Name _____ **Student ID Number** _____
last *first*

PHYS 110 Midterm #2

No phone/computer/internet usage is allowed. For multiple choice questions, please circle the <u>best</u> answer.

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1) Which of the following statements about the history of computing are correct?

A) Calculating aids, such as abacuses, date to ancient times

B) Some of the first large scale computing machines were developed during WWII by the Allies to break German encryption with the Enigma machine

C) The first personal computers with a mouse were introduced in the early 1980's

D) The first consumer tablet computer, the iPad, was released 10 years ago

E) All of the above

2) Both FM radio and television signals are broadcast using radio light.

A) Because a television signal needs more data than an audio signal, television stations require a higher frequency radio color (bluer). This is why FM radio is given a lower frequency (e.g. 102.1 MHz) and digital TV a higher frequency (e.g. 190 MHz).

B) The number of television and radio stations is essentially infinite, because each station can be given a slightly different color.

C) Because a television signal needs more data than an audio signal, it requires a larger range of reserved radio colors (bandwidth). The central color does not matter, but the range of color does. This is why television stations are given wider allocations of radio color than FM radio stations.

D) Because photons of light are introverts (fermions), they anti-bunch, limiting the amount of data you can send in a radio signal.

3) The plot at right shows the classic experiment of dropping milliKelvin ^{3}He (5 fermions) and ^{4}He (6 fermions) atoms and looking at whether they arrive randomly (1.00 on the vertical scale means random). Which of the following statements describes the observed results?

A) Helium atoms move like waves. Because they are so cold (narrow color), the ripple length of the Helium atoms is very long—almost a millimeter.

B) Because ^{3}He has an odd number of fermions, it acts like an introvert and anti-bunches when the ripples overlap. At short distances ^{3}He arrives less often than random.

C) Because ^{4}He has an even number of fermions, it acts like an extrovert and bunches when the ripples overlap. At short distances ^{4}He arrives more often than random.

D) All three of the above are correct and needed to fully explain the results.

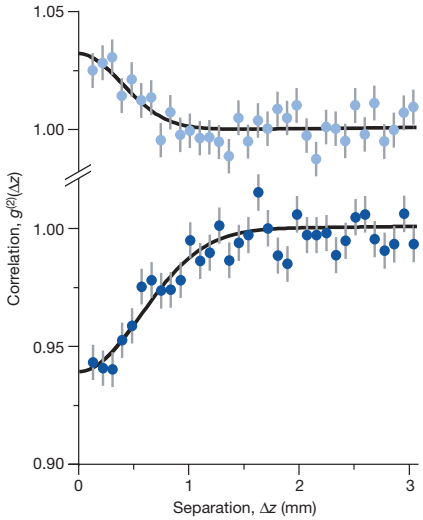

Figure 2 | Normalized correlation functions for ^{4}He* (bosons) in the upper plot, and ^{3}He* (fermions) in the lower plot. Both functions are measured at the same cloud temperature (0.5 μK), and with identical trap parameters. Error bars correspond to the square root of the number of pairs in each bin. The line is a fit to a gaussian function. The bosons show a bunching effect, and the fermions show antibunching. The correlation length for ^{3}He* is expected to be 33% larger than that for ^{4}He* owing to the smaller mass. We find 1/e values for the correlation lengths of 0.75 ± 0.07 mm and 0.56 ± 0.08 mm for fermions and bosons, respectively.

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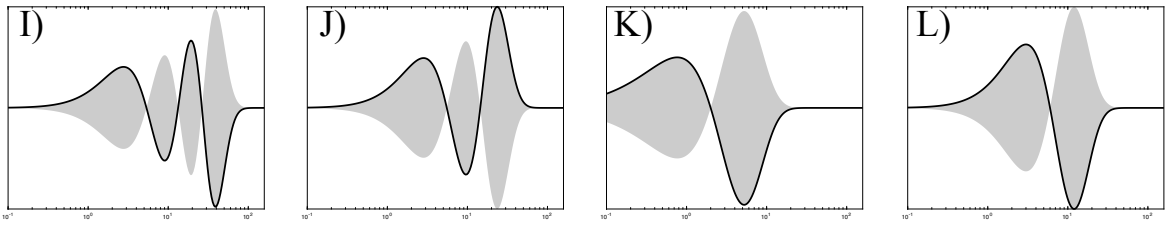
4) The following plots show a selection of electron waves found in the hydrogen atom, arbitrarily labelled I, J, K, L. Which of the following statements best describes the energies of the electron waves?



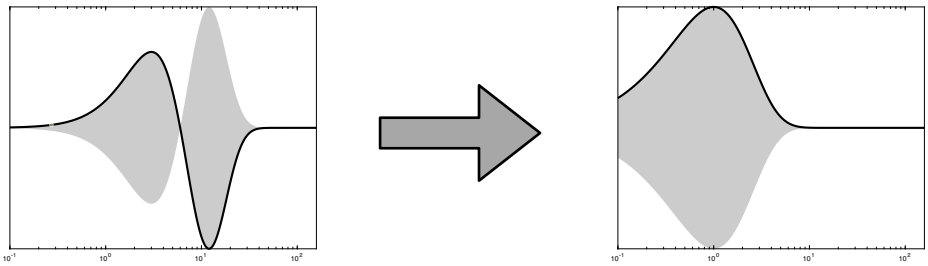
A) From highest to lowest energy the waves are ordered I, J, L, K. The shape of the I, J, and L are similar, with the highest frequency wave having the highest energy. While K and L both have two peaks, K is closer to the nucleus and so has lower energy.

B) From highest to lowest energy the waves are ordered K, L, J, I; because the energy is determined by the distance of the highest peak from the nucleus.

C) From highest to lowest energy the waves are ordered L, K, J, I. The shape of the I, J, and L are similar, with the shortest wave length having the lowest energy. While K and L both have two peaks, K is closer to the nucleus and so has lower energy.

D) Because electrons are particles, the energy depends on which peak of the wave the electron is found it (lowest energy to the left). This means the energy of the electron cannot be easily determined from these figures—you need to know which peak it is in.

5) The electron wave within a hydrogen atom changes from the wave on the left to the wave on the right. Describe what we see when this happens.



A) Not much. The energy of the electron changes but we cannot see this.

B) When the electron wave shifts from the first shape to the second, a photon of light is produced. The color of the light is determined by the amount of energy the electron lost during the change of wave shape.

C) When the electron wave shifts from the first shape to the second, a photon of light is produced. The color of the light is given by the energy of the electron in the final wave.

D) When the electron wave shifts from the first shape to the second, a photon of light is produced. The color of the light is given by the energy of the electron in the initial wave.

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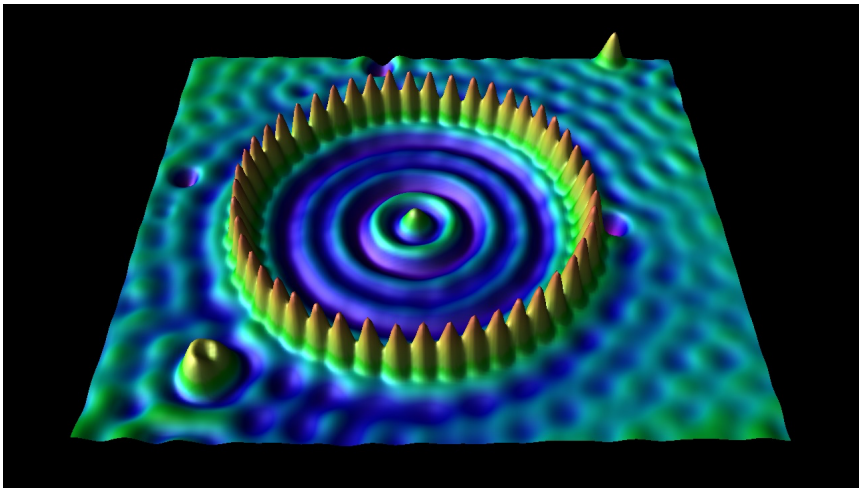
6) Which statement most accurately describes the image of the quantum corral shown below?



A) The spiky ring shows the positions of iron atoms. The circular stripes inside are the interference of many electrons from the iron atoms.

B) The spiky ring shows the positions of iron atoms that act as a fence for a single electron. The wave of the trapped electron is seen in the ripples inside the ring.

C) The spiky ring shows a ring of electrons around the edge of a quantum dot. Because the electrons are fermions (introverts), they avoid each other and space themselves around the edge of the dot.

D) The spiky ring shows a ring of electrons around the edge of quantum dot. The ripples inside the ring show the wavy copper surface of the corral produced by the pinching of the electrons.

7) Which statement accurately describes the resolution of a telescope?

A) A telescope can only sort the light from two objects (stars, for example) if the combined waves appear different at opposite edges of the telescope. In analogy with water on the beach, if the light waves look the same at both edges of the the telescope the telescope will not be able distinguish the sources.

B) The larger the telescope the better it can distinguish closely spaced sources.

C) In the beach analogy, there is a characteristic distance where locations on the beach farther apart see different waves, whereas locations on the beach closer together see very similar waves. As the sources of the waves move <u>together</u>, the characteristic distance on the beach where waves become different <u>increases</u>.

D) Because photons of light move like waves, when you look at a distant star <u>each</u> photon of light will fill the entire pupil of your eye. In fact, each photon is very wide and will even fill the aperture of an interferometer that covers the earth.

E) A-D are all correct.

F) B & C are correct, but A & D are incorrect.

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Essay Question: Select and answer <u>one</u> of the following questions:

A) Describe how bandwidth (color range) relates to the length of a particle ripple, and how this is related to spectrum allocation.

B) Explain how quantum dots work, and why different dots have different colors.