is not a problem. Polarization difference between the two paths is another degree of freedom that can contribute to distinguishability. As it is easily controlled using the wave plates, it is possible to verify that the interference is between the two spatial modes and not between two polarization modes. We measured the interference visibility while gradually rotating the photon's polarization on one path using a HWP (see Fig. 4). With no rotation, the polarizations of both paths match, and interference is observed. When a relative rotation between the two paths is applied, distinguishability is introduced and the interference decreases. At 90°, there is non-vanishing visibility of about 5%, which is attributed to some elliptical polarization mismatch. As stated above, this also affects the maximal observed visibility.

5. Conclusions

In conclusion, we have demonstrated a method to control the spatial properties of entangled down-converted photons. Two-photon path entangled states were generated from a two-dimensional periodically poled nonlinear crystal. Bunching on a beam splitter is not required as the states are emitted directly from the source. The two paths of the generated state were combined at a fiber coupler and quantum amplitude oscillations with a doubled phase sensitivity were observed. This source demonstrates the ability to simultaneously phase-match more than one quantum process in such two-dimensional crystals. This method can be further extended for generating entangled photons with controlled spatial, spectral and polarization properties. For example, polarization entangled photons can be created using a slightly different scheme in which the same crystal is pumped with *y*-polarized pump, thereby generating pairs of orthogonally polarized photons through the d_{yzy} process [30]. After the submission of this work, a similar independent result was submitted to the Arxiv [31].

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