2019 NSF/DOE/AFOSR Quantum Science Summer School
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QS^3 2019
Question Session 2

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Test of Response System

Question 0

Does this response system work correctly?

A. Yes
B. No

Test of Response System

Question 0

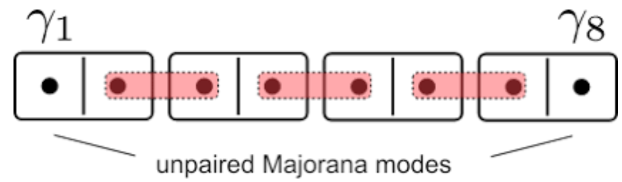
Does this response system work correctly?

A. Yes

Yes this works

Topological Superconductivity

Question 1



What happens if we remove the last Majorana site of a Kitaev chain in the topological phase?

1. We get a chain with a single Majorana mode
2. We cannot remove a single Majorana site because electrons (pairs of Majoranas) are the only physical degrees of freedom
3. The Hamiltonian becomes topologically trivial
4. Removing a single Majorana is not allowed by particle-hole symmetry

A) 1

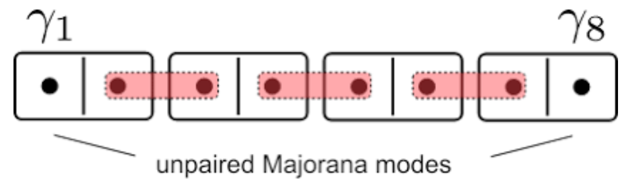
B) 2

C) 3

D) 4

Topological Superconductivity

Question 1



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Topological Superconductivity

Question 2

Particle-hole symmetry in the Bogoliubov-de Gennes Hamiltonian implies

1. There can be no state at zero energy
2. The bands at positive energy mirror the bands at negative energy
3. Crossing at zero energy is allowed

A) 1

B) 2

C) 3

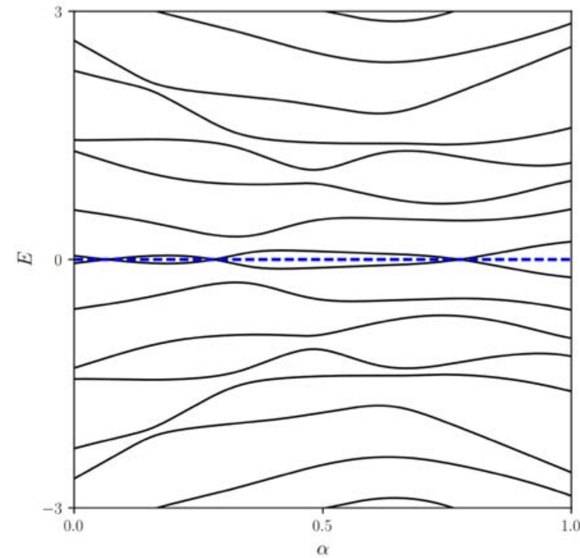
D) 1 and 2

E) 2 and 3

Topological Superconductivity

Question 2

Particle-hole symmetry
in the Bogoliubov-de Gennes
Hamiltonian implies



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Topological Quantum Computing

Question 3

The two ends of a single topological nanowire such as InAs or InSb realize

1. A pair of Majorana fermions
2. Topological degeneracy
3. Non-abelian statistics
4. A topological qubit

A) 1

B) 2

C) 3

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Topological Quantum Computing

Question 3

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2D Heterostructures

Question 4

How to improve properties of graphene?

1. Use highly purified carbon for graphite, and then exfoliate

2. Use CVD growth with purified carbon

3. Exfoliate graphene and then transfer it on boron nitride

A) 1

B) 2

C) 3

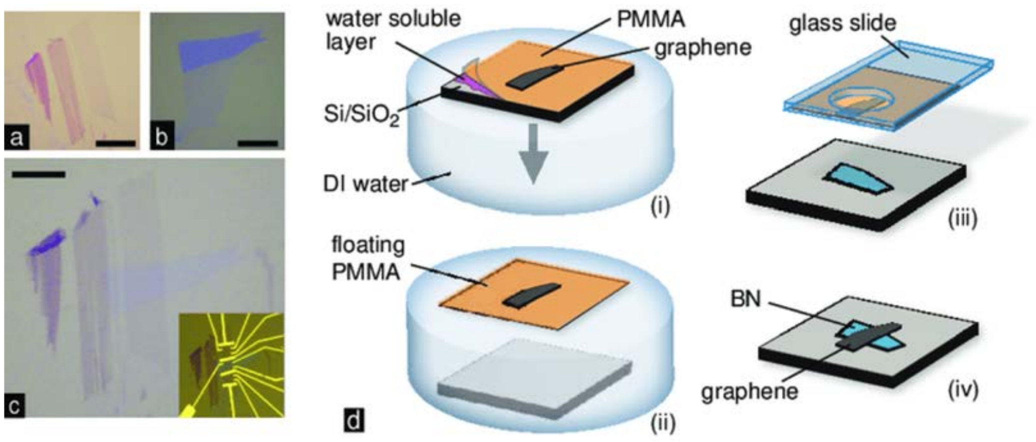
D) 1 and 2

E) 2 and 3

2D Heterostructures

Question 4

How to improve properties of graphene?



A) 1

B) 2

C) 3

D) 1 and 2

E) 2 and 3

Intrinsic TMD

Question 5

What are the effects of reducing the number of layers on the electronic structure of MoS_2?

1. Electronic bands split into spin-up and spin-down bands for the single layer.

2. The band gap becomes a direct gap

3. For a single layer a Dirac cone is formed at the Fermi energy

A) 1

B) 2

C) 3

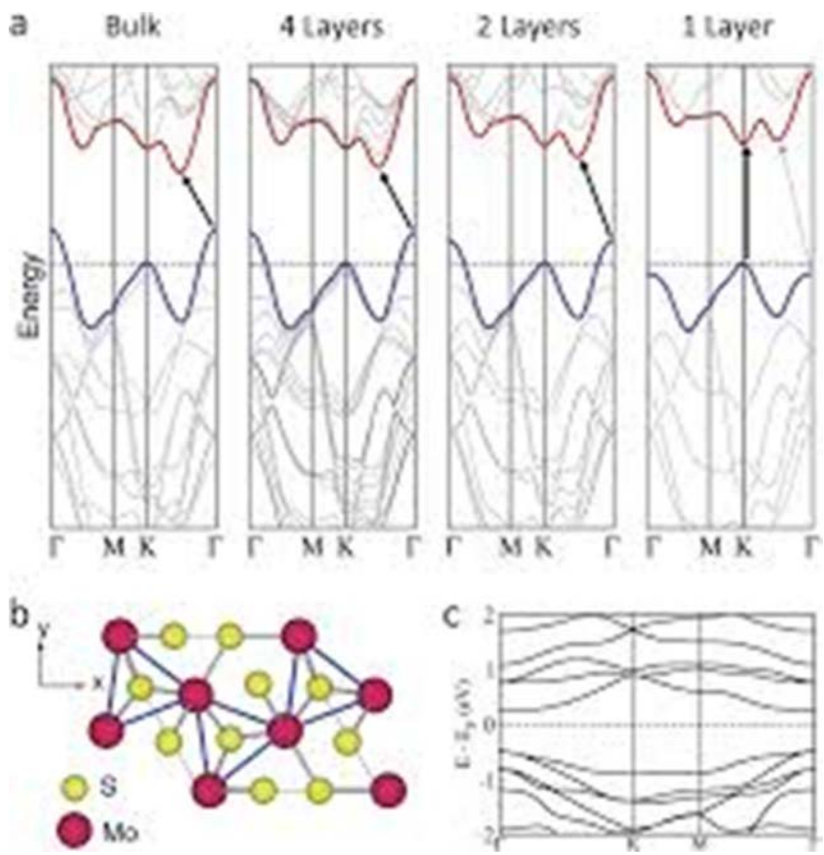
D) 1 and 2

E) 2 and 3

Intrinsic TMD

Question 5

What are the effects of reducing the number of layers on the electronic structure of MoS_2?



A) 1

B) 2

C) 3

D) 1 and 2

E) 2 and 3

2D TMD semiconductors

Question 6

What is the (order of magnitude) binding energy and size of 1s excitons in a monolayer TMD semiconductor?

1. 10 meV and 100 nm
2. 100 meV and 1nm
3. 10 meV and 1 nm
4. 100 meV and 100nm
5. 10 eV and 1 nm

A) 1
B) 2
C) 3
D) 4
E) 5

2D TMD semiconductors

Question 6

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2D TMD semiconductors

Question 7

Pump-probe Kerr rotation measurements of monolayer TMD probe the lifetime of X, and the time scale is Y.

1. X= e-h recombination time, Y= 1-10 ps
2. X= spin relaxation of electron, Y= 100 ns
3. X= spin/valley locked relaxation of hole, Y= 1 us
4. X= interlayer exciton lifetime in a WSe_2/MoS_2 heterostructure, Y = 1us

A) 1

B) 2

C) 2 and 3

D) 3 and 4

E) 2, 3 and 4

2D TMD semiconductors

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Valleytronics

Question 8

Exciton-based valleytronic computing could offer a material improvement over existing silicon CMOS due to

1. Sub 14nm device size
2. Operating frequency above 4 GHz
3. Strong exciton binding energy
4. Atomically thin channel
5. Reduced switching energy

A) 1

B) 2

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Valleytronics

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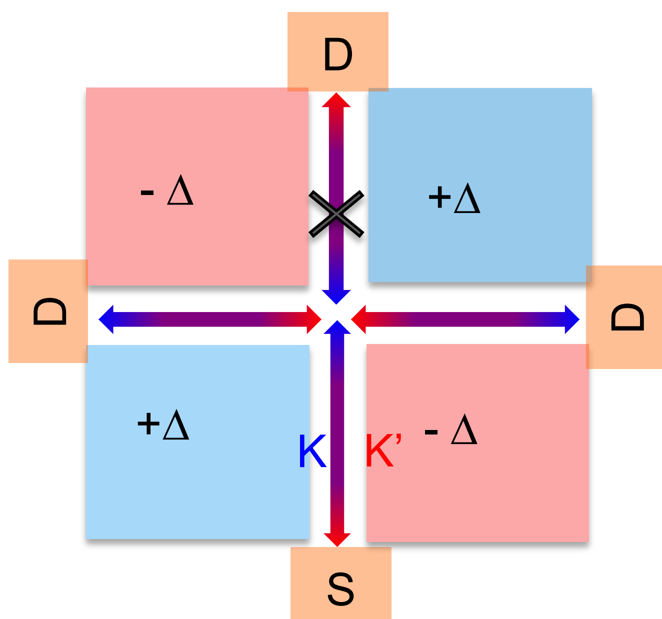
Topological Valleytronics in Bilayer Graphene (Zhu Lab)

1. First make valley-momentum locked topological 1D channels in bilayer graphene (quantum valley Hall effect)

2. Change the topology to control the way valley and momentum are locked.

3. Topological valley valve and beam splitter



https://youtu.be/thJpzhYkO7Y

https://www.youtube.com/watch?v=Bj6IIDBadME&t=1s

https://www.youtube.com/watch?v=iOsout7aVGc

J. Li… JZ, *Nature Nano*. 11, 1060 (2016).
J. Li… JZ, *Science* 362, 1149 (2018).

Spin Transfer Torque Based Magnetic Random Access Memory

Question 9

What are the fundamental challenges of STT-switched MTJs

1. Switching speed
2. Data retention over a long period of time
3. Reliability of switching (error rate < 10^{-9})

A) 1

B) 3

C) 1 and 2

D) 2 and 3

E) All of them

Question 9

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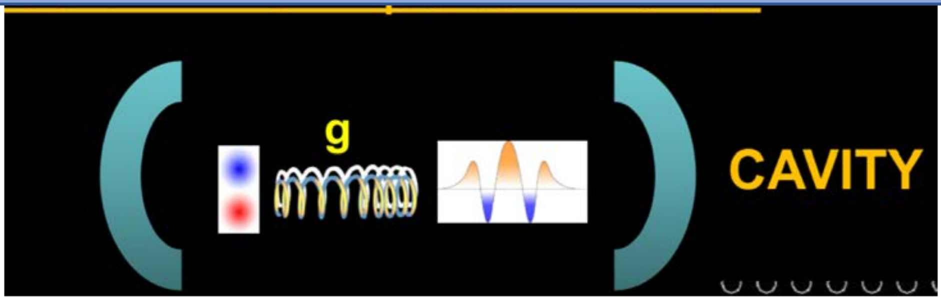
Photons as qubits

Question 10



To make a qubit out of a qdot-cavity system, we need to

1. Overlap the photonic cavity with the quantum dot spatially

2. Achieve resonance between the emission modes of the qdot and the modes of the cavity

3. Engineer strong coupling between the two

4. Reduce loss of the cavity

A) 1 and 2

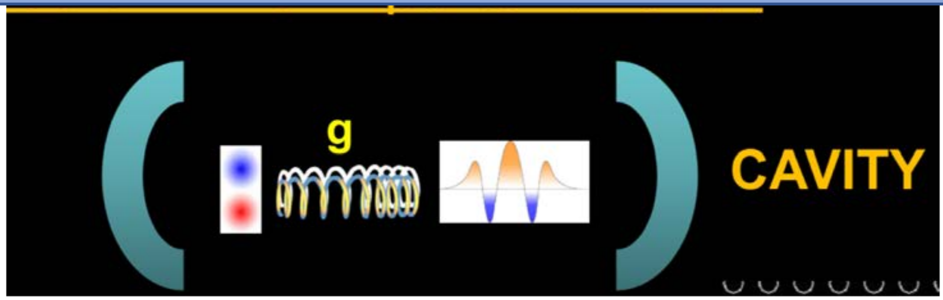
B) 2 and 3

C) 1, 2 and 3

D) All of them

Photons as qubits

Question 10



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