Extended Abstract:

The main experimental challenge of MDI-QKD is to perform a high-fidelity Bell State Measurement (BSM) between photons from different light sources, which is not required in conventional QKD schemes. For this, it is necessary to include feedback controls to compensate, among other quantities, the time-dependent polarization rotations caused by the fibres.

Recently, some researchers analyzed the reference frame independent quantum key distribution and exploited orbital angular momentum in combination with optical polarization to encode the information in twisted photons in order to implement free space QKD. Moreover, this rotation invariant space can be considered as decoherence-free subspace, which is insensitive to the noise associated with unknown relative rotations.

In this paper, we adopt the hybrid encoding approach of polarization-OAM qubit and present an available extension MDI-QKD protocol, which only needs to insert four q-plates in transmittance procedure. This in turn means that the initial encoding and final decoding of information in our MDI-QKD implementation protocol can be convenient performed in the polarization space, while the transmission is done in the rotation invariant hybrid space. In particular, comparing to the original MDI-QKD protocol, our method can effectively decrease the error rate caused by random rotation and the numerical calculations show that both the secure key rate and transmission distance can be improved with our modified protocol owing to the lower quantum bit error rate.

The schematic of our modified MDI-QKD model is shown in Fig.1 and the modified MDI-QKD protocol runs as follows:

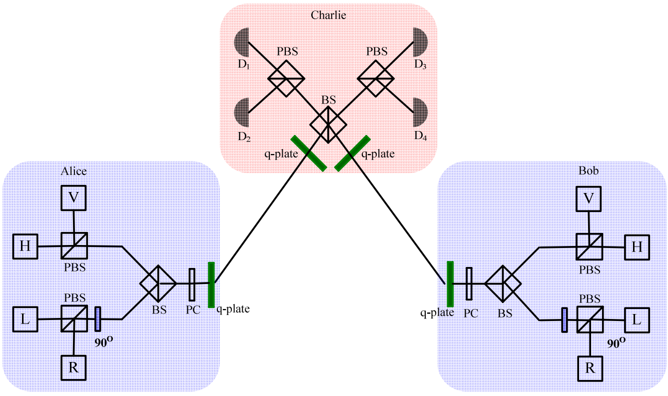

Figure.1. A schematic of our modified MDI-QKD protocol.

Similar to the original polarization encoding MDI-QKD protocol, Alice randomly chooses a polarization basis and then couples the two states into one of the qubit basis. In our modified MDI-QKD protocol, the four polarized basis(having zero OAM) firstly pass through a q-plate, which maps polarization encoding qubit into hybrid polarization-OAM states. By passing through the q-plate, encoded polarization states are transformed into rotation invariant hybrid states, which are transmitted to the receiving station. Interestingly, any rotation will leave such states unaffected since the phase shift related to the polarization state will be exactly cancelled out by the phase shift of the OAM eigenstate. Before Eve performs a partial BSM on the received pulses, a second q-plate with the same value of q transforms the four rotation invariant hybrid states back in the original polarization states. Therefore, the BSM in our MDI-QKD implementation protocol can be convenient performed in the polarization space. A successful BSM result corresponds to the observation of precisely two detectors being triggered. Our simulations show that the total error rate is dramatically reduced by using the hybrid rotation invariant state to eliminate the channel misalignment errors.

The main contribution of this paper is to present a MDI-QKD system that uses twisted photonics states to overcome the polarization misalignment problem mentioned above without including any feedback control. In particular, we demonstrate error rate performance that are fully compatible with practical application requirements and our results extend previous achievements of polarization encoding MDI-QKD protocol. Furthermore, Our hybrid encoding approach only needs to insert four q-plates in practical experiment and our simulation results show that the modified protocol is practical.

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Thanks very much for your attention to our paper.

Sincerely yours,

Chen Dong