2019 NSF/DOE/AFOSR Quantum Science Summer School
June 6, 2019

QS^3 2019
Question Session 1

Joe Checkelsky (MIT), Jun Zhu (PSU), Kyle Shen (Cornell)

Test of Response System

Question 1

Does this response
system work correctly?

A. Yes
B. No

Test of Response System

Question 1

Does this response system work correctly?

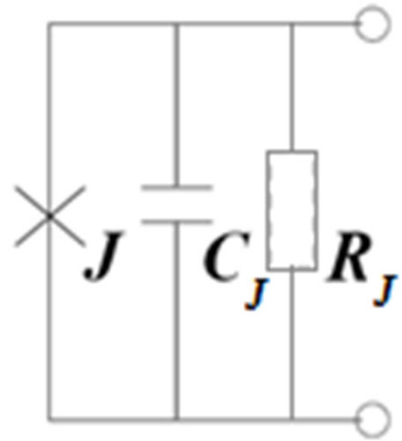
A. Yes

Yes this works

Josephson Junctions I

Question 2

Consider the “RSJ” model of a Josephson junction. Which statements regarding the effective resistance “R” are **TRUE**?



1. R is related to the normal state resistance of the junction
1. R is related to the resistance of the normal state contacts
1. The larger R is, the smaller the damping term in the RSJ model
1. The Josephson plasma frequency is strongly dependent on R

A) 1 and 3
B) 2 and 3
C) 1, 2, and 3
D) 1, 3, and 4
E) All of the above

Josephson Junctions I

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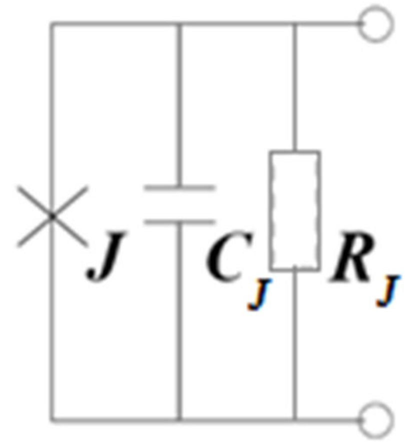

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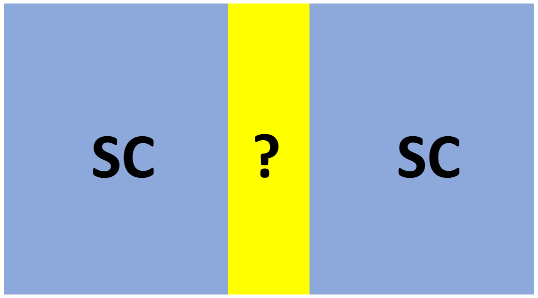
Josephson Junctions II

Question 3

A Josephson junction can be formed between two superconductors and one of the following materials:



1. Insulator
2. Metal
3. A different superconductor
4. Topological Insulator

A) 1 only
B) 2 only
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Josephson Junctions II

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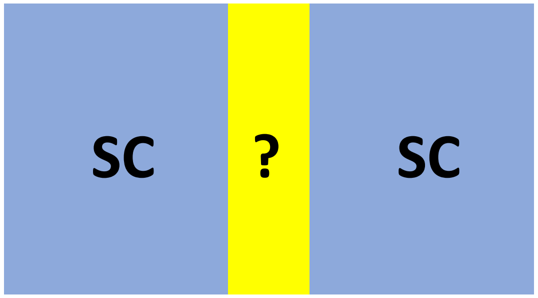

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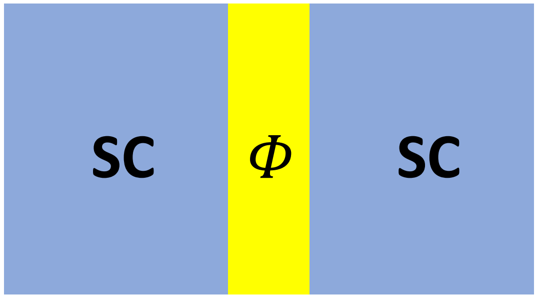
Josephson Junctions II

Question 4

When tuning the flux through a Josephson junction and examining the current phase relation, you may learn about



1. The spatial distribution of the supercurrent
2. The pairing symmetry of an unknown superconductor
3. A 4 π periodicity may be evidence of Majorana zero mode

A) 1 only
B) 1 and 2
C) 2 and 3
D) All of the above

Josephson Junctions II

Question 4

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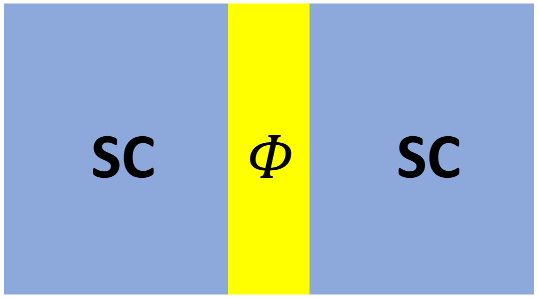

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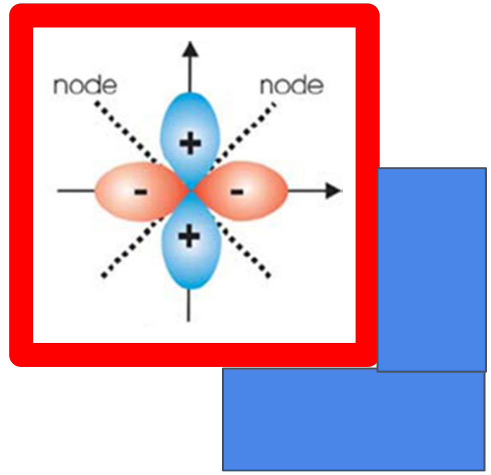
Josephson Junctions : Unconventional Superconductors

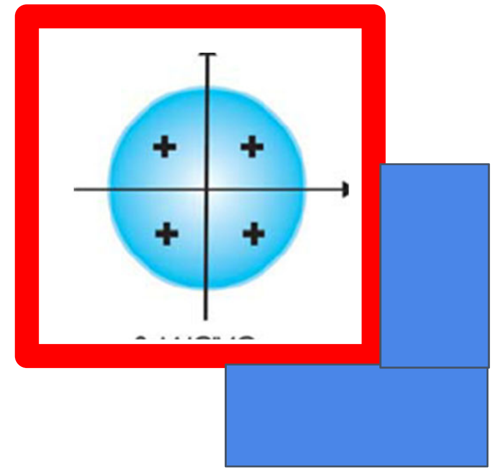
Question 5

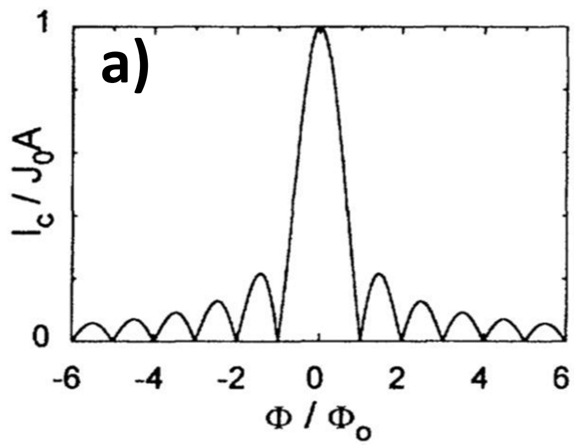
Consider the following junctions between either a *d*-wave superconductor (i) and an s-wave SC (ii) into a conventional SC (blue). What would the critical current vs. flux characteristics look like?

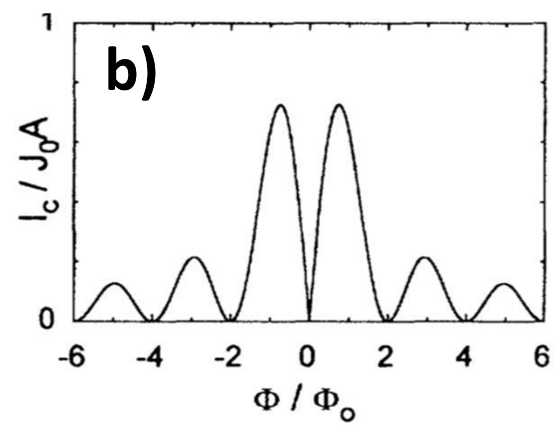
i)



ii)







A) i) -> a; ii) -> a

B) i) -> b; ii) -> a

C) i) -> a; ii) -> b

D) i) -> b; ii) -> b

E) None of the above

Josephson Junctions : Unconventional Superconductors

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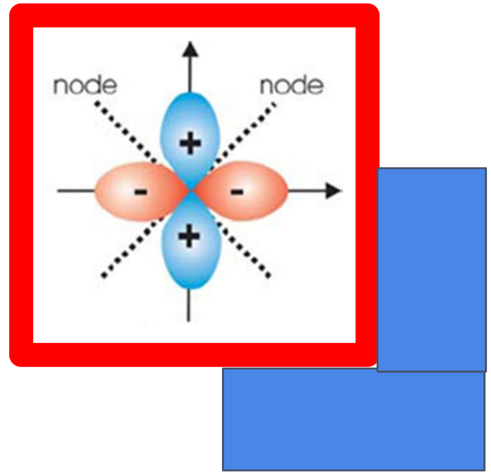

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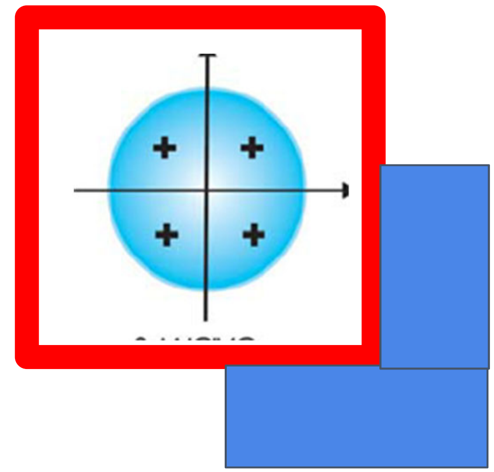

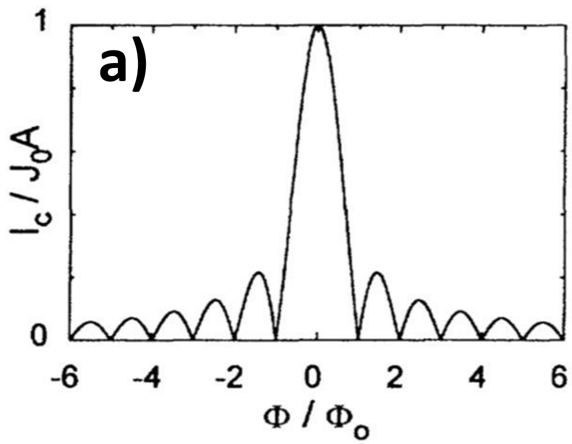

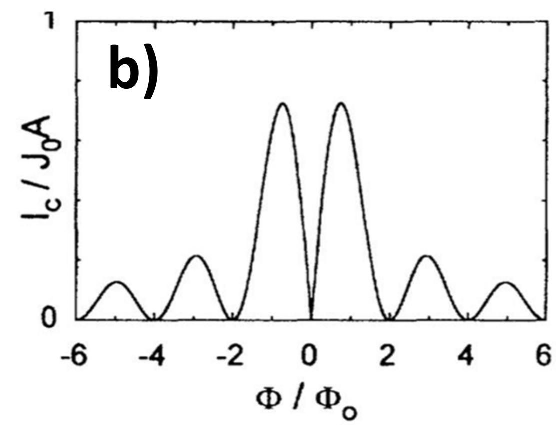

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B) i) -> b; ii) -> a

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Majorana I

Question 6

Majorana fermions are

1. It's own antiparticle
2. Charge neutral
3. Emergent states of a topological superconductor pinned at zero energy
4. Non-Abelian anyons

A) 1

B) 1, 2 and 3

C) 1, 2 and 4

D) 1, 2, 3 and 4

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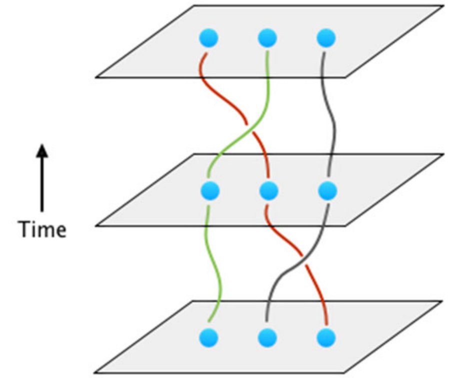
Majorana II

Question 7

When you braid two Majorana fermions, the wave function acquires a



1. "+" sign because there are two of them
2. "-" sign because they are fermions
3. A phase that is expressed in exp (iθ), θ can be anything
4. A new quantum mechanical state at the same energy
5. A new quantum mechanical state with a slightly different energy

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

Majorana II

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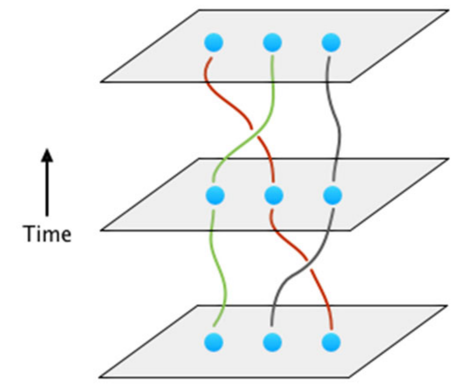

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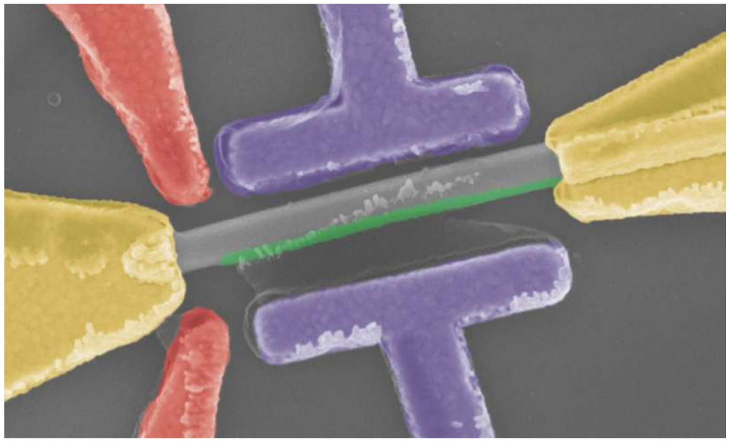
Majorana III

Question 8

What are the ingredients to create Majorana zero modes in nanowires



1. Strong spin orbit coupling

2. An in-plane magnetic field to generate a Zeeman splitting

3. Superconducting proximity effect

A) 1 and 2

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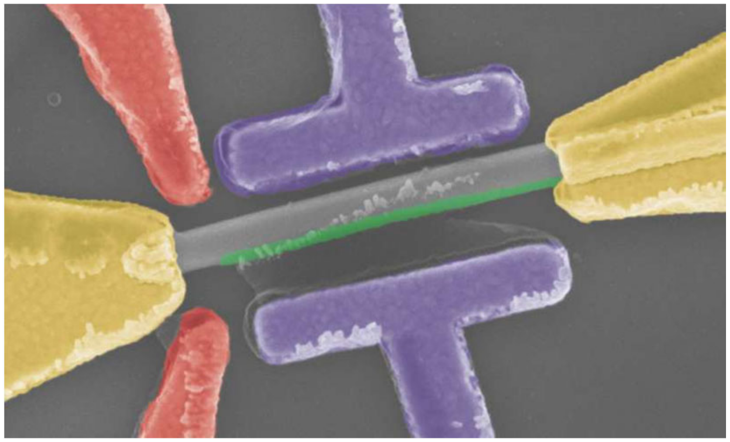

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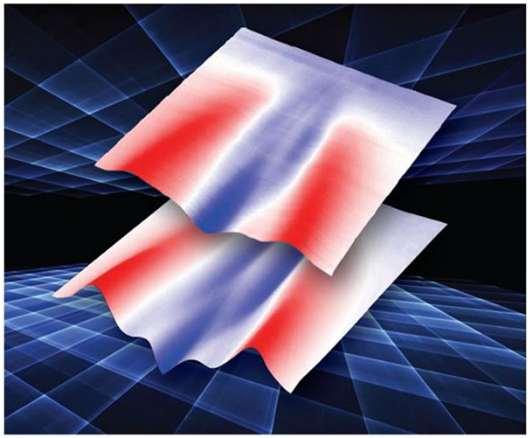
Majorana IV

Question 9



If you observe a conductance peak near the zero bias of the dI/dV spectrum when tunneling into the type of nanowire/SC hybrid device Prof. Frolov works on, what could it be due to?

1. Resonant tunneling into electronic states in the middle of the SC gap

2. Majorana zero modes bound at the ends of the nanowire

3. Andreev bound states

A) 1 and 2

B) 2 and 3

C) 1 and 3

D) 1, 2 and 3

Majorana IV

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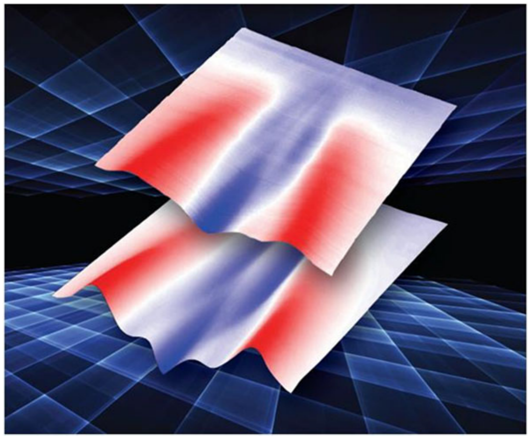

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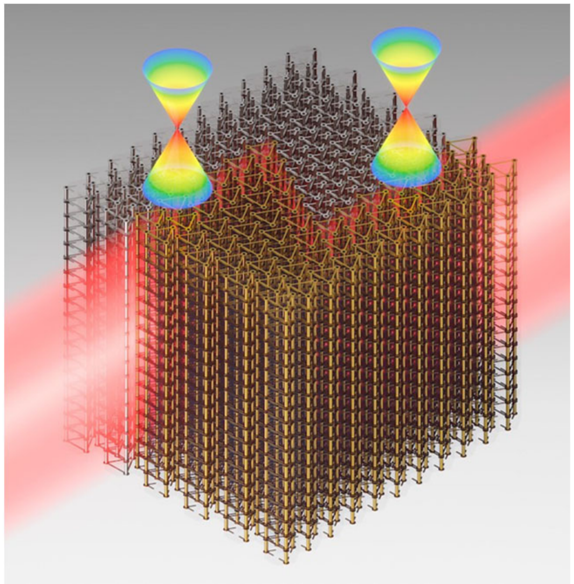
Topological Photonics I

Question 10

What are necessary conditions for the realization of a photonic topological insulator?



1. Breaking time (z) - reversal symmetry
2. Unit cell has more than a one-member basis
3. Must be in the microwave frequency regime
4. High-power beams as a probe
5. Periodicity

A) 1

B) 1 and 2

C) 1, 2, 5

D) 3, 4

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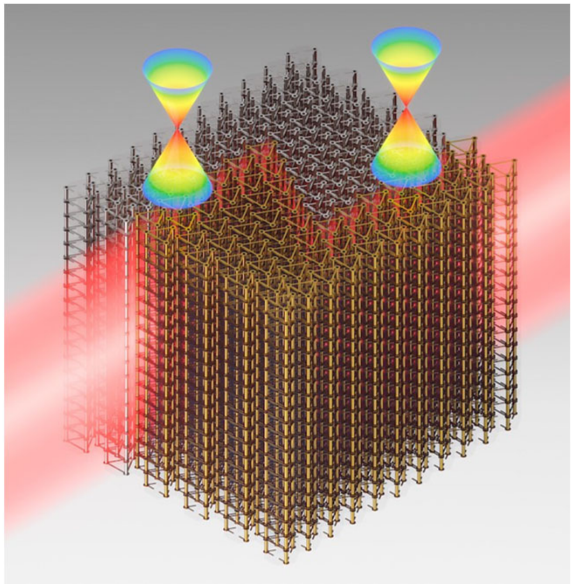

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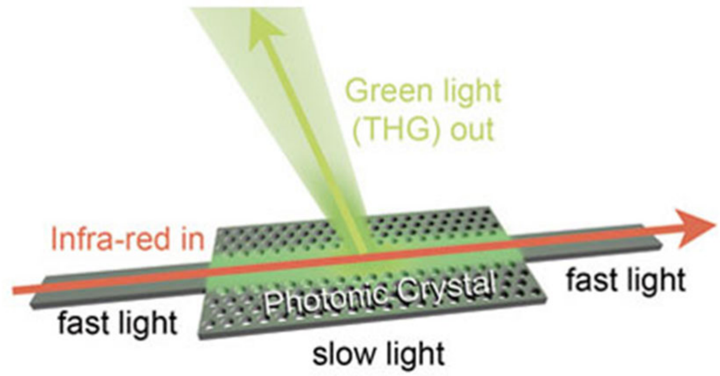
Topological Photonics II

Question 10

What are the drawbacks of conventional slow-light devices?



1. Poor in-coupling
2. Enhanced scattering by disorder
3. Poor bandwidth
4. Weak nonlinearity
5. Strong polarization dependence

A) 1
B) 1, 2, 3
C) 1, 2, 3, 4
D) 2, 3, 4

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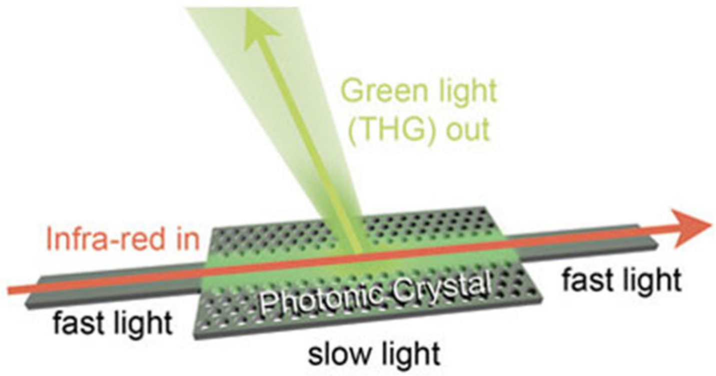

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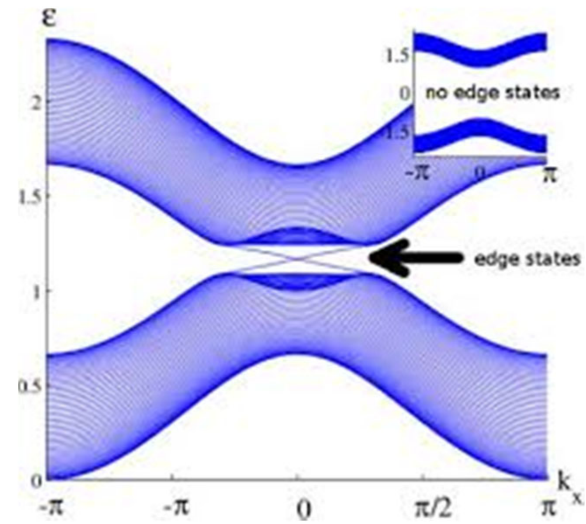
Topological Photonics III

Question 11

What is the solid-state analogue to the photonic Floquet topological insulator presented in the lecture?



1. Graphene irradiated by circularly-polarized light
2. Boron nitride irradiated by circularly-polarized light
3. The surface of a 3D TI irradiated by circularly-polarized light
4. The surface of a 3D TI irradiated by linearly-polarized light

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

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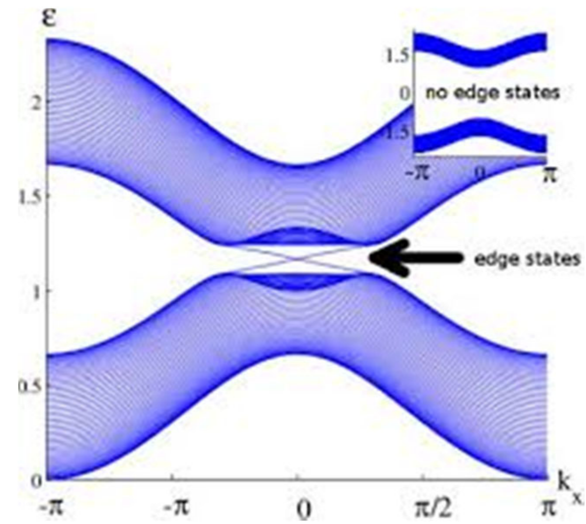

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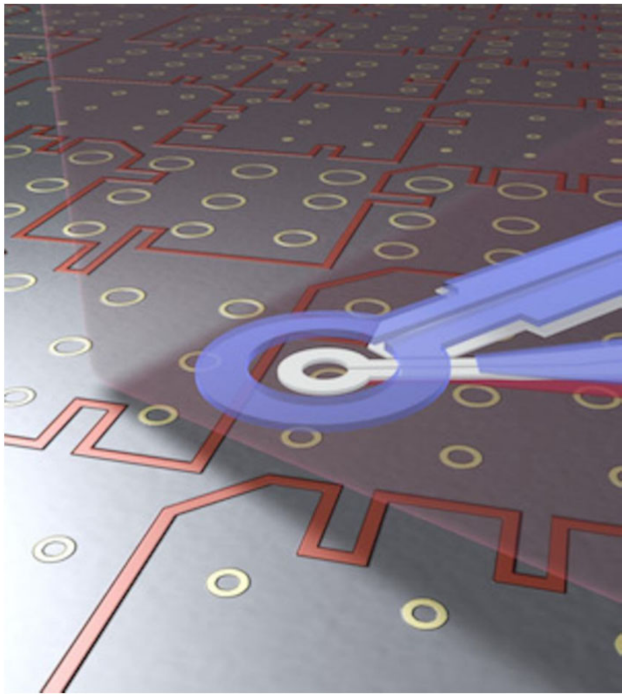
Scanning SQUIDs

Question 12



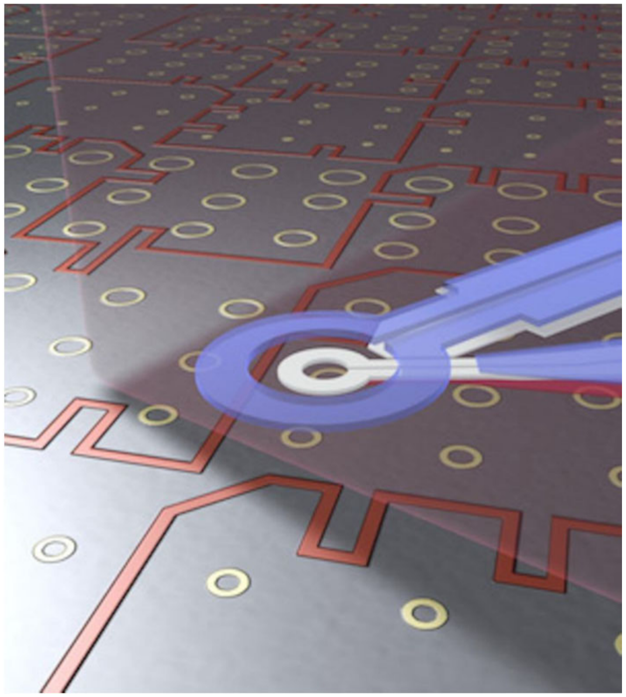
Which of the following can be probed using a scanning SQUID

1. Local Temperature
2. Electrical Currents
3. Spins
4. Electric Polarization

A) 1 and 2
B) 2 and 3
C) 1, 2, and 4
D) 1, 2, and 3
E) 1, 2, 3, 4

Scanning SQUIDs

Question 12



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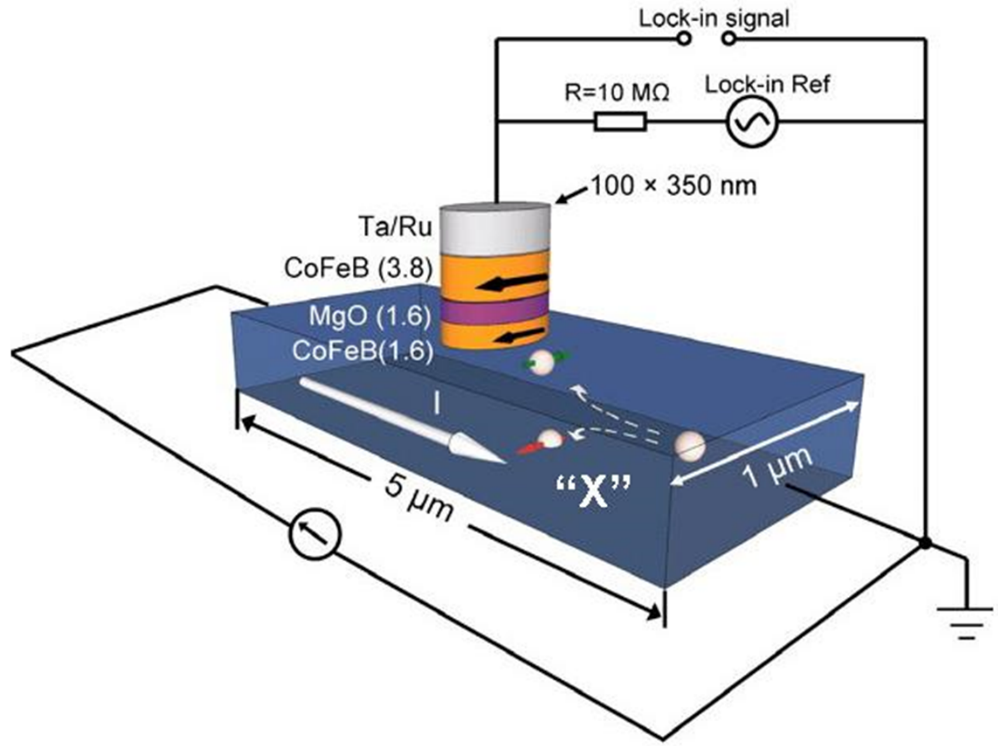
Spintronics I

Question 13



Which materials would be good choice for the layer "X" in the quantum device shown to the right?

1. Cu
2. W
3. Si
4. Na
5. Ta_3Sb

A) 1 and 2
B) 2 only
C) 1, 2, 4
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Spintronics I

Question 13

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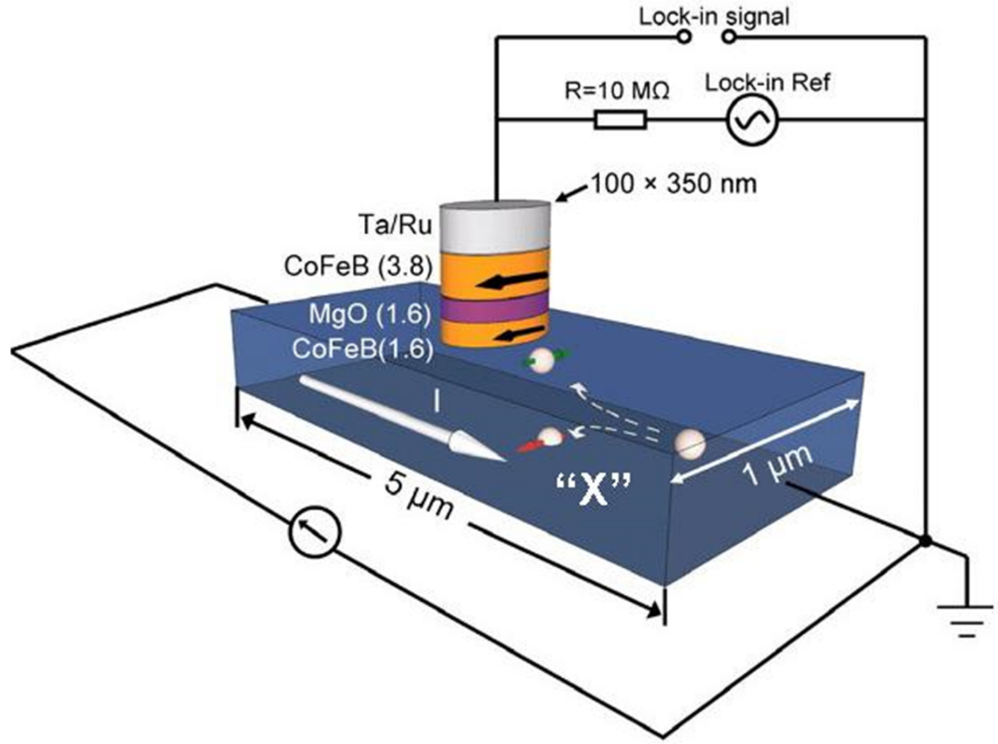

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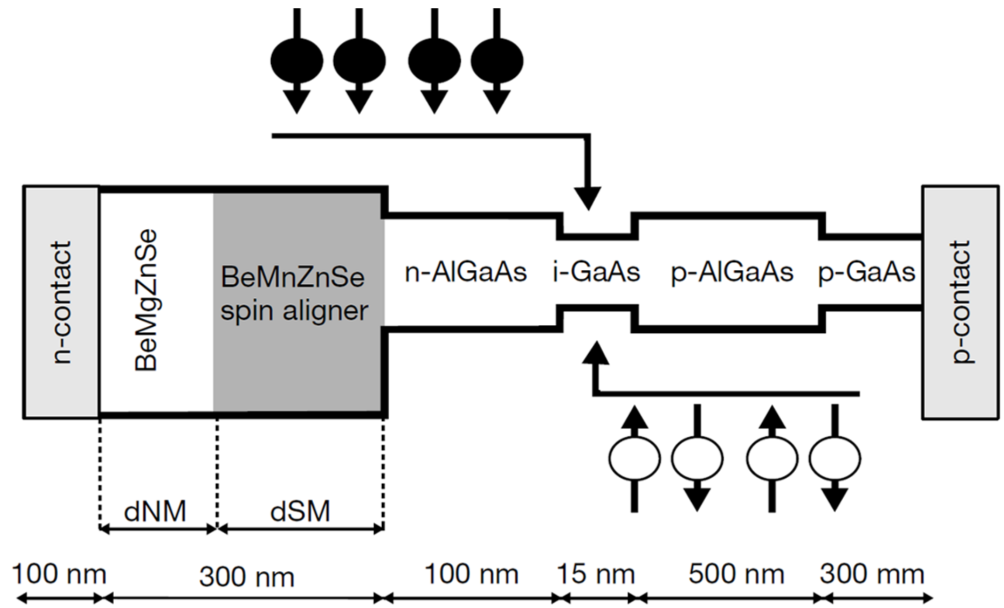
Spintronics II

Question 14

What is the device shown to the right?



1. Datta-Das Spin Transistor
2. Spin Light Emitting Diode
3. Giant Magnetoresistance Sensor
4. Tunneling Magnetoresistance Sensor

A) 1
B) 2
C) 3
D) 4
E) None of the Above

Spintronics II

Question 14

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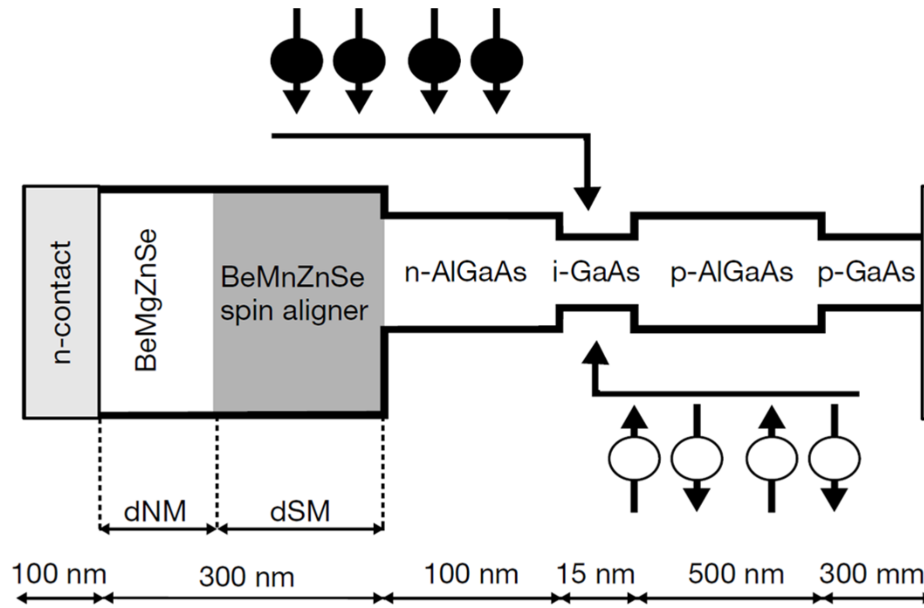

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Hands-on Activities

Question 15

VR is useful for visualizing crystal structures:

A) Yes
B) Somewhat
C) No
D) Not sure at present stage
E) It made me dizzy