TopoGraph

Engineering topological superconductivity in graphene

FLAG-ERA

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Engineering topological superconductivity in graphene

TUDelft (Netherlands)

BME-Eötvös (Hungary)

CSIC (Spain)

Overview

- The road to Quantum Computation
  - Cold atoms
  - NV centers in diamond
  - Spin Qubits
  - Superconducting Qubits
  - Topological Qubits (Majorana)
    - Atomic chains
    - Semiconducting nanowires
    - Epitaxial semiconductors
    - 2D crystals?

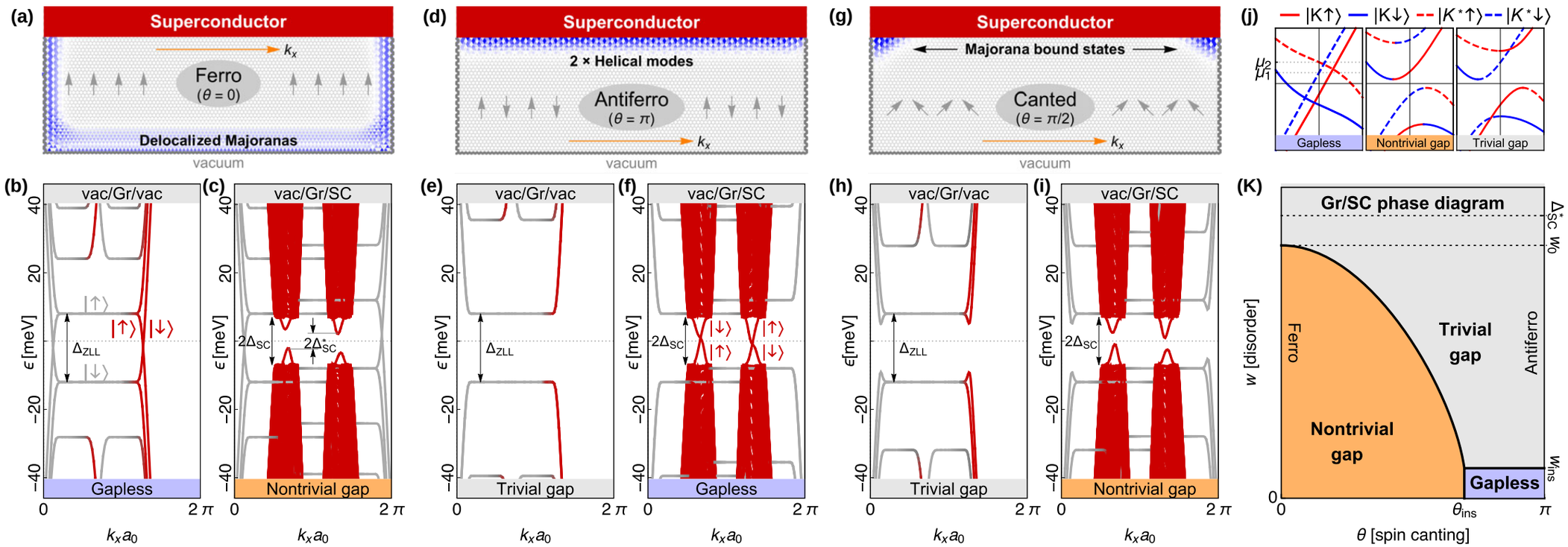
Goals

- *"To develop the basic components for graphene-based topological qubits"*
- Topological superconductivity and Majoranas in graphene

PHYSICAL REVIEW X **5,** 041042 (2015)

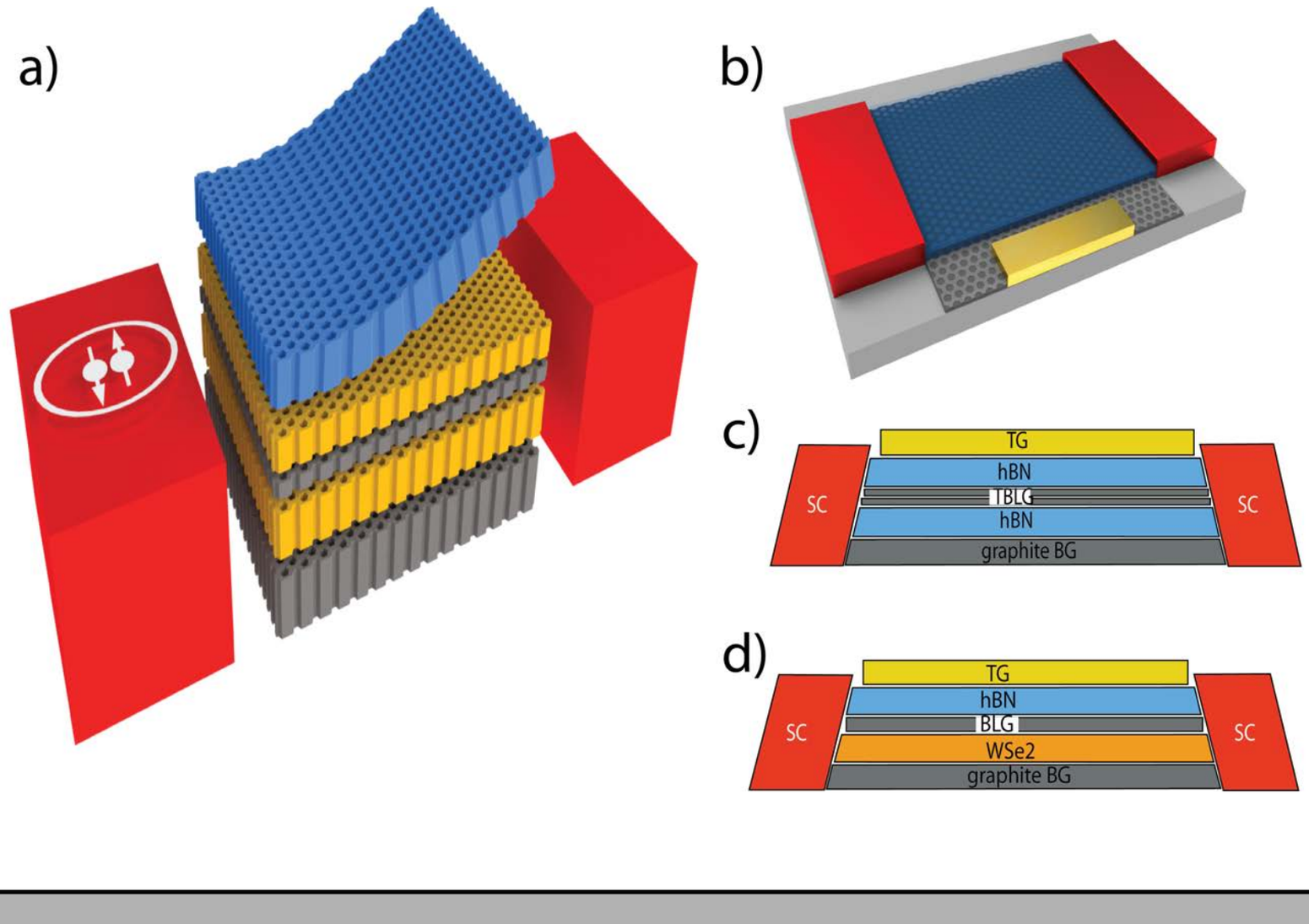
Majorana Zero Modes in Graphene

P. San-Jose,[1] J. L. Lado,[2] R. Aguado,[1] F. Guinea,[3,4] and J. Fernández-Rossier[2,5]



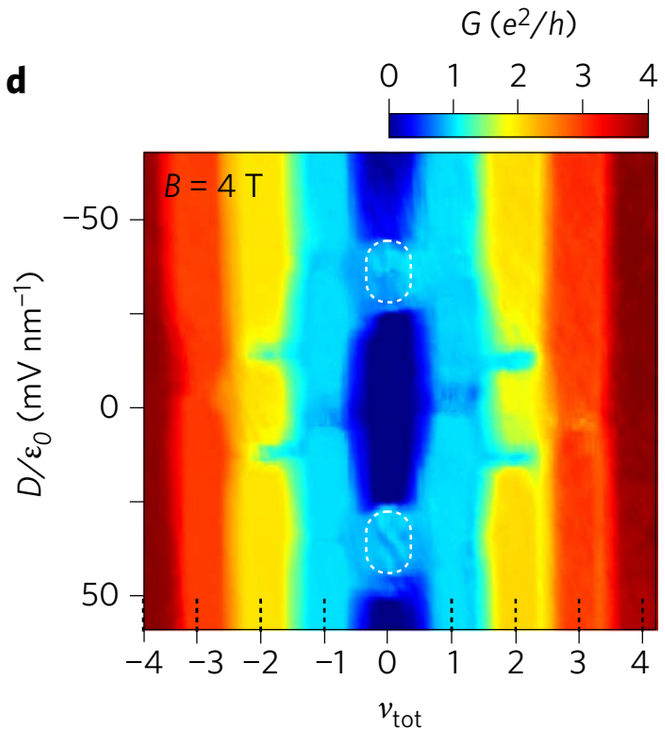
Goals

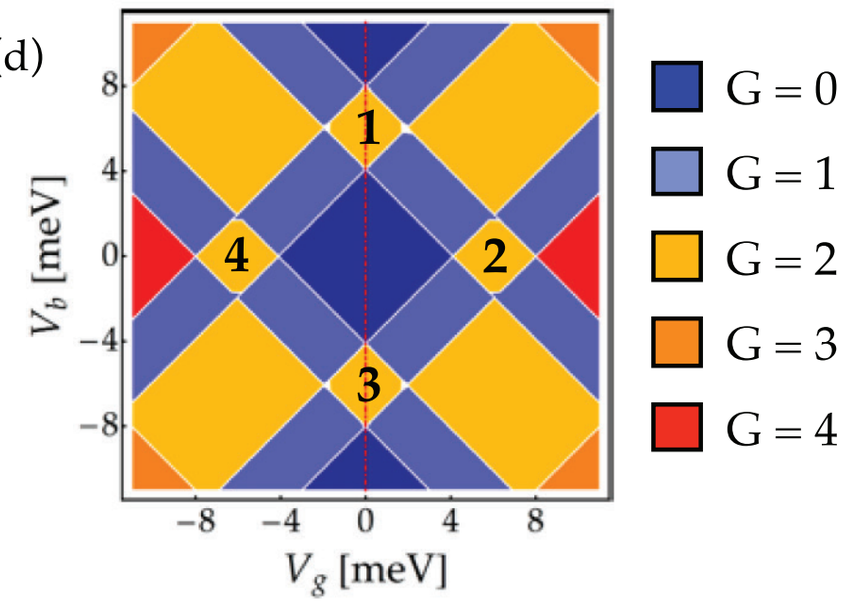
- Requirements:
  - High-mobility, low-disorder crystals: **encapsulation**
  - Induced superconductivity: **clean lateral contacts**

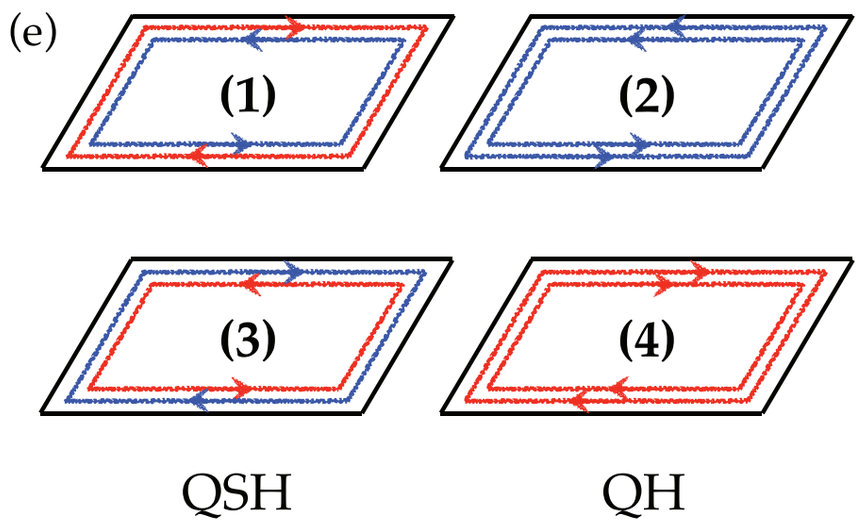


Goals

- Requirements:
  - Quantum Spin Hall effect (QSHE)
    - With spin-orbit coupling (SOC): induced by substrate
    - Without SOC: bilayer + interactions + Quantum Hall

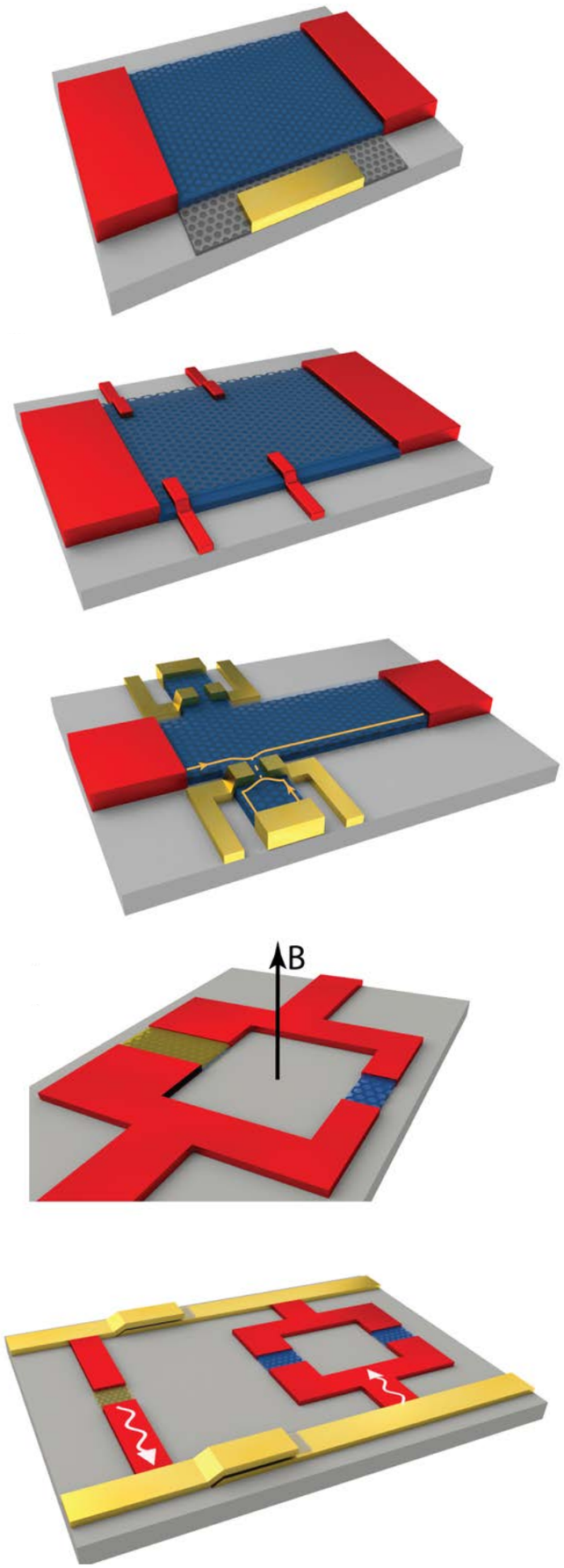






Methods

- Fabrication
  - Dry pickup method for encapsulation (hBN, TMDC)
  - Edge contact method (MoRe and NbTiN)
- Measurement
  - Local tunnelling spectroscopy
  - Current-phase relations in SQUID geometry
  - Fraunhofer patterns
  - Microwave spectroscopy
- Simulation
  - MathQ / QBox.jl codes (CSIC)
  - EQuUs codes (BME)



Work Packages

- WP1: Design and optimisation of basic components
  - Characterise substrate-induced SOC (WSe2)
  - Optimise SC contacts
  - Optimise geometries
- WP2: engineer QSHE+SC, with SOC induced by substrate
  - Topological phase diagram (CPR, WAL, Shapiro, microwave, tunnel…)
- WP3: engineer pseudo-QSH+SC on bilayer graphene in the QH regime
  - Topological phase diagram (CPR, WAL, Shapiro, microwave, tunnel…)

No of Milestone	Delivery month	WP involved	Title
M1	12	1	QSH state with SC contacts observed
M2	24	1	Benchmark of new codes for critical currents
M3	30	2,3	Demonstration of MBSs from ABS measurements
M4	36	2,3	Demonstration of MBSs using current-phase relation measurements

Resources

Partner 1 (Coordinator): [BME, Hungary]			
Type	Item description and justification	Total cost	Requested
Personnel	1 PhD – 36 PM or 2 *1/2 PhD for 36, etc. (see text)	40’000	20’000
Travel		14’000	13’000
Consumables		35’000	20’000
Equipment		55’000	42’000
Subcontracting	Cleanroom-fee, maintenance fee, etc.	11’000	7’000
Others	Open access publication fee, etc.	2’000	2’000
Overheads		9’000	21’000
Total (as also entered in the online submission system):		187’000	125’000

Partner 2: [CSIC, Spain]			
Type	Item description and justification	Total cost	Requested
Personnel	1 Postdoc – 24 PM	82’000	82’000
Travel		9’000	9’000
Consumables		1’000	1’000
Equipment	1 laptop, 1 workstation, 1 monitor	10’000	10’000
Subcontracting			
Others	Open access publication fee	3’000	3’000
Overheads	(Not eligible in this call)		
Total (as also entered in the online submission system):		105,000	105,000

Partner 3: [TU Delft, Netherlands]			
Type	Item description and justification	Total cost	Requested
Personnel	1 Postdoc – 36 PM	207117	207117
Travel		11383	11383
Consumables		28500	28500
Equipment	Glove box	80000	80000
Subcontracting		0	0
Others	Open access publication fees	3000	3000
Overheads		0	0
Total (as also entered in the online submission system):		330000	330000

Project start
1st May 2018

Project type
Experiment + Theory

Project duration
36 months

Team size
8 + 3 in 3 nodes

Total person/month
198

Total budget
560 K€