Spacetime and the Quantum World Questions   Fall 2010

1. Clicker Questions from Class:

(1) In a toss of two dice, what is the probability that the sum of the outcomes is 6?
   (a) $P(x_1 + x_2 = 6) = \frac{1}{36}$ - about 3%
   (b) $P(x_1 + x_2 = 6) = \frac{1}{18}$ - about 6%
   (c) $P(x_1 + x_2 = 6) = \frac{5}{36}$ - about 14%
   (d) $P(x_1 + x_2 = 6) = \frac{1}{9}$ - about 11%
   (e) This can't be determined from the info given

   c

(2) As forecast on Monday (November 1) morning, suppose that the likelihood of precipitation on Election Day, Tuesday November 2, is 10 % for each 3 hour interval. For instance, the probability of precipitation from 10 AM to 1 PM is 10 %. Similarly for the rest of the day. So for the entire 24 hour period, what is the probability of precipitation?
   (a) You multiply the hourly forecasts so you get $0.1^8 = 1 \times 10^{-8}$ so 1×10^{-6} % of the time. Essentially, it *will not* rain today.
   (b) You add the hourly forecasts so you get $0.1 \times 24 = 2.4$ so 240 % of the time. Essentially, it *is* raining!
   (c) You take one hourly interval and use that. There is a 10 % chance of rain for the 24 hour period.
   (d) The chance it will not rain in one 3 hour interval is 90% so for the whole day we have $1 - (0.9)^8 \approx 0.57$. Roughly, there is a 60% chance of rain.
   (e) None of the above

   d

(3) What happens to a current-carrying loop in a **uniform** magnetic field?
   (a) Not much. It stays where it is.
   (b) It oscillates.
   (c) It precesses but otherwise stays put.
   (d) It precesses and accelerates into the stronger part of the field.
   (e) We need more information before it is possible to determine the correct answer.

   c

(4) What happens to a current-carrying loop in a **non-uniform** magnetic field?
   (a) Not much. It stays where it is.
   (b) It oscillates.
   (c) It precesses and otherwise stays put.
   (d) It precesses and accelerates in the direction determined by the projection of its magnetic arrow.
   (e) It precesses and accelerates into the weaker part of the field.

   d

(5) If each electron behaved like a current-carrying loop, what would the Stern-Gerlach data look like?
   (a) Just what they saw in 1927.
   (b) A bump with tails - most would land near the center of the beam.
   (c) A uniform even spread from the bottom-most deflection to the top-most
   (d) Three, separate bumps.

b

(6) If each electron had a “ticket” telling it whether its projection was + or -, and the tickets were distributed randomly, what would the Stern-Gerlach data look like?
  (a) Just what they saw in 1927.
  (b) One central bump, most would land near the center of he beam.
  (c) A uniform even spread from the bottom-most deflection to the top-most
  (d) Three, separate bumps.
  (e) We need more information before it is possible to determine the correct answer.

a (i.e. a local deterministic scheme would work for this experiment)

(7) Is it possible to construct projections $+m_B$ or $-m_B$ of one arrow for all axes?
  (a) Yes, they are at right angles.
  (b) Yes, but it is hard to draw
  (c) No way.
  (d) No, I can prove it geometrically
  (e) We need more information before it is possible to determine the correct answer.

c or d

(8) What would be outcome of the repeated Stern-Gerlach experiment 4.1?
  (a) $+m_B$ 50 % of the time and $-m_B$ 50 % of the time
  (b) $+m_B$ 100 % of the time
  (c) $-m_B$ 100 % of the time
  (d) $+m_B$ 75 % of the time and $-m_B$ 25 % of the time
  (e) None of the above

b

(9) What would be outcome of the repeated Stern-Gerlach experiment 4.2?
  (a) $+m_B$ 50 % of the time and $-m_B$ 50 % of the time
  (b) $+m_B$ 100 % of the time
  (c) $-m_B$ 100 % of the time
  (d) $+m_B$ 75 % of the time and $-m_B$ 25 % of the time
  (e) None of the above

c

(10) What would be outcome of the repeated Stern-Gerlach experiment 4.3?
  (a) $+m_B$ 50 % of the time and $-m_B$ 50 % of the time
  (b) $+m_B$ 100 % of the time
  (c) $-m_B$ 100 % of the time
  (d) $+m_B$ 75 % of the time and $-m_B$ 25 % of the time
  (e) None of the above

a

(11) What would be outcome of the “-30 to +60 degree” repeated Stern-Gerlach experiment?
  (a) $+m_B$ 50 % of the time and $-m_B$ 50 % of the time
  (b) $+m_B$ 100 % of the time
  (c) $-m_B$ 100 % of the time
  (d) $+m_B$ 25 % of the time and $-m_B$ 75 % of the time
  (e) $+m_B$ 75 % of the time and $-m_B$ 25 % of the time

a

(12) Referring to the chart of probability as a function of angle θ, what would be outcome of the “$\theta = 45$” degrees repeated Stern-Gerlach experiment?
  (a) $+m_B$ 50 % of the time and $-m_B$ 50 % of the time
  (b) $+m_B$ 100 % of the time

(c) $-m_B$ 100 % of the time
(d) $+m_B$ 15 % of the time and $-m_B$ 85 % of the time
(e) $+m_B$ 85 % of the time and $-m_B$ 15 % of the time

e

(13) Referring to the chart of probability as a function of angle θ, what would be outcome of the "$\theta = 37$" degrees repeated Stern-Gerlach experiment?

(a) $+m_B$ 100 % of the time
(b) $-m_B$ 100 % of the time
(c) $+m_B$ 90 % of the time and $-m_B$ 10 % of the time
(d) $+m_B$ 10 % of the time and $-m_B$ 90 % of the time
(e) None of the above

c

(14) For the initial state $m_z = +m_B$ going into the switching Stern-Gerlach apparatus, what is the probability of the $+m_B$ outcome, given the setting c?

(a) $P(+|c) = \frac{1}{4}$
(b) $P(+|c) = 1$
(c) $P(+|c) = \frac{1}{2}$
(d) $P(+|c) = \frac{3}{4}$
(e) This can't be determined from the info given

a

(15) For the initial state $m_z = +m_B$ going into the switching Stern-Gerlach apparatus, what is the probability of the $+m_B$ outcome, given the setting b?

(a) $P(+|c) = \frac{1}{4}$
(b) $P(+|c) = 1$
(c) $P(+|c) = \frac{1}{2}$
(d) $P(+|c) = \frac{3}{4}$
(e) This can't be determined from the info given

a

(16) For the switching Stern-Gerlach apparatus, what is the probability of the $+m_B$ outcome, given each of the settings a, b, c are equally likely?

(a) $P(+m_B) = \frac{1}{4}$
(b) $P(+m_B) = 1$
(c) $P(+m_B) = \frac{1}{2}$
(d) $P(+m_B) = \frac{1}{3}$
(e) $P(+m_B) = \frac{1}{6}$

c ($\frac{1}{3} \cdot 1 + \frac{1}{3} \cdot \frac{1}{4} + \frac{1}{3} \cdot \frac{1}{4} = \frac{1}{2}$)

(17) You have a friend who gives two of you boxes to take to Phoenix and Chicago. She tells you that the boxes contain giant pumpkin 6 seeds. Once you are in Chicago you open the box and see 2 seeds. How many are in the box in Phoenix?

(a) 4
(b) 4
(c) 4

hmmm

(18) Instantaneously and certainly your know the number of these giant pumpkin seeds in Phoenix. Does this mean that there is faster-than-light signals between Chicago and Phoenix?

(a) Yes, otherwise the state in Phoenix would not determined.
(b) No, the only thing that changed was your knowledge of a previously existing situation.

b

(19) In the original EPRB experiment does Alice know the results of Bob's experiments with certainty (probability of 1)?
 (a) Yes.
 (b) No.
 (c) Yes, but only after she has taken her measurements.
 (d) No, since she does have access to Bob's distant analyzer.
c
(20) Can the EPR experiment be used to communicate?
 (a) Yes.
 (b) No.
b
(21) Are these EPR experiments consistent with special relativity?
 (a) Yes.
 (b) No.
a
(22) We have that the probability

$$P(m_m = +m_B | m_a = +m_B) = \frac{1}{4}$$

What is the probability $P(m_m = -m_B | m_a = +m_B)$?
 (a) 1 since it is the same outcome.
 (b) 0 since it never occurs.
 (c) 3/4 since $1 - 1/4 = 3/4$.
 (d) 1/2 since each outcome is equally likely.
 (e) 1/4 since it is the same as the one above.
 (f) None of the above.
c
(23) What is the probability of the + or "R" outcome, given a state prepared in the $m_a = +m_B$ state, for all possible settings?
 (a) 1 since is my favorite number today.
 (b) 0 since it never occurs.
 (c) 1/2 since $1/3 + 1/12 + 1/12 = 1/2$
 (d) 1/2 since $1/4 + 1/4 = 1/2$.
 (e) 1/4 since it is the same as the one above.
 (f) None of the above.
c
(24) What is the probability of the − or "G" outcome, given a state prepared in the $m_a = +m_B$ state, for all possible settings?
 (a) 1 since is my favorite number today.
 (b) 0 since it never occurs.
 (c) 1/2 since $1/3 + 1/12 + 1/12 = 1/2$
 (d) 1/2 since $1/4 + 1/4 = 1/2$.
 (e) 1/2 since $1 - 1/2 = 1/2$.
d or e
(25) It turns out that $P(m_m = -m_B | m_a = -m_B)$ also equals $\frac{1}{4}$. What then happens to our prediction for the probabilities of the "R" and 'G" outcomes for random settings in the EPRB experiment?
 (a) Not much. The probabilities are unchanged, 50/50 as before.
 (b) Oh dear, we better re-do this to find out.

(c) I'm just not sure.

a

(26) In the local deterministic hypothesis, what is the probability of different outcomes for random settings?
(a) 4/9
(b) 1/2
(c) 5/9

a

(27) What is the probability for case VIII?
(a) 1
(b) 1/2
(c) 5/9
(d) 0
(e) 1/4
(f) None of the above

c

(28) Can the local deterministic hypothesis explain the EPRB experiment?
(a) No
(b) Yes

a

(29) Using the Stern-Gerlach interferometer of chapter 9 and shown on the board, we block off the $m_x = -m_B$ path through the device. What is the probability that an atom makes it to point C, given we stared with the state $m_z = +m_B$ at A?
(a) $P(C|m_z = +m_B, A) = \frac{1}{2}$
(b) $P(C|m_z = +m_B, A) = \frac{1}{4}$
(c) $P(C|m_z = +m_B, A) = \frac{1}{8}$
(d) $P(C|m_z = +m_B, A) = 1$
(e) None of the above

b

(30) Using the Stern-Gerlach interferometer, we block off the $m_x = +m_B$ path through the device. What is the probability that an atom makes it to point C, given we stared with the state $m_z = +m_B$ at A?
(a) $P(C|m_z = +m_B, A) = \frac{1}{2}$
(b) $P(C|m_z = +m_B, A) = \frac{1}{4}$
(c) $P(C|m_z = +m_B, A) = \frac{1}{8}$
(d) $P(C|m_z = +m_B, A) = 1$
(e) None of the above

b

(31) Using the Stern-Gerlach interferometer, leave both paths open. What is the probability that an atom makes it to point C, given we stared with the state $m_z = +m_B$ at A?
(a) $P(C|m_z = +m_B, A) = \frac{1}{2}$
(b) $P(C|m_z = +m_B, A) = \frac{1}{4}$
(c) $P(C|m_z = +m_B, A) = \frac{1}{8}$
(d) $P(C|m_z = +m_B, A) = 1$
(e) None of the above

d Since the state at C is $m_z = +m_B$ and since the interferometer doesn't change the state, $P(C|m_z = +m_B, A) = 1$.

(32) Wills asks, In this setup "...if the relative angle between the boxes is 90 degrees, shouldn't the probabilities be 50% / 50% ?"
   (a) No. That result holds only when we know the state.
   (b) No. The interferometer in this case does nothing so the state is unchanged.
   (c) Yes. It *must* have gone through one of a and b so its state must be either $m_x = +m_B$ or $m_x = -m_B$.

   a or b
(33) With bright light we can see every atom that passes through the interferometer what result do we find? What is the probability that an atom makes it to point C?
   (a) $P(C|m_z = +m_B, A) = \frac{1}{8}$
   (b) $P(C|m_z = +m_B, A) = \frac{1}{4}$
   (c) $P(C|m_z = +m_B, A) = \frac{1}{2}$
   (d) $P(C|m_z = +m_B, A) = 1$
   (e) None of the above

   e $P(C|m_z = +m_B, A) = \frac{1}{2}$ if there is a glint and $P(C|m_z = +m_B, A) = 0$ if there is no glint.
(34) With really dim light so there are too few photons to scatter off the atoms, what result do you find?What is the probability that an atom makes it to point C?
   (a) $P(C|m_z = +m_B, A) = \frac{1}{4}$
   (b) Two cases: $P(C|m_z = +m_B, A) = \frac{1}{4}$ if there is a glint and $P(C|m_z = +m_B, A) = 1$ if there is no glint.
   (c) Two cases: $P(C|m_z = +m_B, A) = \frac{1}{2}$ if there is a glint and $P(C|m_z = +m_B, A) = 1$ if there is no glint.
   (d) $P(C|m_z = +m_B, A) = 1$
   (e) None of the above

   e $P(C|m_z = +m_B, A) = \frac{1}{2}$ if there is a glint and $P(C|m_z = +m_B, A) = 0$ if there is no glint.
(35) You ask a whale to watch the paths, using light that will allow the whale to see the glint of light (or the shadow) from the atom passing through one path or the other. What is the probability that an atom makes it to point C, given we stared with the state $m_z = +m_B$ at A?
   (a) $P(C|m_z = +m_B, A) = \frac{1}{2}$
   (b) $P(C|m_z = +m_B, A) = \frac{1}{4}$
   (c) $P(C|m_z = +m_B, A) = \frac{1}{8}$
   (d) $P(C|m_z = +m_B, A) = 1$
   (e) None of the above

   a
(36) Lauren asks, "How does observing change the outcome??" Charley asks, "Does electron behavior depend on an observer?" Is it only and solely the act of observation that determines the outcome?
   (a) Yes. It is when folks (that's us) become aware of the result.
   (b) No. It is the physics that tells us; if **it is possible, in principle**, to determine **which way** information then then the atom acts as if a and b is known because it is knowable.

   b
(37) Brandon asks, "Is it enough to know that it had an m_x state or do we have to know which one in order for the m_z information to be lost?"
   (a) It is not enough. If it is **possible, in principle**, to determine **which way** information then then the atom acts as if it is in the $m_x = +m_B$ state or in the $m_x = -m_B$ state.
   (b) It is not enough. We need to actually measure the m_x state.
   (c) It is enough. The atom passed through the field in the x direction and so is changed.

   a

(38) Curren asks, “Why could the probability change if we are looking at it or not?”
   (a) Because we change the system when we learn the result of an experiment.
   (b) It doesn’t. The probability only depends on what goes on in the experiment.

b