

Derivation of the phase compensation

A simple derivation and simulation done for the phase compensation used for remote state preparation

Derivation

Assume initial state of pump beam after the double crystal to be $|\Psi_i\rangle$.

$$|\Psi_i\rangle = \frac{|HH\rangle + e^{i\psi}|VV\rangle}{\sqrt{2}} = \begin{pmatrix} 1 \\ 0 \\ 0 \\ e^{i\psi} \end{pmatrix} \quad (1)$$

Here, ψ is the relative phase created by the double crystal. Ψ_i can be represented by a 4×1 matrix. The optical components acting on this entangled state can be represented by the following matrix forms.

$$\hat{A}_{PBS} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = \langle H| \quad (2)$$

$$\hat{A}_H(\alpha) = \begin{pmatrix} -\cos 2\alpha & -\sin 2\alpha \\ -\sin 2\alpha & \cos 2\alpha \end{pmatrix} \quad (3)$$

$$\hat{A}_Q(\alpha) = \begin{pmatrix} \sin^2 \alpha + i \cos^2 \alpha & (i-1) \sin \alpha \cos \alpha \\ (i-1) \sin \alpha \cos \alpha & i \sin^2 \alpha + \cos^2 \alpha \end{pmatrix} \quad (4)$$

Here, H is for half-wave plates, and Q is for quarter-wave plates. Assume the measured angles to be θ_{H_1} , θ_{H_2} , and θ_{Q_2} respectively for each component. Then the final measured coincidence rate should be as follows.

$$coincidence = Amp * \left(\langle H | \hat{A}_H(\theta_{H_1}) \otimes \hat{A}_{PBS} \hat{A}_H(\theta_{H_2}) \hat{A}_Q(\theta_{Q_2}) | \Psi_i \rangle \right) \quad (5)$$

Amp represents the amplitude. Therefore, by fitting measured data of coincidence versus θ_{H_2} , the phase can be calculated.

Question

To test on my theory, I tried to print the function. I chose $\theta_{H_1} = 22.5$, $\theta_{Q_2} = 23$, and $Amp = 1$. Then I printed out the calculated values for coincidence versus θ_{H_2} for different phase values. The resulting graph is shown in Fig 1. Then, I plotted out my measured data in Fig 2. This set of data only contains a few data points because I didn't have time to do more. However, the trend doesn't look similar to the simulated function.

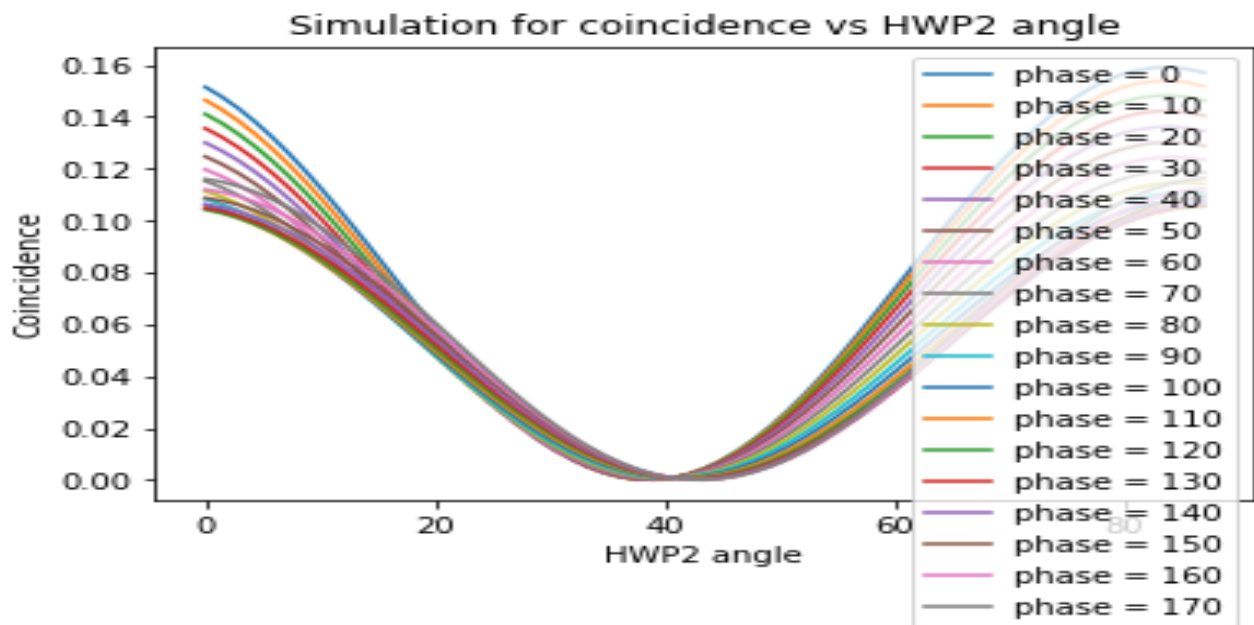


Figure 1: Simulation data

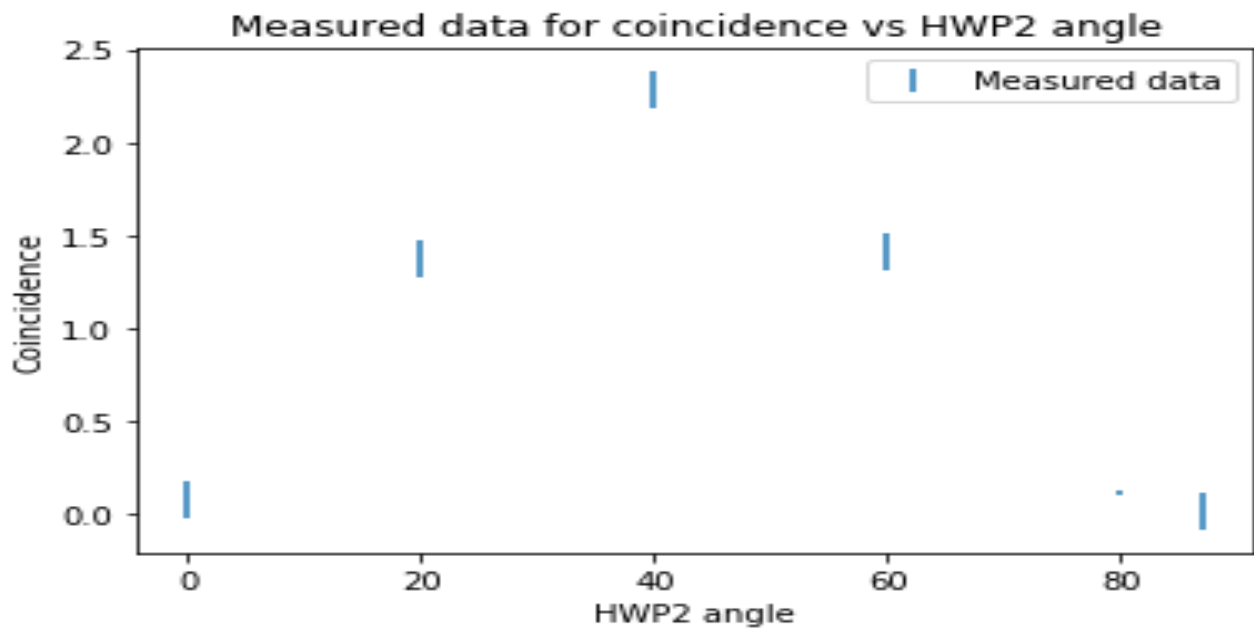


Figure 2: Measured data