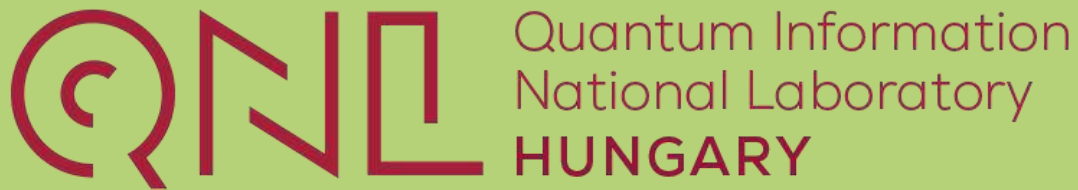


WP3: SZILÁRDTESTFIZIKAI ALAPÚ KVANTUMBIT- TÁROLÓK FEJLESZTÉSE



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MEGVALÓSULÓ
PROJEKT

Determination of current-phase relation of a Josephson junction with μ wave



Josephson junction

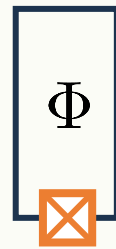
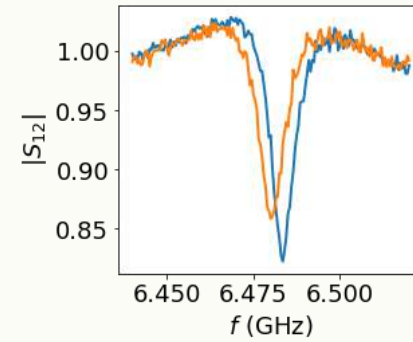
- Current-phase relation: $I_s = f(\varphi)$
- InAs 2DEG, Al contacts
- $10 \times 0.5 \mu\text{m}$
- Gate electrode (AlO_x dielectrics)
→ Tunable critical current
- Superconducting loop (RF SQUID)
→ Phase tuning with \mathbf{B} field

In _{0.81} Ga _{0.19} As (10 nm)
InAs (7 nm)
In _{0.81} Ga _{0.19} As (9 nm)
In _{0.81} Al _{0.19} As barrier (7 nm)
Si δ ($3 \cdot 10^{11} \text{ cm}^{-2}$)
In _{0.81} Al _{0.19} As barrier (43 nm)
In _{0.84} Al _{0.16} As (300 nm)
In _x Al _{1-x} As buffer layer ($0.15 < x < 0.81$) in 24 steps of 50 nm
AlGaAs/GaAs superlattice layer
GaAs (001) substrate

IOM CNR, Giorgio Biasiol

Quarterwave resonator

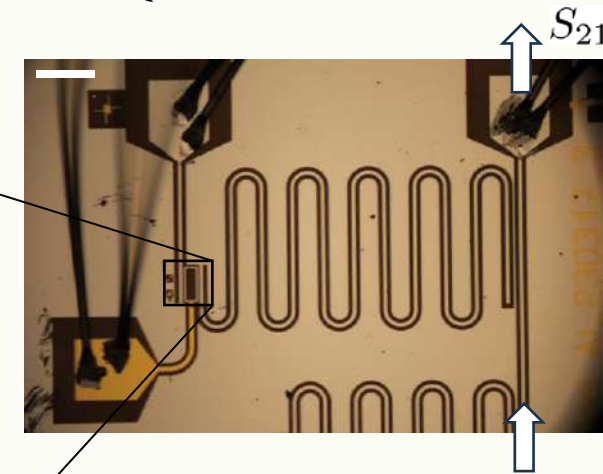
- Epitaxial Aluminum
- $f_0 = 6.5 \text{ GHz}$
- Inductive coupling to the SQUID



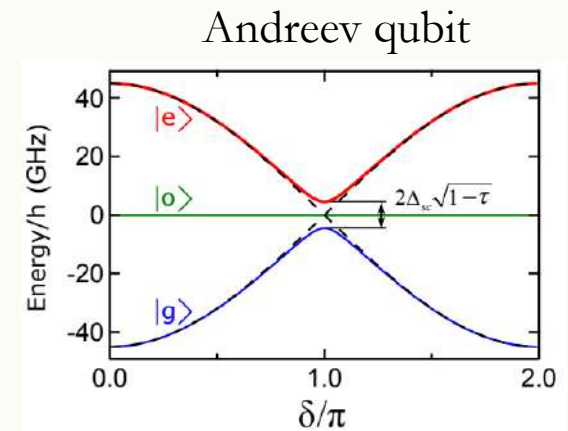
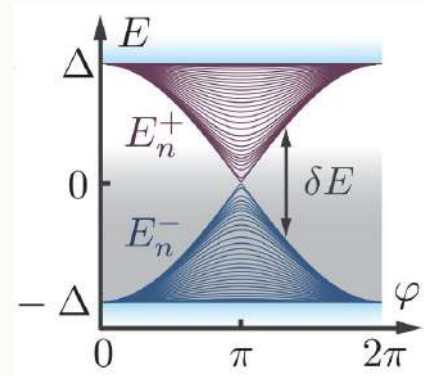
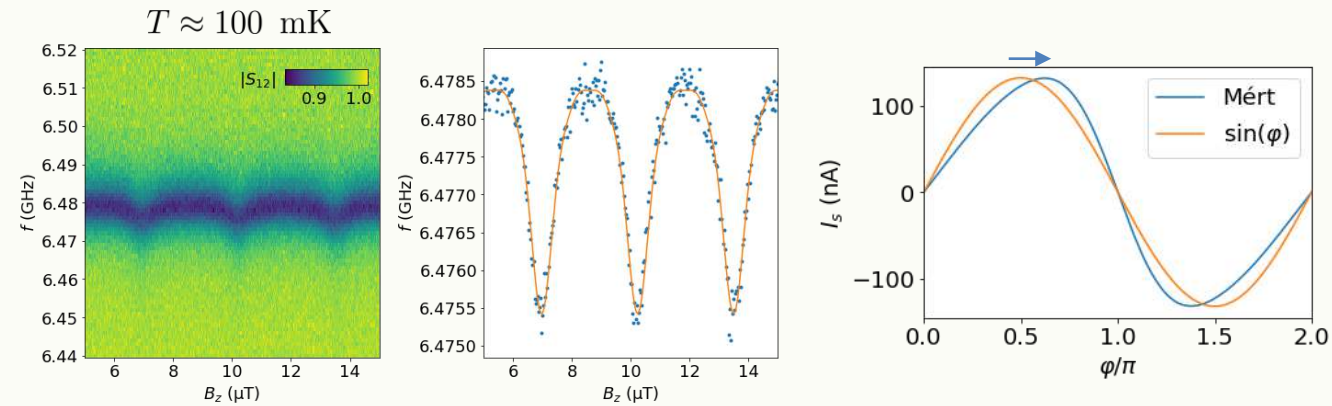
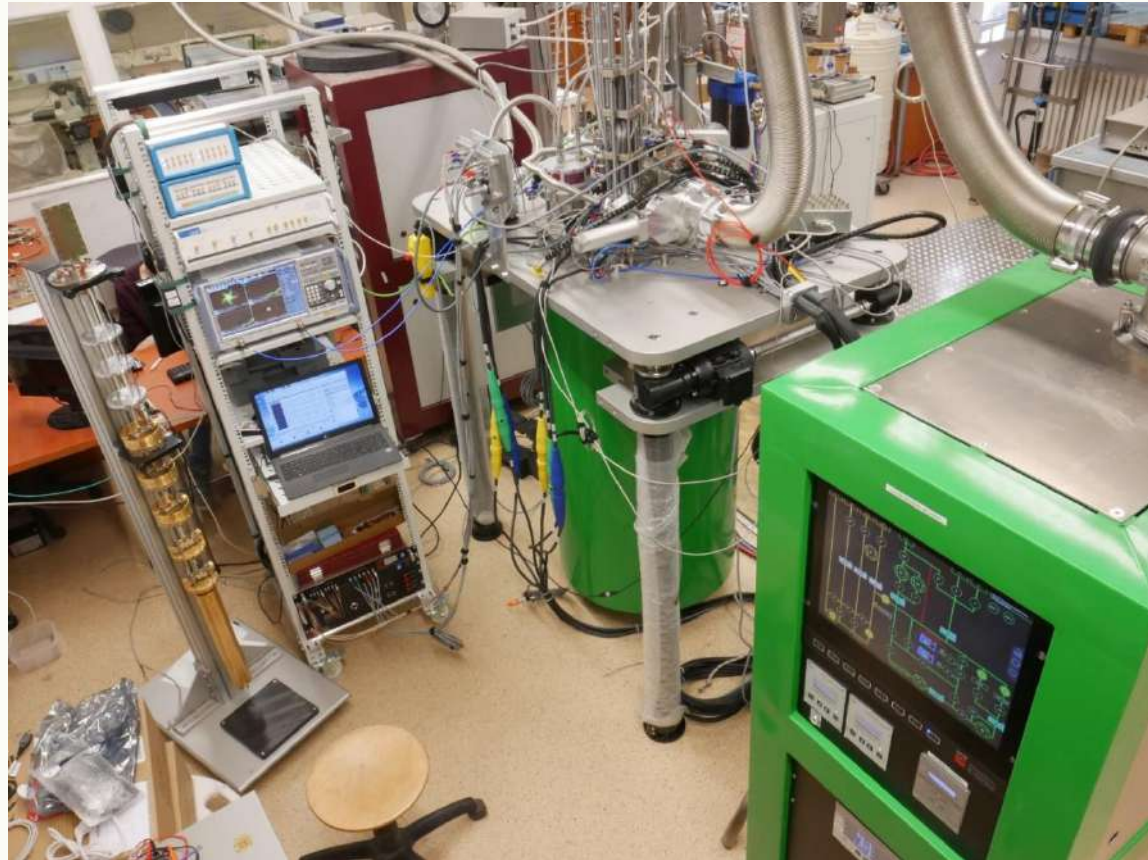
$$\varphi = \frac{2\pi\Phi}{\Phi_0}$$



Sample: Sütő Máté

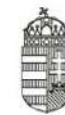


Determination of current-phase relation of a Josephson junction with μ wave



R. Haller, G. Fülöp et al., PRR 4, 013198 (2022)

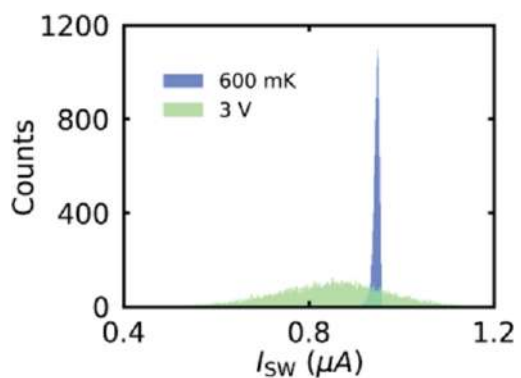
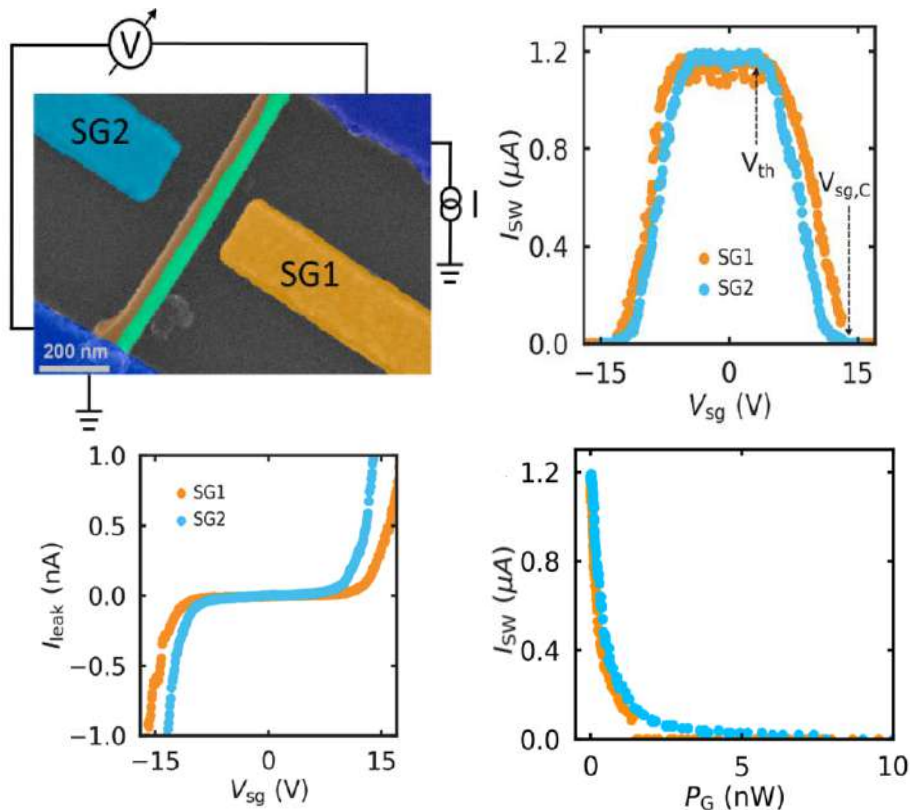
M. Camille Janvier, PhD thesis (2016)



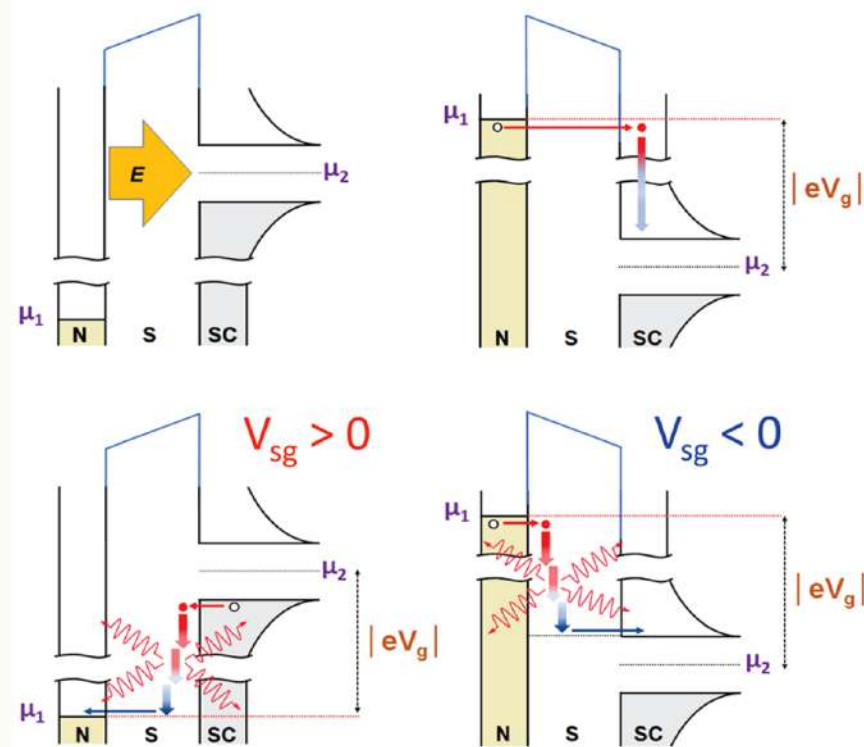
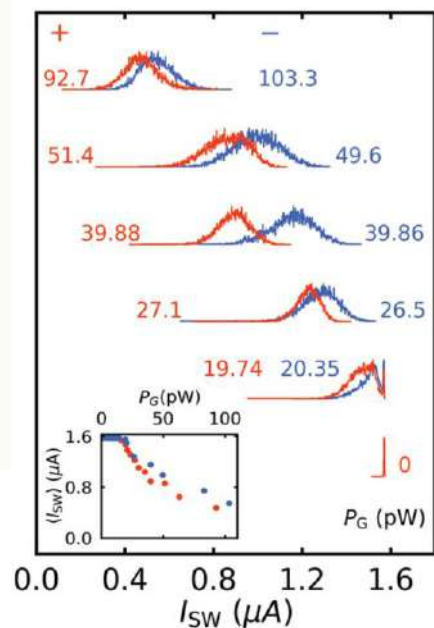
NEMZETI KUTATÁSI, FEJLESZTÉSI
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PROJEKT

Gate-controlled supercurrent (GCS) in Ta/InAs NWs



GCS is not a thermal effect



Out-of-equilibrium phonons \rightarrow high-energy electrons

SG2 with larger separation has stronger influence than SG1 (the origin is not electric field-based)

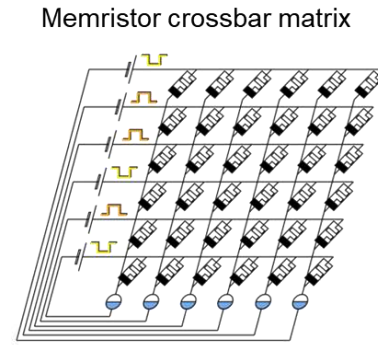
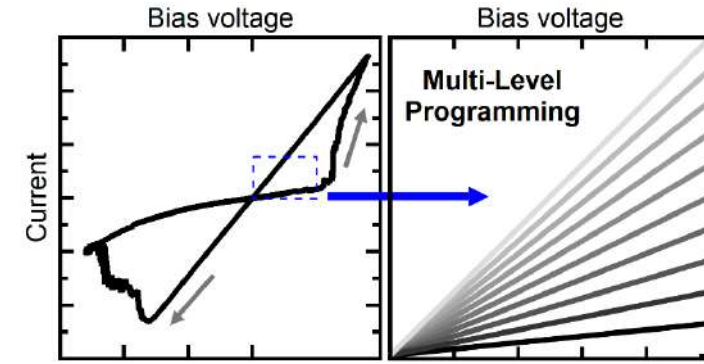
$$P_G = V_{sg} \cdot I_{leak} \text{ is the relevant parameter.}$$

POSTER 57, Berke Martin

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PROJEKT

Quantum transport properties of tantalum oxide based artificial synapses



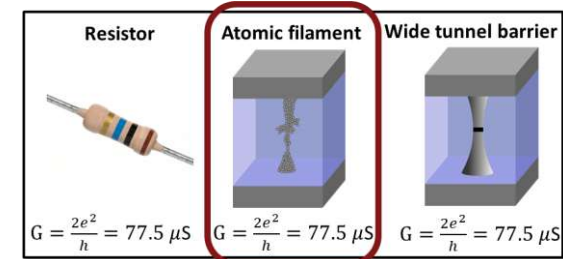
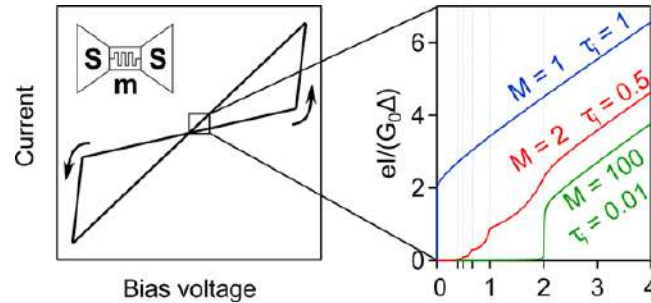
Tantalum oxide resistive switching memory:

- Artificial synapse with multilevel programmability
- Application in artificial neural networks (see poster of G. Fehervari)
- Török et al. *Breaking the Quantum PIN Code of Atomic Synapses*, NANO LETTERS 20, 1192 (2020)
- T.N. Török, P. Makk, Z. Balogh, M. Csontos, A. Halbritter, *Quantum transport diagnostics of tantalum-oxide resistive switching filaments*, arXiv:2302.03214

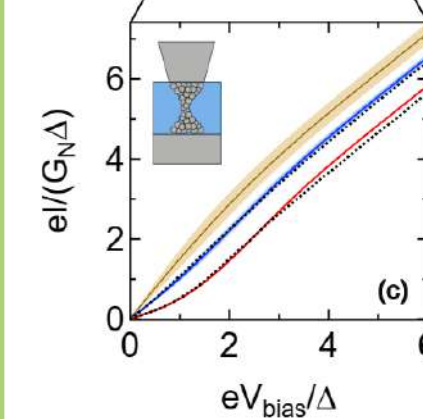
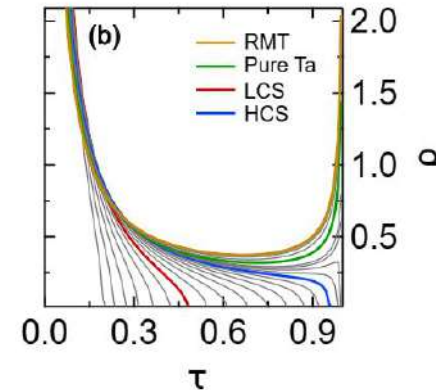
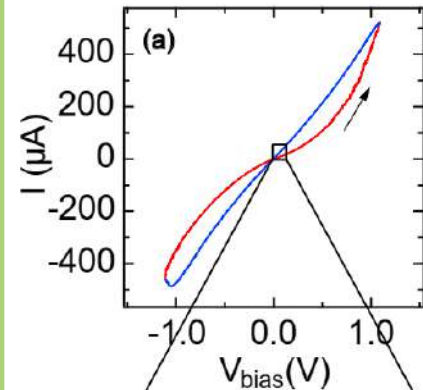
QUANTUM TRANSPORT DIAGNOSTICS

of Tantalum-oxide artificial synapses:

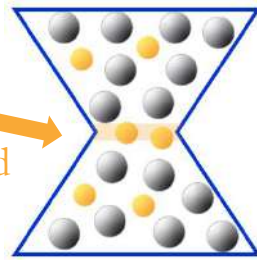
TOOL:
super-
conducting
subgap
spectroscopy



RESULT 1:
synapse with a single-
atom diameter and
single quantum
channel is operational



Formation of an
extended barrier as
the device is switched
OFF

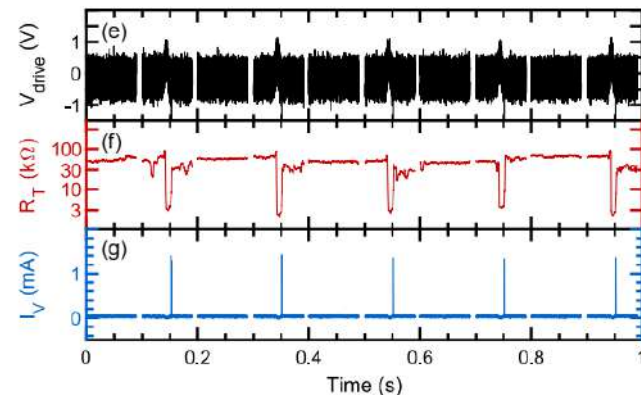
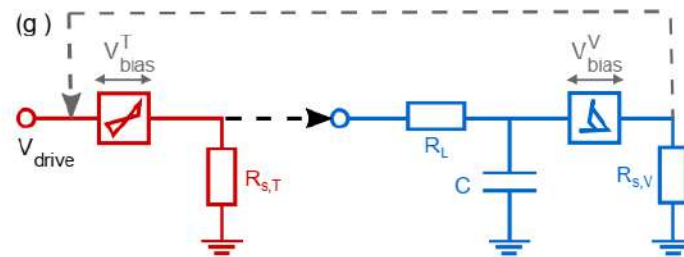
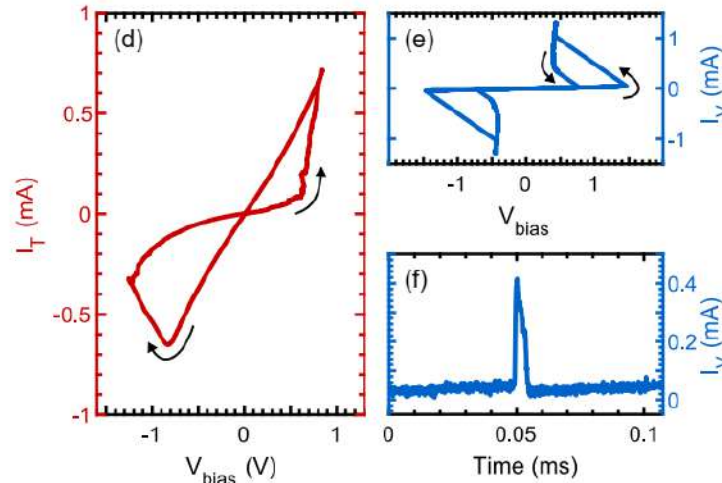
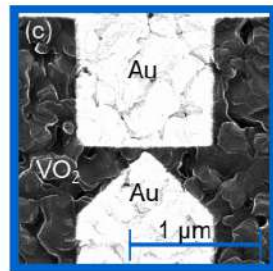
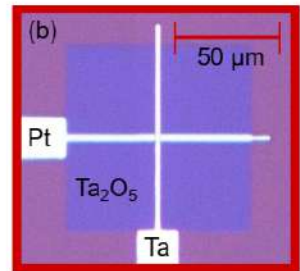
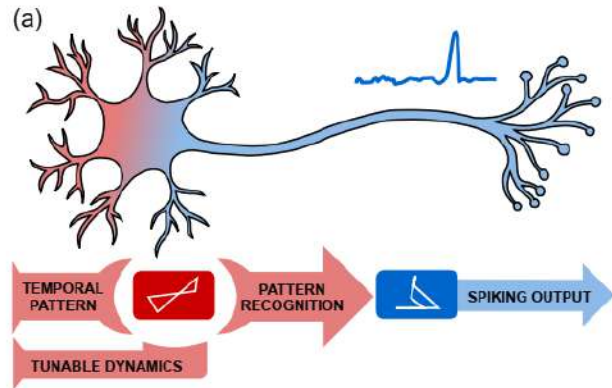


RESULT 2: Insight to the quantum channels in larger filaments, formation of an extended barrier instead of the variation of the diameter

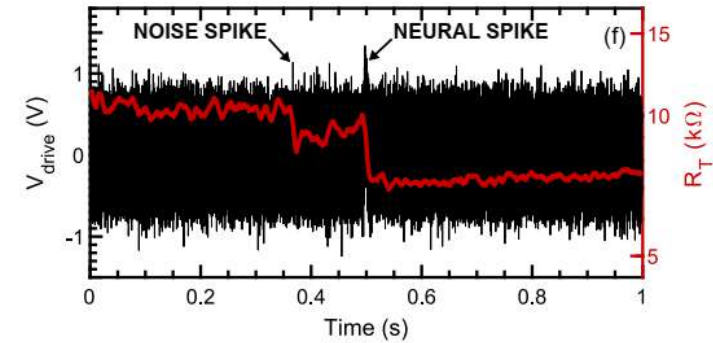
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PROJEKT

Autonomous neural information processing by a dynamical memristor circuit



By the proper tuning of the Ta₂O₅ dynamics a small neural spike will drive the system to a long-term memory state, whereas a noise spike only induces short-term memory



➔ **POSTER 24, MOLNÁR DÁNIEL**

The Ta₂O₅ unit detects the neural spike in a noisy environment, this triggers a spiking output of the VO₂ circuit, which also resets the Ta₂O₅ unit awaiting the next input pattern



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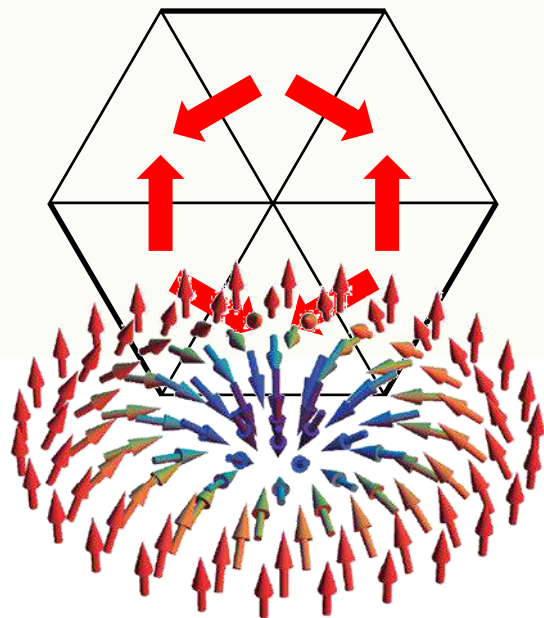
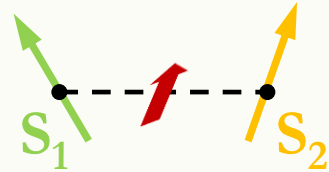
D. Molnár, T.N. Török, R Kövec, L. Pósa,
P. Balázs, Z. Balogh, Gy. Molnár,

N. Jimenez Olalla, J. Leuthold, J. Volk, M. Csontos, A. Halbritter, Autonomous neural information processing by a dynamical memristor circuit (prepared)

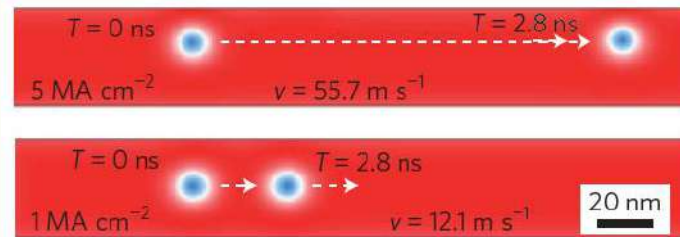
Topologikus spin struktúrák: mágneses skyrmionok

spin-spin kölcsönhatás:

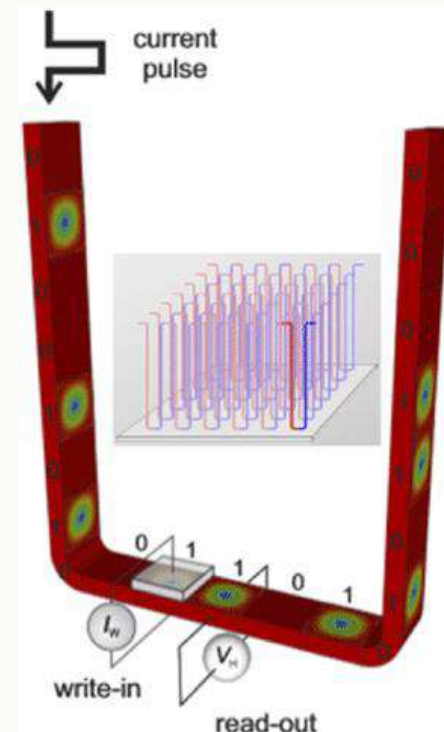
$$-J\mathbf{S}_1 \cdot \mathbf{S}_2 - \mathbf{D} \cdot (\mathbf{S}_1 \times \mathbf{S}_2)$$



A. Fert, et al., Nat. Nano. (2013).



S. S. P. Parkin, et al.,
Science (2008).

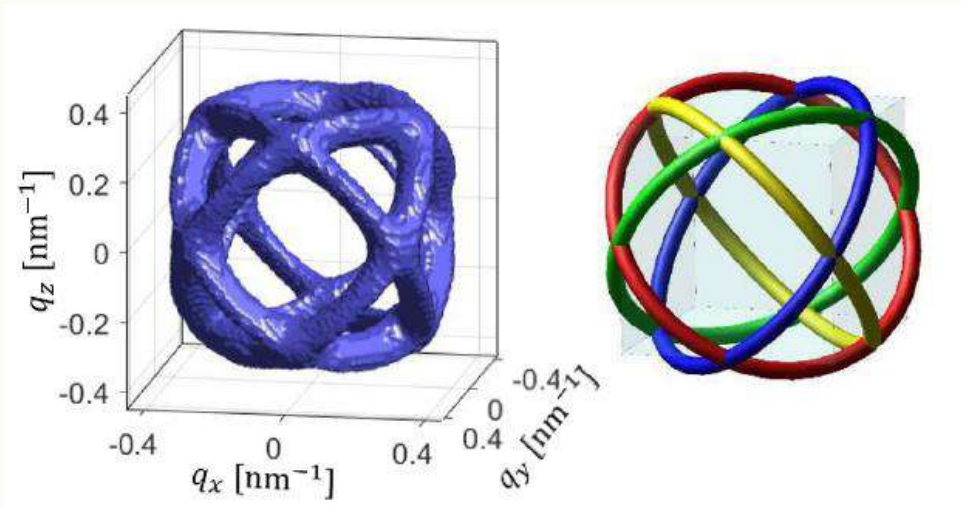


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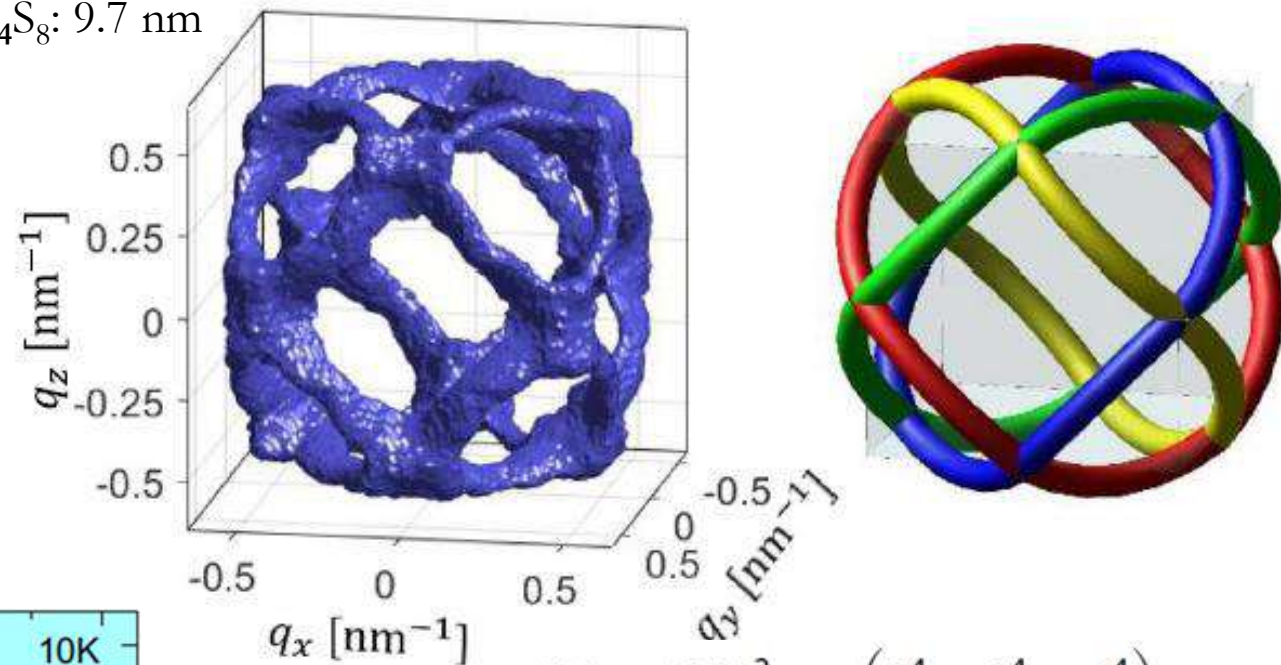
AZ NKFI ALAPBÓL
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Mágneses skyrmionok összezsugorítása a spin-pálya csatolás növelésével

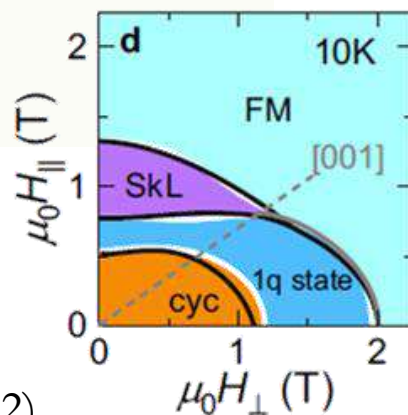
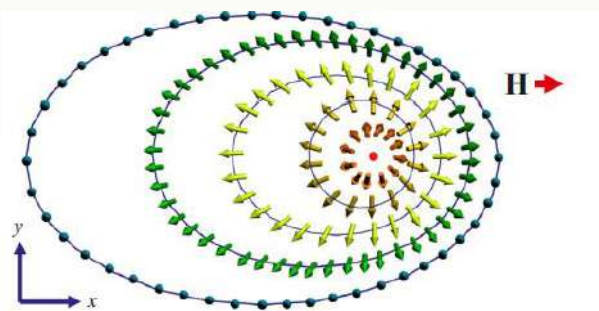
GaV₄S₈: 18 nm



GaMo₄S₈: 9.7 nm



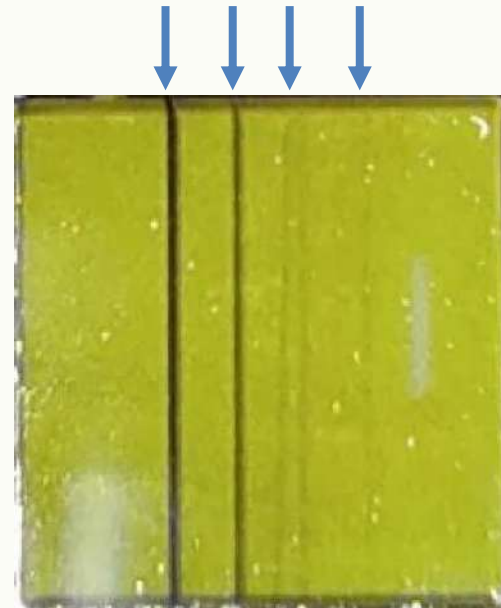
$$\mathcal{V}(\mathbf{q}) = (\hat{\mathbf{n}}\mathbf{q})^2 + a(\hat{q}_x^4 + \hat{q}_y^4 + \hat{q}_z^4) + \dots$$



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ODMR studies in NV centers in cryogenic conditions



Patterned NV centers in diamond

ATOMKI: Tandetron, focused p -beam
Rajta István, Gaál Zoltán

Studies

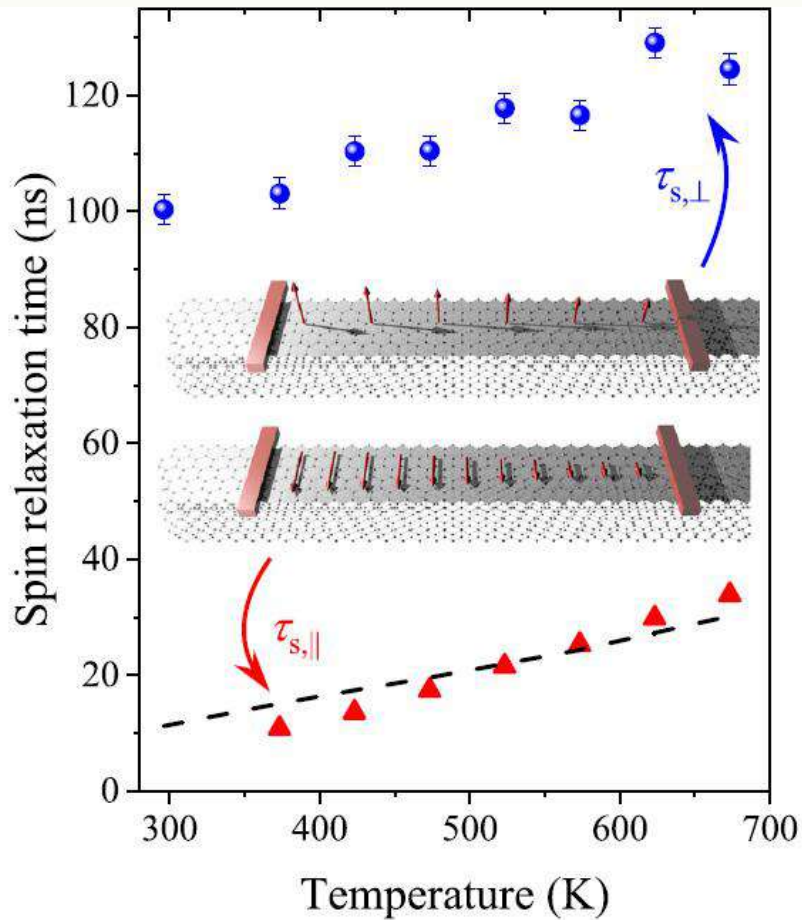
BME: ODMR, ESR

Wigner: Raman/PL (Himics László,
Veres Miklós)

Theory (Gali Ádám)

Extension of ODMR with a Janis cryo-free optical cryostat. Home-made 3 axis positioning of the cryostat block

Ultralong spin-relaxation lifetime in graphite



Evidence from saturation ESR
Supported by DFT calculations (M. Gmitra and J. Fabian)

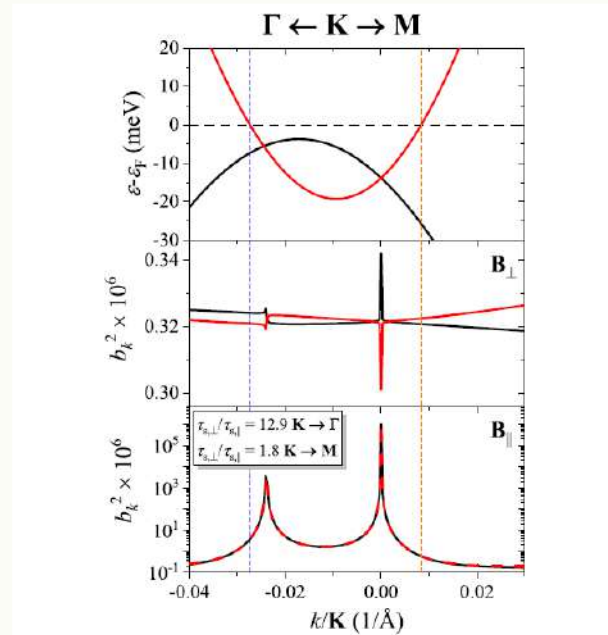


Fig. 1 | Top: calculated low-energy electronic band structure of graphite at K along the lines towards Γ and M points. Note the band degeneracy near the K point. Middle and bottom: spin-mixing parameters b_k^2 for the spin quantization (magnetic field B) along c and in the plane (a, b), respectively. Also indicated are the spin relaxation anisotropies for the momenta at the vertical dashed lines, implied by the calculated b_k^2 there.

B. G. Márkus *et al.* Nat. Comm. **14**, 2831 (2023).



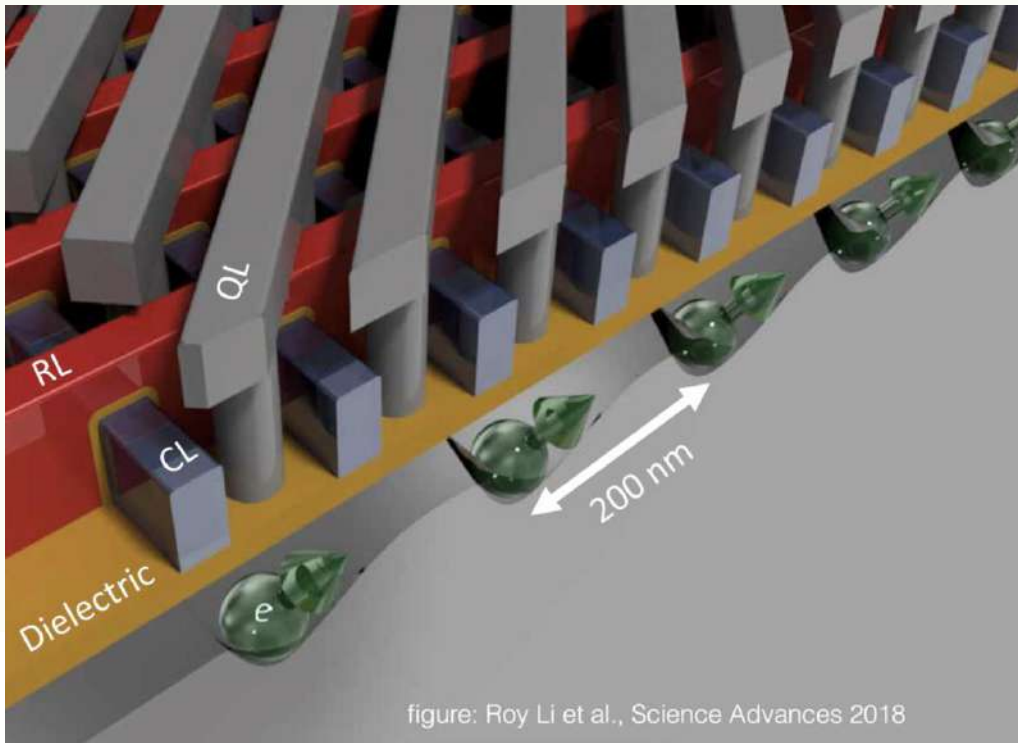
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PROJEKT

Electrically driven spin-qubit control with bichromatic driving

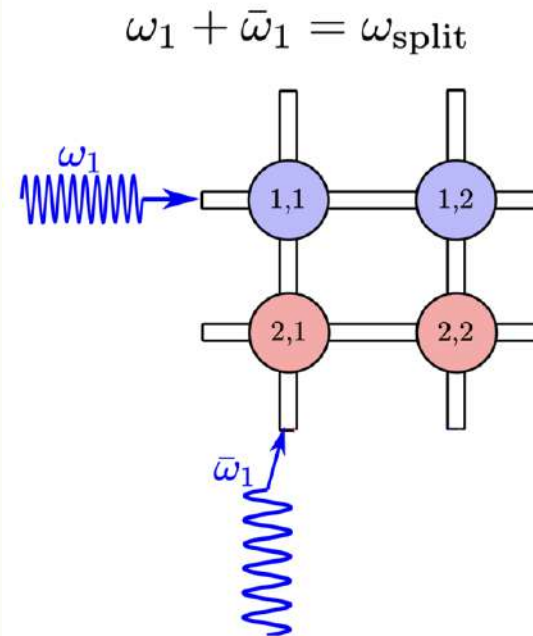
Z. György, A. Pályi, G. Széchenyi, Electrically driven spin resonance with bichromatic driving, Phys. Rev. B 2022

Crossbar architecture: could relax the wiring problem

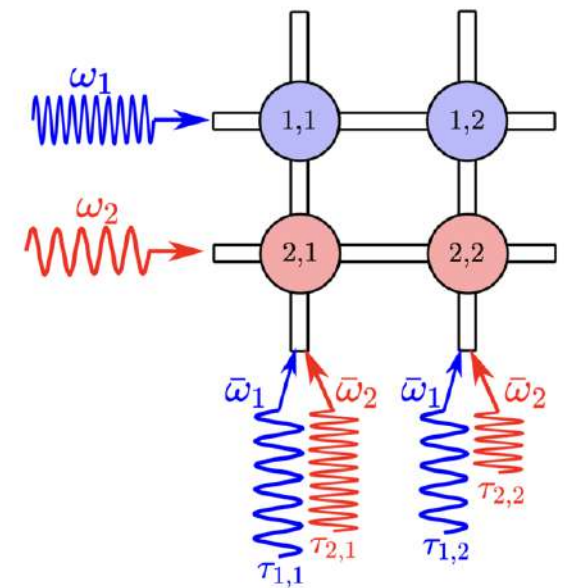


Bichromatic excitation in a crossbar qubit array can be used for ...

... selective addressing of qubits



... parallelization of qubit operations



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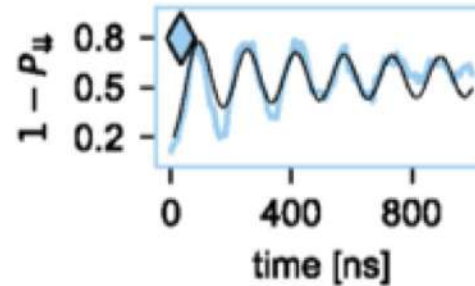
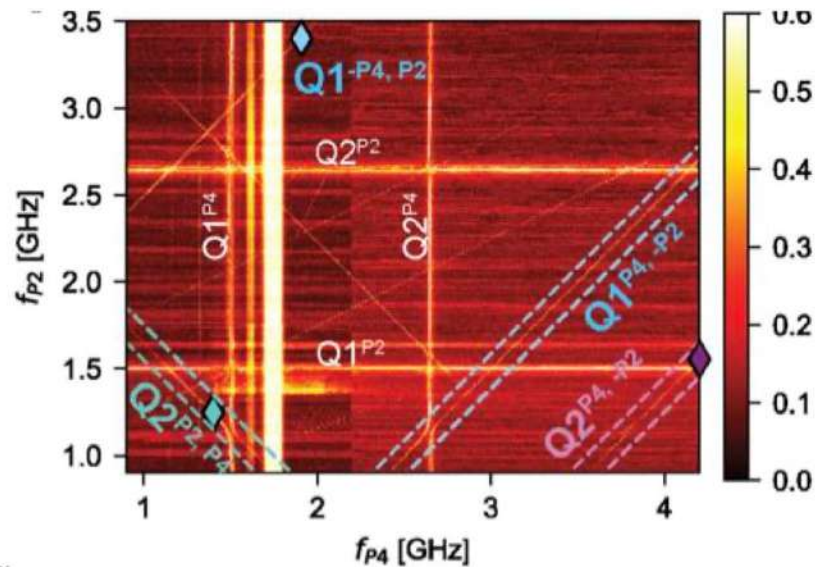
Electrically driven spin-qubit control with bichromatic driving

Z. György, A. Pályi, G. Széchenyi, Electrically driven spin resonance with bichromatic driving, Phys. Rev. B 2022

Bichromatic Rabi control of semiconductor qubits

Valentin John,¹ Francesco Borsoi,¹ Chien-An Wang,¹ Zoltán György,² Gábor Széchenyi,² Floor van Riggelen,¹ William I. L. Lawrie,¹ Amir Sammak,³ Nico W. Hendrickx,¹ Giordano Scappucci,¹ András Pályi,^{4,5} and Menno Veldhorst¹

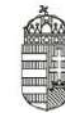
QNL Quantum Information National Laboratory HUNGARY



Bichromatic spin control has been confirmed experimentally by Delft group⁵

Joint QNL – TU Delft manuscript combining theory and experiment to be submitted in June 2023.

2021



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