Lecture 17: Multiple Detectors

Wed Sep 25 2019

0.1 Multiple Detectors on a Beam Splitter

Suppose we have detectors C between $1c$ and $2c$ on a beam splitter path, $\hat{c}$ between $2c$ and $3c$, and $\hat{D}$ between $2d$ and $3d$. $\left|1c, C^0\right\rangle \to |2c, C^*\rangle$, etc. Our evolution of states is:

$$|\psi_0\rangle = |0a\rangle \tag{1}$$

$$|\psi_1\rangle = \frac{1}{\sqrt{2}}\left(\left|1cC^0\hat{C}^0\hat{D}^0\right\rangle + \left|1dC^0\hat{C}^0\hat{D}^0\right\rangle\right) \tag{2}$$

$$|\psi_2\rangle = \frac{1}{\sqrt{2}}\left(\left|2cC^*\hat{C}^0\hat{D}^0\right\rangle + \left|2dC^0\hat{C}^0\hat{D}^0\right\rangle\right) \tag{3}$$

$$|\psi_3\rangle = \frac{1}{\sqrt{1}}\left(\left|3cC^*\hat{C}^*\hat{D}^0\right\rangle + \left|3dC^0\hat{C}^0\hat{D}^*\right\rangle\right) \tag{4}$$

Let's define a family of histories F:

$$Y^c = [\psi_0] \otimes [1cC^0\hat{C}^0\hat{D}^0] \otimes [2cC^*\hat{C}^0\hat{D}^0] \otimes [3cC^*\hat{C}^*\hat{D}^0] \tag{5}$$

$$Y^d = [\psi_0] \otimes [1dC^0\hat{C}^0\hat{D}^0] \otimes [2dC^0\hat{C}^0\hat{D}^0] \otimes [3dC^0\hat{C}^0\hat{D}^*] \tag{6}$$

These are the only nonzero chainkets in this family.

$$Pr([1c]_1 \mid C_2^*) = 1 \tag{7}$$

$$Pr([1d]_1 \mid C_2^0) = 1 \tag{8}$$

$$Pr([2d]_2 \mid C_2^0) = 1 \tag{9}$$

$$Pr(D_3^* \mid C_2^0) = 1 \tag{10}$$

0.1.1 Wave Function Collapse

How would this look if we interpreted it as a wave function collapsing?

$$|\psi_0\rangle \xrightarrow{T} |\psi_1\rangle \xrightarrow{\text{collapse}} \begin{cases} \left|2cC_2^*\hat{C}_2^0\hat{D}_2^0\right\rangle & \text{if } C_2^* \\ \left|2dC_2^0\hat{C}_2^0\hat{D}_2^0\right\rangle & \text{if } C_2^0 \end{cases} \xrightarrow{T} \begin{cases} \left|3cC_3^*\hat{C}_3^*\hat{D}_3^0\right\rangle & \text{Probability } = 1 \\ \left|3dC_3^0\hat{C}_3^0\hat{D}_3^*\right\rangle & \text{Probability } = 1 \end{cases} \tag{11}$$

The wave function "collapses" before the second state because of the C detector. However, if that detector is turned off, does that wave function still collapse? We know the state of that detector even if it's turned off!