

**For these questions, use the simulation “Interferometer experiments with single photons” (Single Photon Lab) in the QuVis HTML5 collection.**

1) Have a play with the simulation for a few minutes, getting to understand the controls and displays. Note down three things about the controls and displayed quantities that you have found out.

2) a) Consider the setup with only a single beam splitter in place. What does the photon visualization suggest to you is happening at the beam splitter? What are the detection probabilities for this case in Detectors 1 and 2?

b) Now consider the setup with two beam splitters and no phase shifter in place. What are the detection probabilities in Detectors 1 and 2? Try to explain this result.

3) Consider the situation where all phase shifters have a fixed phase shift of  $\pi$  (Optics Table 1) and the second beam splitter is placed in the setup.

a) Set up three distinct experiments with the second beam splitter in place. For each of them:

- i) describe the experimental setup
- ii) state what you observe
- iii) explain your observation

b) Come up with general rules for

- i) situations where you add the values of phase shifts to determine the detection probabilities
- ii) situations where you subtract the values of phase shifts to determine the detection probabilities
- iii) situations where the phase shifts do not impact the detection probabilities

Try to explain the underlying reasons for these rules, given the fact that a phase shifter increases the time needed to traverse a given path.

4) Now consider the situation where the phase shifters are variable (Optics Table 2), and the second beam splitter is placed in the setup.

Set up three distinct experiments with the second beam splitter in place. For each of them:

- i) describe the experimental setup
- ii) state what you observe
- iii) qualitatively explain your observation

5) Which of the Challenges did you find most difficult and why? Explain how you solved this challenge. If none of the Challenges were difficult, choose the one you found most interesting and explain how you solved it.