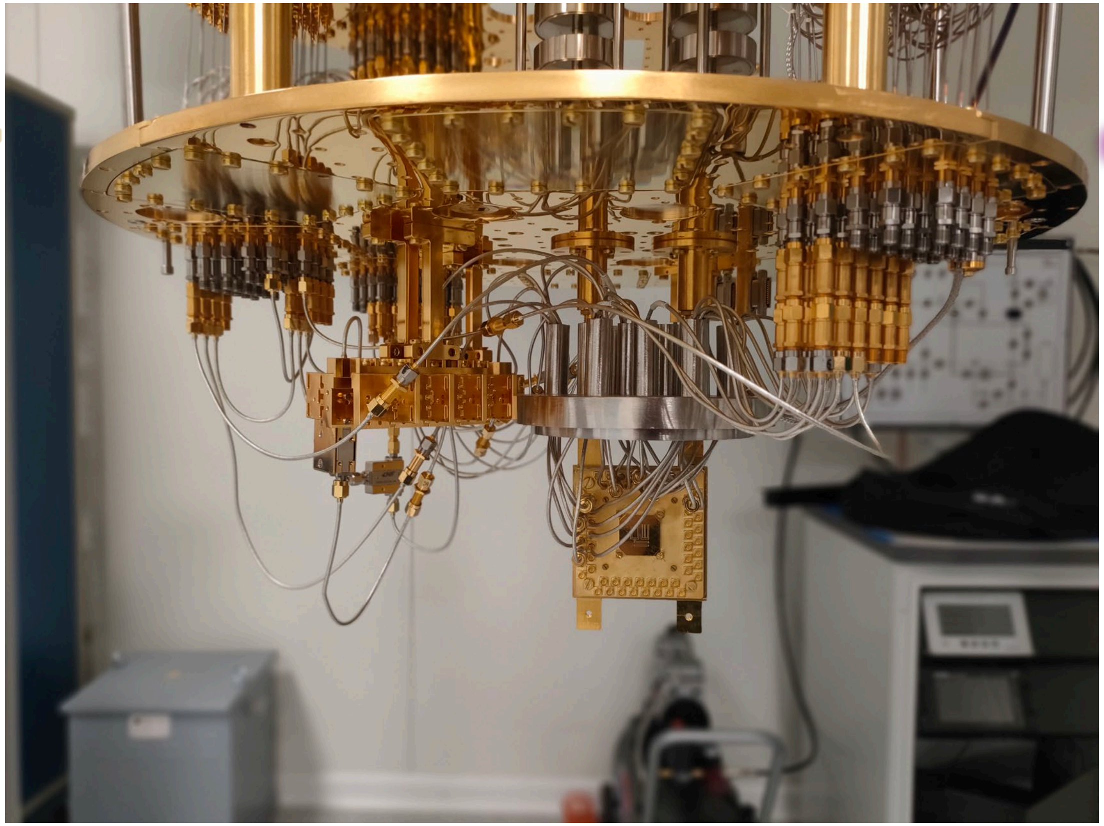
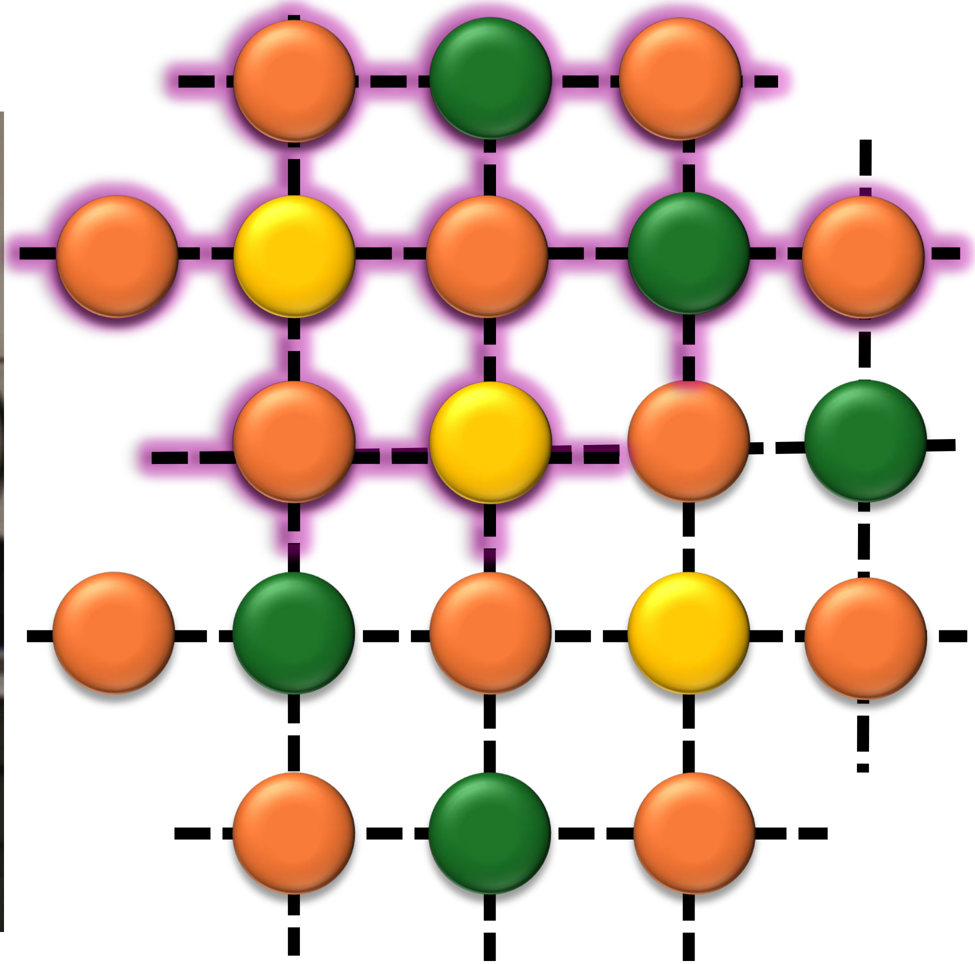




Epilogue





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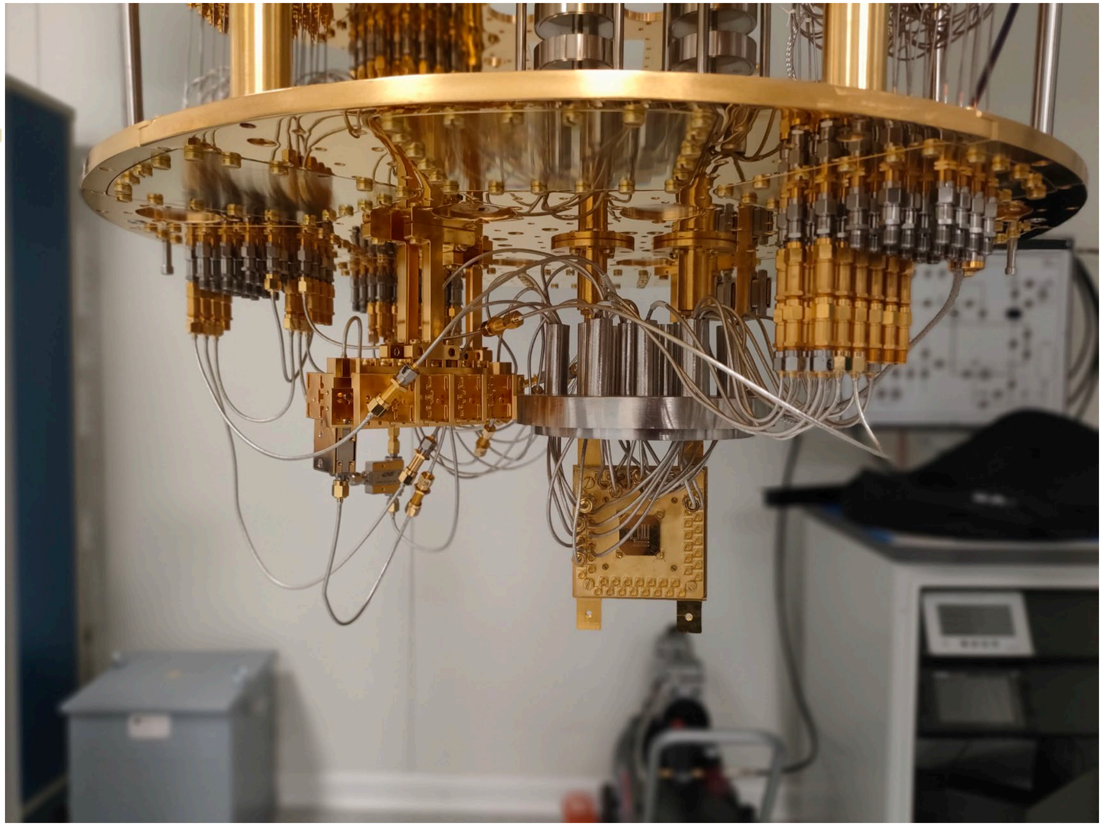

- ✓ 40 qubits by the end of the year
- ✓ external users, in situ and then in the cloud
- ✓ Novel hardware and the ferromon
- ✓ Interface with classical HPC
- ✓ Complete production chain

Increasing the number of qubits for new algorithms!

1224 • 2024
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Università degli Studi di Napoli Federico II

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