Preliminary Questions

Wednesday, October 27, 2021 5:08 PM

Day 1:

1) What 5 properties determine a photon?

A: position, wavevector, energy, polarization, $\underbrace{\text{phase}}_{\text{undefined for a Fock state?}}$

2) How is a wave different than a particle?

A: A particle has well-defined position, whereas a wave is merely a moving change in some underlying object like a potential. Basically, if it makes sense to ask "where is it right now?" then it's a particle.

Conversely, a wave has a phase in a way that a particle doesn't — a ball moving straight through space doesn't precess; there's no "rotation"; whereas a wave necessarily has those properties.

It should be noted that above, I listed <u>both</u> as properties of a photon.

Day 2:

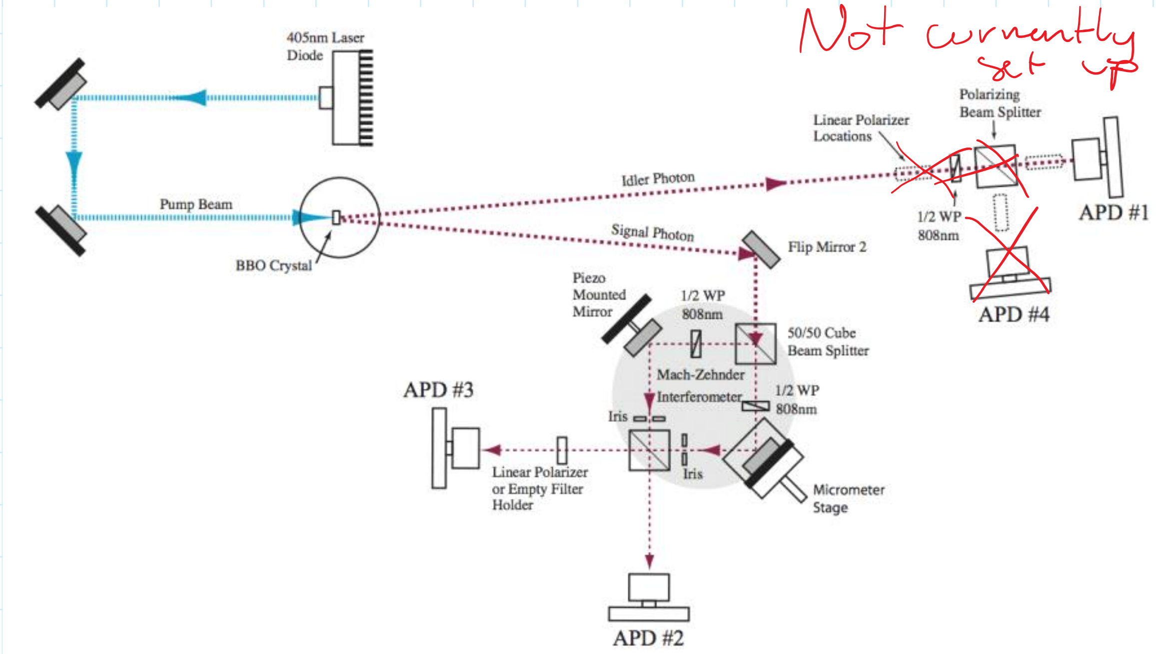
1) 100% destructive — no signal except shot noise

2) The two beams don't interfere; the intensities

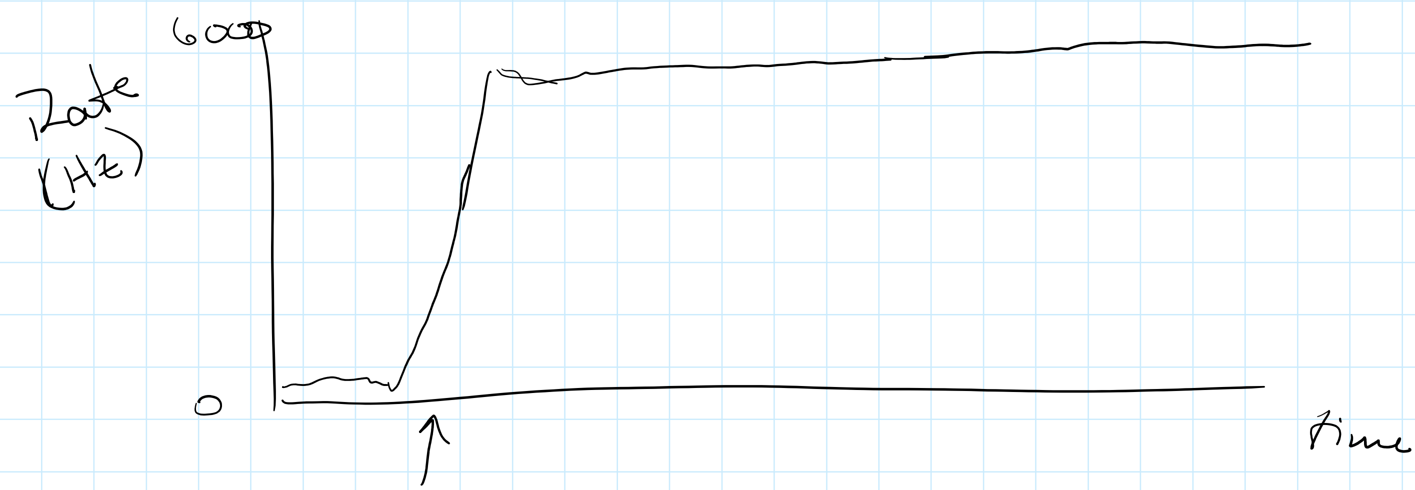
at each path just add in quadrature.

Day 1

Friday, October 29, 2021 1:53 PM



Began by testing the rate counting with the incandescent lights — we see



when we turned on the light

Step 1.

- Set both polarizers to vertical, set the coincidence sweep to run .1V/step, 1sec/step, ..

55 – 60 V. We can see a clear sinusoidal interference pattern developing

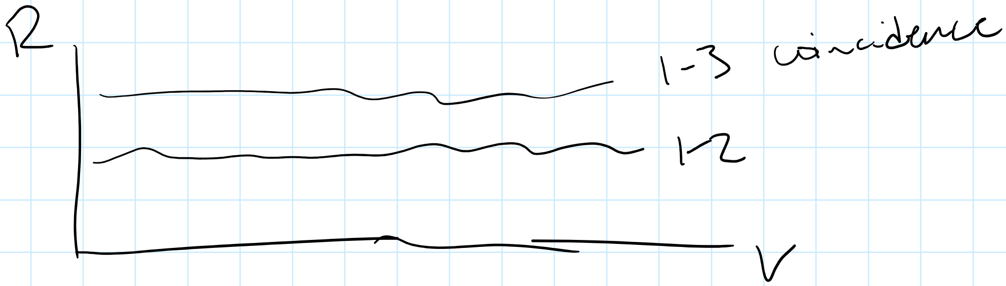
Files: 0-0-none-test1.txt
0-0-none-test2.txt

For the second trial, we increase the voltage step to 1 V for the ability to take more data.

Step 2.
– Set the motorized $\lambda/2$ plate to $\theta = \frac{\pi}{2}$
We observe an interference pattern — conclude that probably the $\lambda/2$ plate changes the polarization by 2θ, which I thought sounded familiar

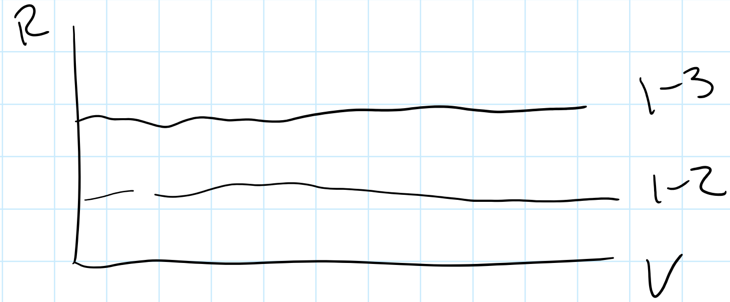
Step 3.
– Set the motorized $\lambda/2$ plate to $\theta = \frac{\pi}{4}$, we see no interference pattern

File: 0-90-none-test1.txt



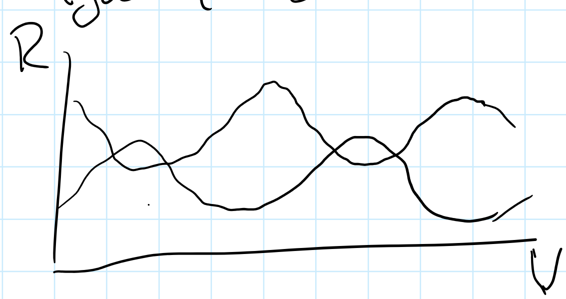
Step 4, To confirm no preferred axis, set manual

1/2 to 20° and motorized to 65° — Still no interference



File: 20-65-none-test1.txt

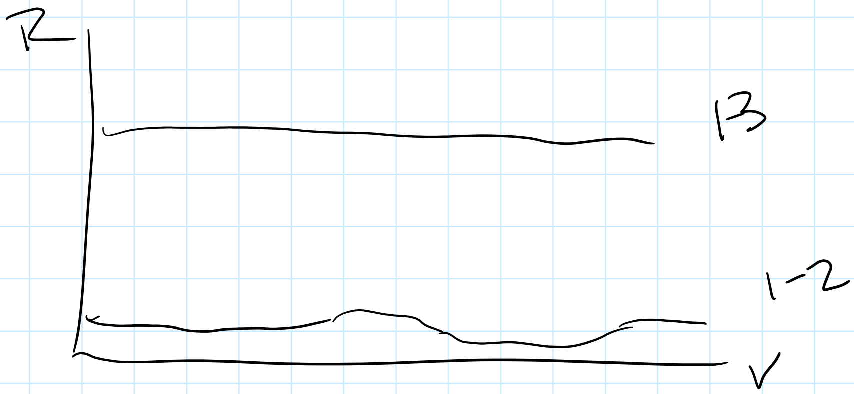
Step 5. Same deal, but with both plates at 20°. Again, we see interference



File: 20-20-none-test1.txt

Step 6. Reset to 20-65 and insert a filter on APD 3 at 0° to see if interference comes back.

Yes? An intensity dip in one channel accompanied by a small interference fringe



Two weird things:

The affected channel is the 1-2 channel, even though we added the filter on APD 3. There is some difference between the labeling in the manual and the lab equipment — channels 2 & 3 are backwards relative to the manual

A small interference fringe appears on the affected channel — the contrast is small, but it's there

File: 20-65-0-test1.txt

7. Configuration 20-65-20:

Qualitatively the same as the previous step

File: 20-65-20-test1.txt

8. Configuration 20-65-40

Again, qualitatively the same. Low contrast fringes on the affected channel.

File: 20-65-40-test1.txt

9. Configure 20-65-60

Similar, but the contrast on the fringe is even lower now

File: 20-65-60-test1.txt

10. Configure at 20-65-90

Similar shape again

File: 20-65-90-test1.txt

11. Configure at 0, 45, 0

Similar shape, but with a notably different phase on the fringe and a bit lower contrast

File: 0-45-10-test1.txt (Mislabeled 0-45-01-test1.txt)

12 Configure 0, 45, 10

Now the fringe is very small

File: 0-45-10-test1.txt

13 Configure 0, 45, 100

Again, vanishingly small interference fringe

File: 0-45-100-test1.txt

14 Configure 0, 45, 55

Now we see distinctly higher fringe amplitude than we've seen before

File: 0-45-55-test1.txt

For probability that two or more photons are in the interferometer, we note that we have 93,800 counts/sec on APD1, so that's 93,800 photons/sec entering the interferometer.

Each spends a time $\frac{L}{c}$ in the interferometer, where $L \approx 20\text{cm}$ is the length of each arm.

Then we get $93{,}800 \cdot \frac{L}{c}$ avg photons per interferometer-time $\approx 6.25e-5$

Modeling the probability as Poissonian, we get

$$P(n) = \frac{(6.25e-5)^n \left(e^{-6.25e-5}\right)}{n!}$$

Then the probability of finding two or more photons within a one interferometer-time window is

$$\sum_{n=2}^{\infty} P(n) \approx 1.95e-9$$

The relative likelihood of an interferometer-time containing two or more events compared to one is

$$\left(\sum_{n=2}^{\infty} P(n)\right) \Big/ P(1) = 3.13e-5$$

So for every occurrence with so we roughly expect one instance of two photons for every 3e4 instances of one photon

For perspective, that's about 3 two-photon events per second, which is quite negligble.

Day 2

Monday, November 1, 2021 4:34 PM

Plotting the fringe amplitudes as a function of ϑ, they didn't really look like $\sin(2\vartheta)$, so took more data

Realized that we weren't sure if the polarizing filter was the same way around every time.

Retaking a data sweep, this time with the numbered side of the dial AWAY from the APD in <u>all</u> samples

Reran every 10° of filter from 0-45-0 to 0-45-180

On plotting data the samples from Friday do seem to be inconsistently taken/labeled. Without a way to readily account for these issues, I'm resulting to only using today's data for demonstrating a $\sin(2\vartheta)$ dependence of the interference fringe amplitude on the external polarizing filter.