Optical & Terahertz spectroscopy of Quantum Materials

Question 1

What is measured in a time domain THz spectroscopy using an Auston switch

1. Power of THz radiation from the sample
2. Electric field of THz radiation from the sample
3. Magnetic field of THz radiation from the sample
4. All of the above

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

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Question 2

Why is the absorption coefficient of monolayer graphene independent of frequency over a wide range?

1. Because it has no band gap
2. Because the joint density of states is proportional to frequency
3. Because the matrix element of the transition is inversely proportional to frequency
4. Because the Fermi velocity is high
5. All of the above

A) 1

B) 2 and 3

C) 4

D) 5

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2D Materials

Question 3

Why does a single layer of MoS_2 show much stronger photoluminescence compared to a thicker, multilayer sample?

A) Due to a change of optical selection rules as a result of the lattice symmetry breaking in a single layer

B) Due a change in the band structure in the monolayer limit

C) Due to an appearance of a surface plasmon in the monolayer limit

D) Due to the suppression of interlayer Josephson tunneling

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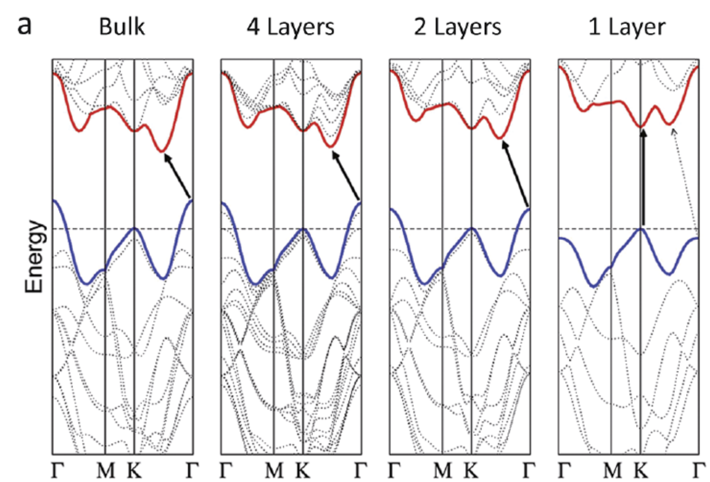

Oxide MBE

Question 4

What are the necessary ingredients for adsorption-controlled MBE growth?

1. There is a volatile element in the compound
2. Supply of an excessive amount of the volatile element
3. Control the growth condition so that it's in the thermodynamic window of the desired phase
4. Supply the element at the desired stoichiometric ratio

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

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Oxide MBE

Question 5

When trying to grow an epitaxial superlattice with atomically sharp interfaces made up of two different materials, A and B, which of the following might be important considerations?

1. The bulk diffusion of A into B
2. The lattice constants of materials A and B
3. The surface diffusion of A and B
4. The surface energies of A and B

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

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E) All of the above

X-ray scattering of quantum materials

Question 6

Elastic x-ray scattering can probe the following phenomena

1. Crystallography
2. Charge density wave
3. The magnetic moment of an atom
4. Short-ranged local order
5. The core energy levels of an atom

A) 1
B) 1 & 2
C) 1, 2 and 4
D) 1, 2, 3, and 4
E) All of them

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Nanomaterials

Question 7

In Vapor-Liquid-Solid growth of nanowires, which of the following statement is true?

1. The diameter of the nanowire is controlled by the size of the catalytic nanoparticle
2. The stock material must go through the catalyst
3. Wires can be single crystal.
4. Controlling interfacial energy at the VLS interface can lead to growth of different crystal structures

A) 1
B) 1 & 2
C) 1 and 3
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Neutron vs. X-ray Scattering

Question 8

You are interested in studying the crystal structure of a material where you suspect the oxygen vacancies form an ordered superlattice. What are the possible advantages of using neutron versus x-ray scattering?

1. Neutron scattering is generally more sensitive to oxygen than x-ray scattering
2. The Neutron doesn't carry charge
3. The Neutron is a massive particle
4. The x-ray scattering cross section depends on the Z number of the elements sensitively so the contribution of oxygen is comparatively small.

A) 1

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Neutron Scattering

Question 9

Assume that we want to attempt to completely eliminate the contribution from incoherent scattering in a neutron scattering experiment. In order to do so, we measure a perfect crystal which is isotopically pure.

Will this completely eliminate the incoherent scattering?

A) True
B) False
C) Don't Know

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A) True
B) False
C) Don’t Know

Investigating a possible Spin Liquid Compound

Question 10

You are investigating a possible spin liquid compound, and want to measure the magnetic excitation spectrum (as a function of ω and q) at low temperatures. Which technique(s) might be best suited for such a measurement?

1. Angle-resolved photoemission spectroscopy (ARPES)
2. Neutron Scattering
3. X-Ray scattering
4. Transmission Electron Microscopy
5. Time-domain THz spectroscopy

A) 2 only
B) 2 and 3
C) 2, 3, and 5
D) 1, 2, and 3
E) 2, 3, and 4

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Energy Scales

Question 11

Order the energy scales of the following phenomena, in ascending order (from lowest energy to highest energy)

1. The average phonon energy in $SrTiO_3$
2. The strength of a chemical bond in a material
3. Microwave radiation
4. The superconducting gap of a conventional superconductor (e.g. Pb)
5. The band gap of MoS_2

A) 4,3,1,2,5
B) 4,3,5,1,2
C) 3,4,5,1,2
D) 3,4,1,5,2
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Measuring Magnetic Ordering

You are investigating small samples of a 2D material (3 microns across; 4 nanometers thick) which you think may exhibit some unusual antiferromagnetic ordering, and are considering some experiments to determine the antiferromagnetic wavevector. Which of the following statements is true?

1. It should be straightforward to determine the magnetic ordering in these samples by neutron scattering
2. It might, in principle, be possible to determine the magnetic ordering in these samples by x-ray diffraction
3. X-ray scattering, being dominated by the core electrons, is completely insensitive to magnetic order
4. X-ray scattering, being dominated by the core electrons, is only ever sensitive to magnetic ordering when the x-rays are tuned to certain atomic resonances

A) 1, 2, and 4
B) 1 and 3
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Optical Measurements

Question 1

What is a difference between Fourier Transform Infrared (FTIR) spectroscopy and Time-Domain Terahertz (TDTS) spectroscopy?

1. No difference, they are measuring the same optical constants using Fourier transforms.
2. TDTS produces Fourier transform of a spectrum in the time domain, FTIR produces Fourier transform in the space domain.
3. They are used to measure different frequency ranges.
4. FTIR is used to measure reflectance of materials, TDTS is used to measure transmission

A) 1

B) 2 & 3

C) 3 & 4

D) 4

E) 2

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