

Homework 1

ECE 4339

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1. (20 pts) Graphene lattice and crystal structure

Use the app in lecture to obtain a graphics of graphene. You can search on the Internet for any graphics of graphene crystal and have them compared. Specifically: How many carbon atoms are there in each unit cell? What are their relative coordinates within a unit cell?

2. (20 pts) Some crystal structures

Use those links to Wolfram demonstration projects to obtain a graphic for each crystal below (you generate, then copy and paste):

2.1 Si crystal (diamond structure)

2.2 GaAs or any III-V semiconductor with zincblende structure

3. (10 pts) Crystal growth

Watch those youtube clips cited in the lecture or select your own about how large single Si crystal ingots (or boules) are grown, then write a few paragraphs (1/3 -1/2 of a page) to summarize what you observed.

4. (20 pts) Basic review about light.

4.1 (5 pts) Speed of light

The speed of light c is 2.99792458×10^8 meter/sec. Express the speed of light in the following units: cm/sec; $\mu\text{m}/\text{ps}$; where: ps = picosecond = 10^{-12} sec. Try to remember the value of c in $\mu\text{m}/\text{ps}$. It is a very useful unit.

4.2 (5 pts) Frequency

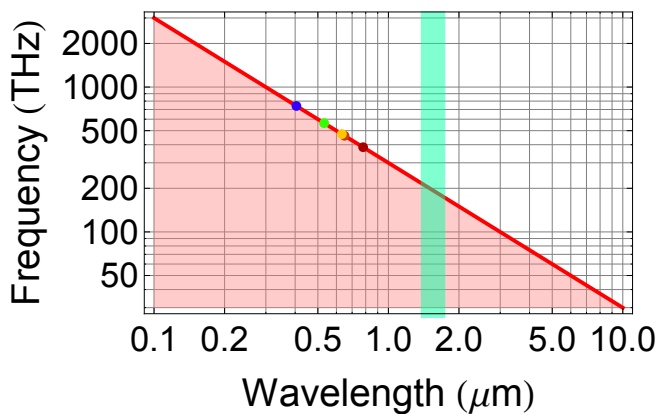
Calculate the frequency of light in unit of THz (Terahertz), which is 10^{12} Hz, using the result of c in the unit of $\mu\text{m}/\text{ps}$ from question 1 above, for the following wavelengths: $0.78 \mu\text{m}$ (the wavelength of CD laser), $0.65 \mu\text{m}$ (the wavelength of DVD laser), $0.633 \mu\text{m}$ (HeNe laser wavelength), $0.532 \mu\text{m}$ (the wavelength of doubled Nd:YAG,

such as green laser pointer), and $0.405 \mu\text{m}$ (BluRay laser). What is the color of each wavelength? (search for pics that shows colors of these wavelength on the Internet).

4.3 (10 pts) λ vs. f

Plot lightwave frequency (in unit of THz) as a function of wavelength (in unit of μm) on log-log scale for λ (wavelength) from $10 \mu\text{m}$ to $0.1 \mu\text{m}$.

Answer given (but you must import and paste into your work - unless you use *Mathematica*, then you can leave as is)



5. (30 pts) photon quantum energy and units.

5.1 (5 pts) Quantum

We discuss Planck's light quantum, the smallest amount of energy that a lightwave carries as: $E = h \nu$ where h is Planck's constant and ν is the light frequency. ($h = 6.62606896 \times 10^{-34}$ Joule/s). Find the photon energy for each laser light in question 4.2 in Joule

Answer

5.2 (5 pts) The unit of eV

A most useful unit of energy is eV= electron-Volt: it is the energy to move an electron across a potential of 1 V. What is one eV in the unit of Joule. (note the charge of an electron is: $e = 1.602176487 \times 10^{-19}$ Coulomb).

Answer

5.3 (5 pts) Question 6: photon energy

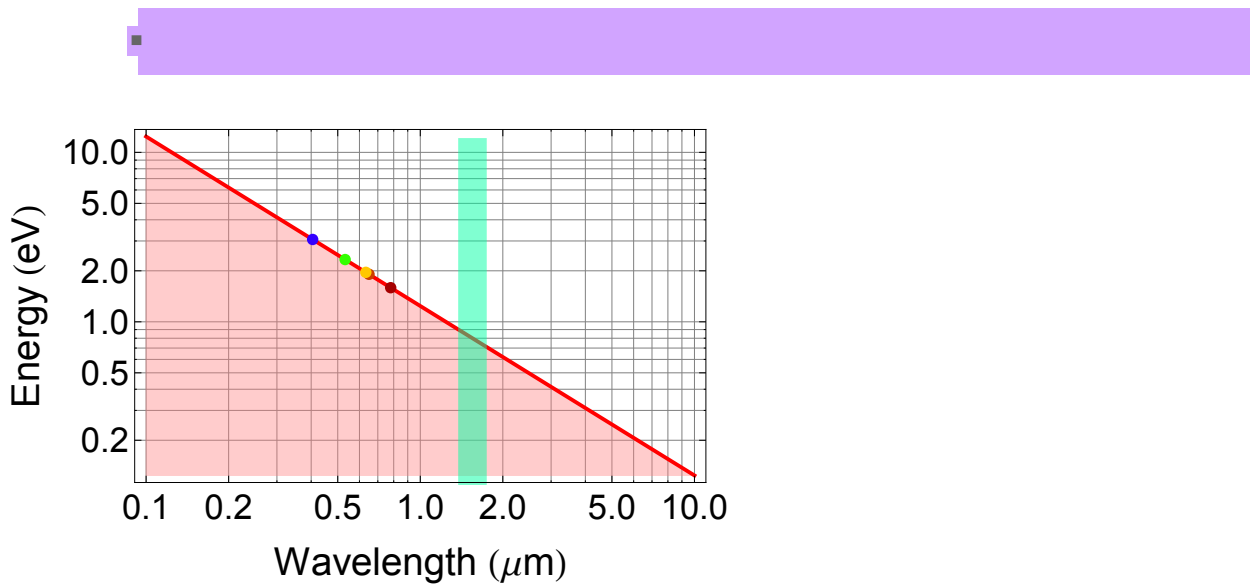
What is the energy of each photon in question 5.1 in unit of eV?

Answer

5.4 (5 pts) Question 7: photon energy vs. λ

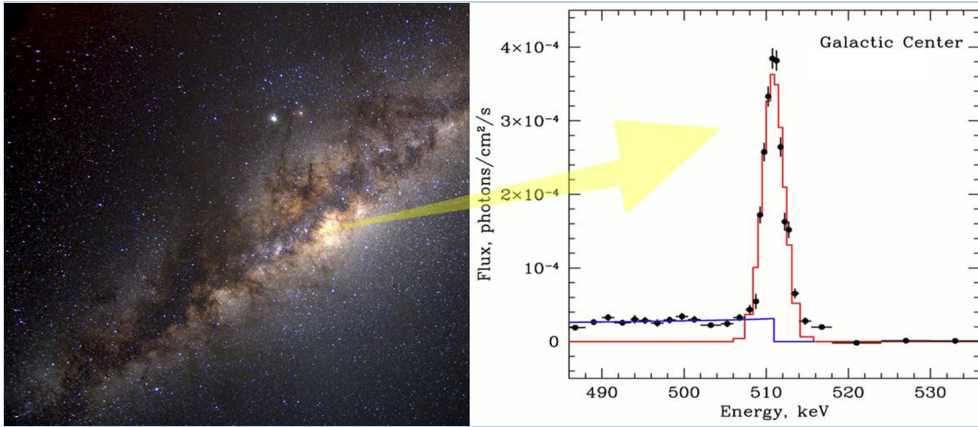
Plot the photon energy (in unit eV) as a function of wavelength on log-log scale for λ (wavelength) from $10 \mu\text{m}$ to $0.1 \mu\text{m}$.

Answer given (but you must import and paste into your work - unless you use *Mathematica*, then you can leave as is)



5.5 (10 pts) Astronomical gamma-ray energy

This is an exercise in unit conversion. Below is the plot of gamma ray intensity as function of photon energy from the center of our galaxy (Milkyway) obtained by Max Planck Institute for Astrophysics. (γ -ray is photon with very high energy.)



Using the formula: $E = mc^2$, and the electron rest mass is $9.10938215 \times 10^{-31}$ Kg, guess what nature of the peak at 511 keV (kilo eV) in the graph is. Calculate the 511-keV-line intensity (the peak of the graph) in unit of W/m^2
 Hint, look up matter-antimatter, and electron its anti-matter.