Protocol for Communication via Differentiation of Hidden Basis from Linear Basis of Entangled Photon Pair Polarization

W. Michel Chandler, February 14, 2025

ABSTRACT:

What is the polarization basis of an entangled photon pair when exiting a beta-barium borate crystal (BBO)? Repeated experiments have confirmed there is no linear polarization basis that can account for the observed (anti-)correlations of the pair. Rather, the pair is initially defined by a real but inaccessible basis of polarization which is orthogonal to all linear polarization bases – a hidden basis[1]. The properties of orthogonality of the hidden basis to all linear polarization bases and the instantaneous decoherence of both members of the pair to a linear polarization basis following measurement of one member are exploited in the following experimental proposal to facilitate limited faster than light communication.

METHODS:

<u>Constructing the device:</u>

Generation of entangled photon pairs: A non-functioning mock-up of the experimental design is shown in Figure 1. Briefly, a 405nm laser is linearly polarized and directed into a beta-barium borate (BBO) crystal cut and oriented for type 2 spontaneous parametric down conversion. As a rare event within the crystal a 405nm photon will undergo down conversion into two 810nm photons which are entangled and in a state of superposition regarding their axes of polarization[2]. This pair will show anti-correlation of the linear polarization basis when measurement results are compared with a conventional communication channel, which will not be utilized in this protocol. The half-opening angle between these resulting 810nm idler and signal arms is approximately 6 degrees.

The idler arm: The first element is a flip-mount mirror. When the mirror is in the DOWN position, light in the idler arm will continue to the polarizing beamsplitter which directs vertically polarized light toward one beamstop with high absorbance at 810nm and horizontally polarized light toward a second similar beamstop. When the flip-mount mirror is in the UP position, light in the idler arm will be directed to the far field (a wall several meters away).

The signal arm: The first element is a modified double slit. Over the front of slit H a horizontal linear polarizing filter is placed (a reflective linear polarizing filter which reflects vertically polarized light and transmits horizontally polarized light). Over the front of slit V a vertical linear polarizing filter is placed. On the back of slit H a true zero order halfwave plate is placed which will retard the horizontally polarized light into vertically polarized light. Nothing is placed on the back surface of slit V. This modified double slit is called a Young Inquisitor. After transiting the Young Inquisitor there is a detection device, which in this case is a camera, but could also be a single photon counting module.

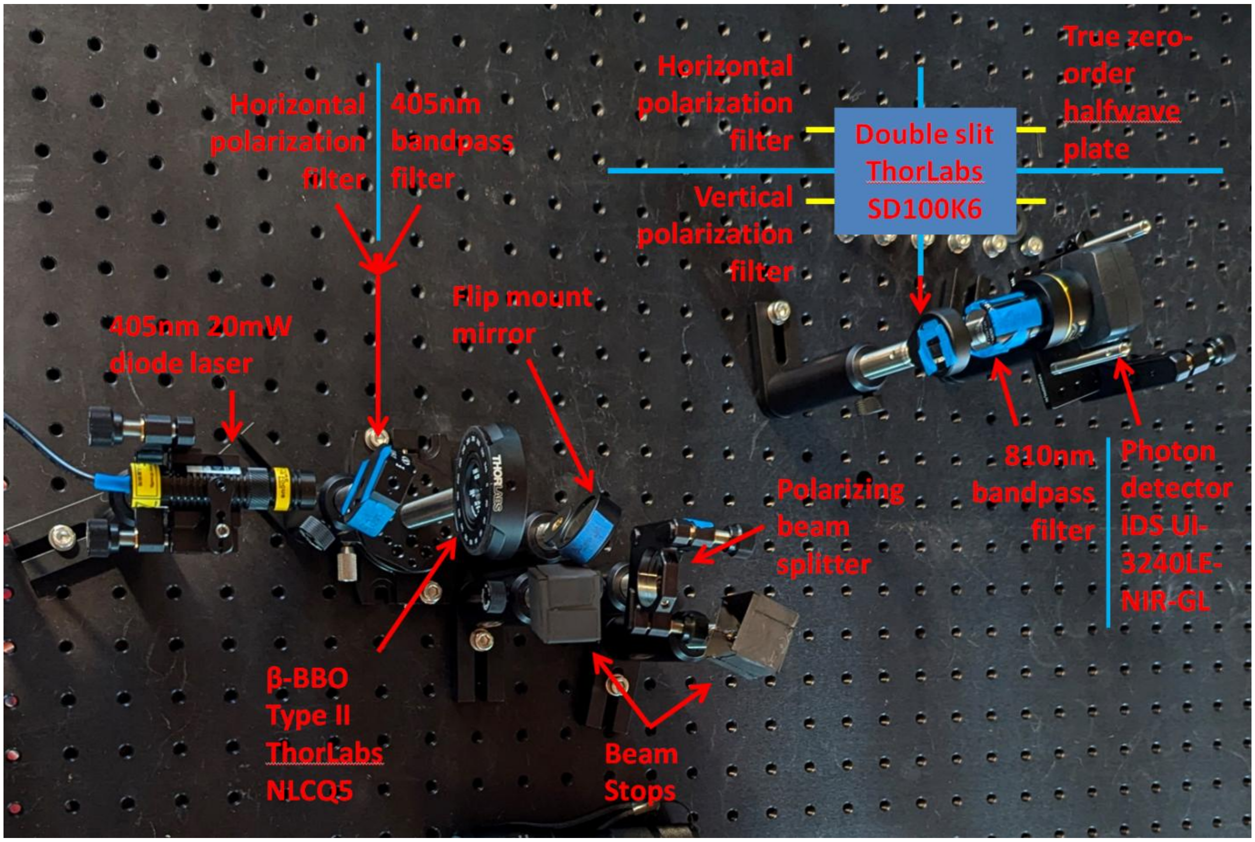

Figure 1: Mock-up of the experiment. The idler arm exits the BBO crystal and diverges toward the flip-mount mirror while the signal arm exits the BBO crystal and diverges toward the photon detector (in this setup an IDS UI-3240LE-NIR-GL)

Transmitting the signal:

A signal is sent from the idler arm to the signal arm without a classical communication channel by flipping the mirror on the idler arm between UP and DOWN positions. When the flip-mount mirror is in the DOWN position the linear polarization basis for the entangled pair is set at the beamstops of the idler arm, which are located closer to the BBO crystal than the Young Inquisitor (Figure 2). When the linear polarization basis is set before the Young Inquisitor each signal arm photon's wave function will travel through only one slit or the other, but not both, and will therefore create a single slit interference pattern at the detector.

When the flip-mount mirror is in the UP position the linear polarization basis for the entangled photon pair is set at the photon detector of the signal arm (Figure 3). When the linear polarization basis is set after the Young Inquisitor each signal arm photon's wave function is in the hidden basis and will traverse both slits to create a double slit interference pattern at the detector.

When transmitting a signal via this method it is necessary to ensure the time between photon detections at the signal arm photon detector is significantly greater than the temporal coherence of the 810nm light. Otherwise, a double slit interference pattern will accumulate at the signal arm detector in both the idler arm mirror UP and DOWN states.

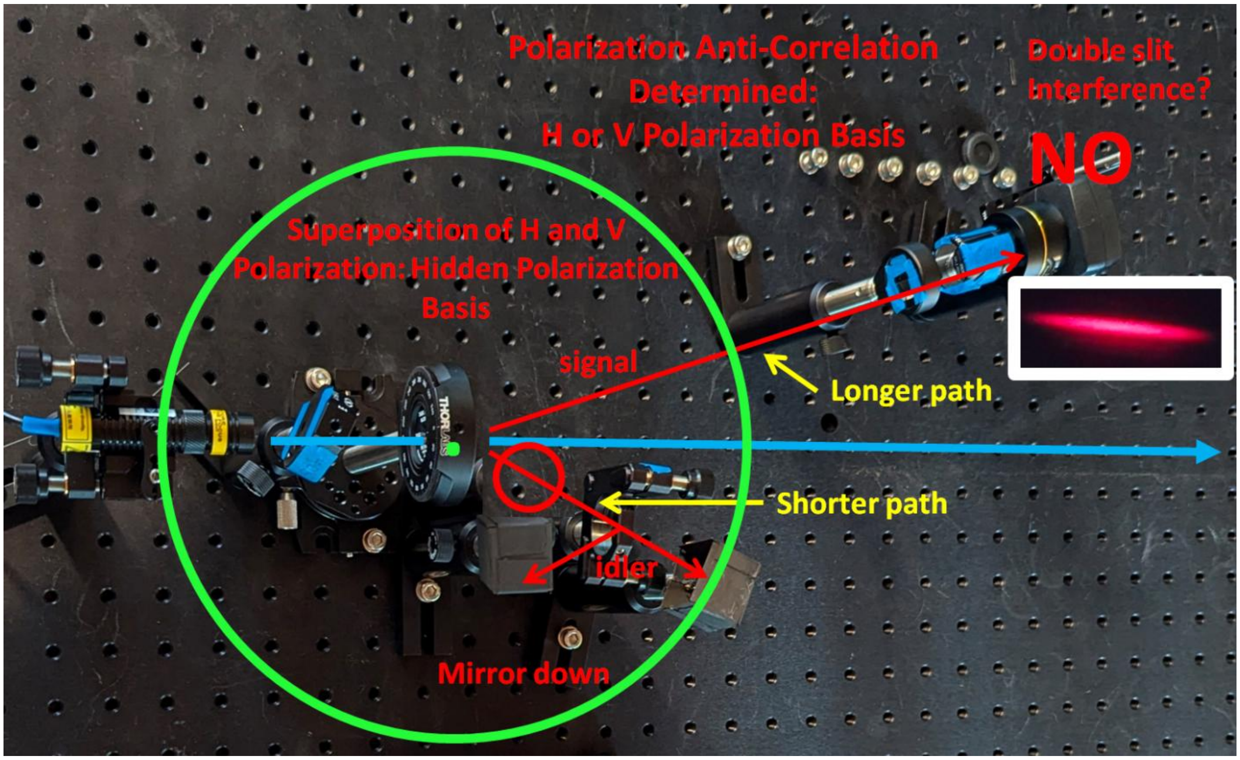

Figure 2: Flip-mount mirror in the DOWN position. A single slit interference pattern will accumulate at the signal arm detector

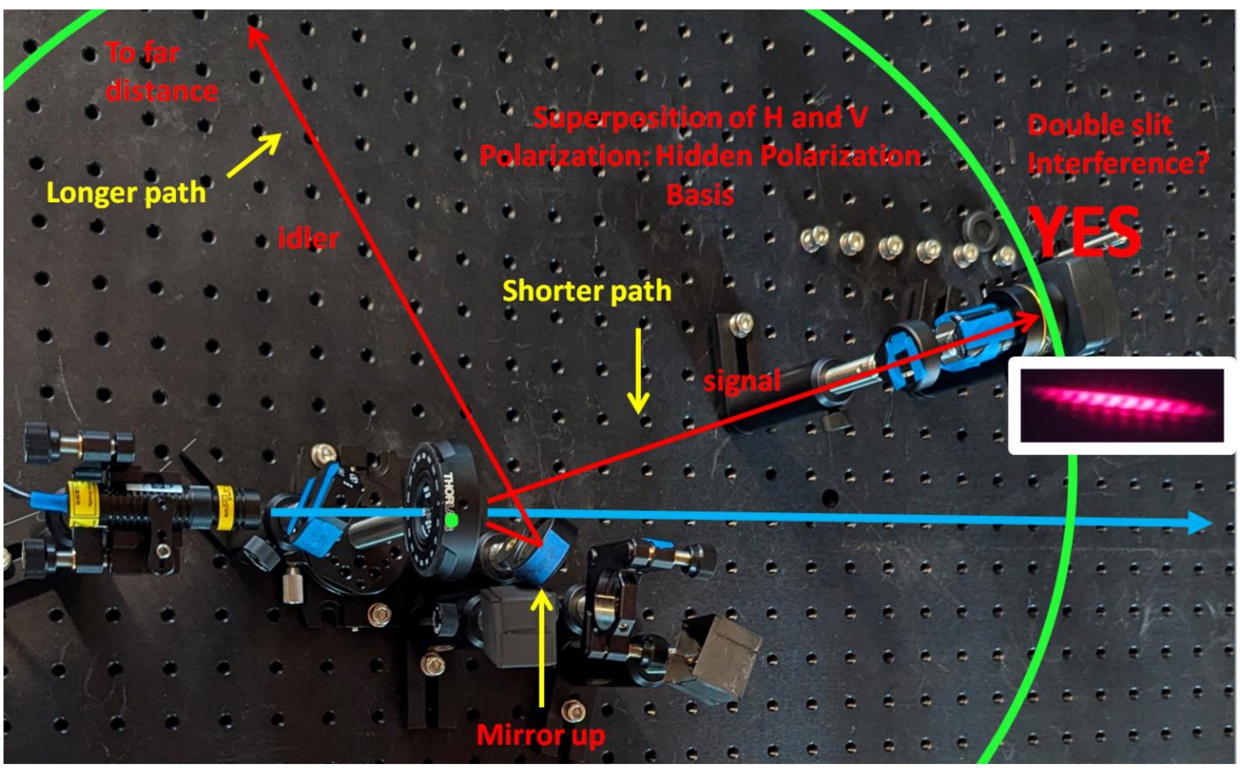

Figure 3: Flip-mount mirror in the UP position. A double slit interference pattern will accumulate at the signal arm detector.

RESULTS:

While several properties of the Young Inquisitor have been demonstrated previously with bright laser light[4,5], the 810 nm light in this experiment is extremely low intensity. Attempts to detect any of the 810 nm light of the signal arm with the depicted imaging system have been unsuccessful due to the dark count rate of this detector. Other experimenters have succeeded in imaging 810nm BBO outputs with more sophisticated imaging devices[1,3].

DISCUSSION:

This communication protocol integrates the findings of multiple well-known prior experiments and makes three synthetic proposals: 1) When a photon pair entangled and in a state of superposition regarding their axes of polarization exits the BBO crystal their polarization basis is can be conceptualized as the "hidden basis" which is a real but inaccessible axis orthogonal to all possible orientations of a linear polarizer[1]; 2) After measurement along a linear polarization basis for one member of the entangled pair, the anti-correlated linear polarization basis for the other member of the pair is instantly established, even if it is 'in flight'; 3) Measurement and decoherence of the entangled pair occurs when there is a meaningful exchange of information between one member of the pair and a mass. Mirrors, beamsplitters, reflective linear polarizers and halfwave plates do not cause decoherence, but an absorptive beamstop or charge coupled device does.

If this communication protocol succeeds, it implies faster than light communication is possible, with limits.

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KEYWORDS:
Beta barium borate, entangled, photon, hidden basis, polarization, faster than light, FTL, communication, Young Inquisitor, double-slit, mirage