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Coherent One Way (COW) QKD Protocol

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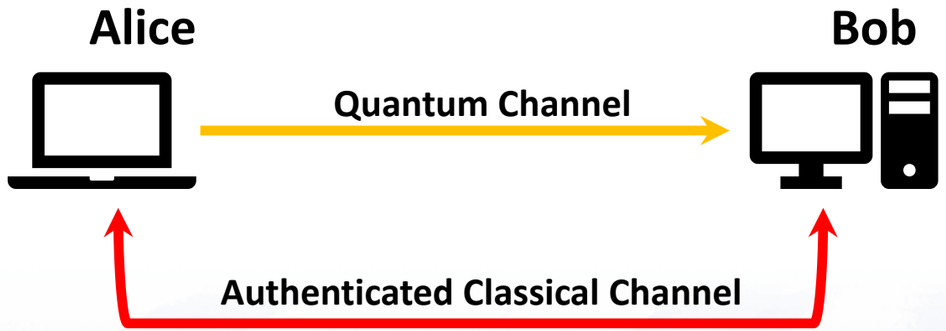
Quantum Key Distribution

- Quantum Key Distribution (QKD)[1] is a secure way of sharing a unique random key between two parties spatially distant.
- Polarization QKD vs Time Bin QKD.

They use:

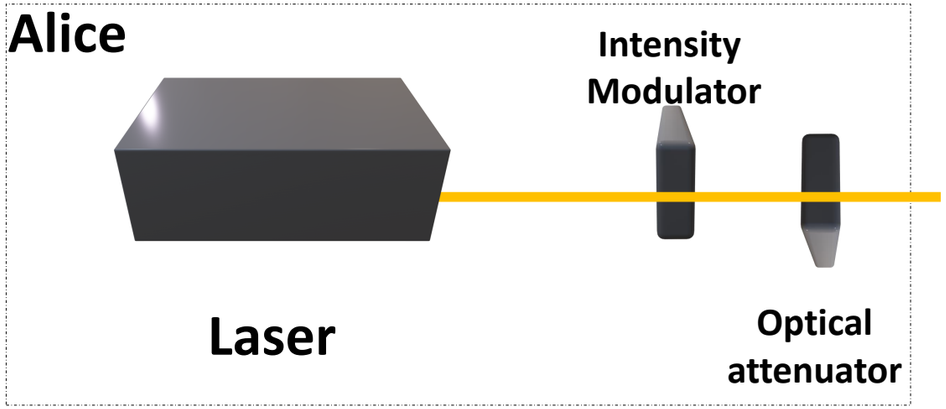
- One quantum channel (One way is this QKD)
- And one authenticated classic channel (can be eavesdropped but can't be modified).



[1] Ouellette, Jennifer. "Quantum key distribution." Industrial Physicist 10.6 (2004): 22-25.

Time Bin QKD

- The Coherent One Way (COW) protocol was elaborated by Nicolas Gisin et al in 2004 [2].
- Uses time bin properties.
- It is has a very simple setup (Bob's apparatus is passive).



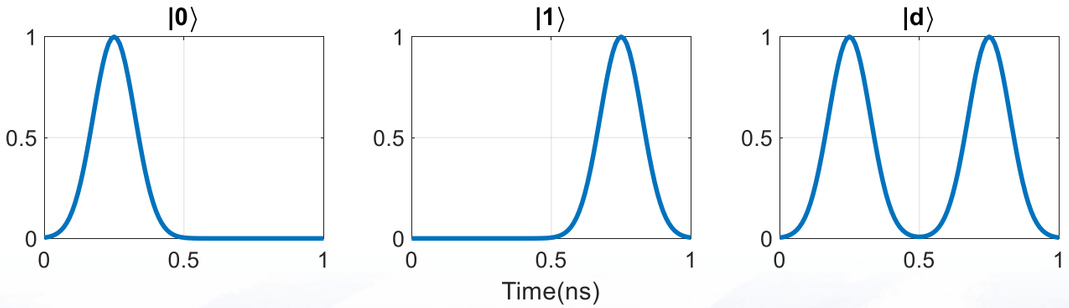
[2] Gisin, Nicolas, et al. "Towards practical and fast quantum cryptography." arXiv preprint quant-ph/0411022 (2004)

Alice - COW protocol

Step 1 Alice creates a random key using:

$$|0\rangle = |\alpha\rangle|\emptyset\rangle = \quad Logical\ 0$$
$$|1\rangle = |\emptyset\rangle|\alpha\rangle = \quad Logical\ 1$$
$$|d\rangle = |\alpha\rangle|\alpha\rangle = DecoyState$$

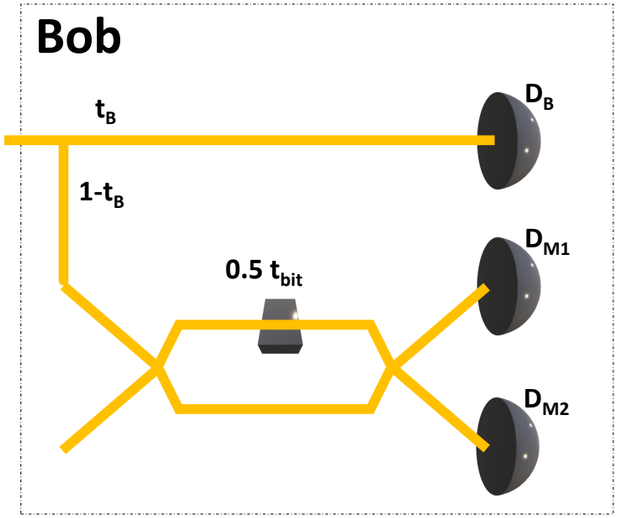
Where $|\emptyset\rangle$ is the vacuum state and $|\alpha\rangle$ is a coherent state of light with intensity $\mu = |\alpha|^2 << 1$.



Bob - COW protocol

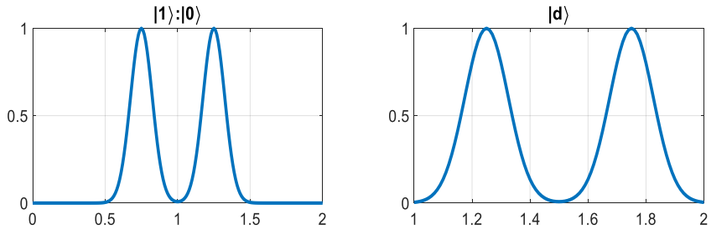
Step 2 A fraction t_B of the photons go into the photon counter D_B, where the bits are discriminated by the time of arrival.

Half of the other photons are delayed by 0.5 t_{bit} interacting with the half of non-delayed bits.

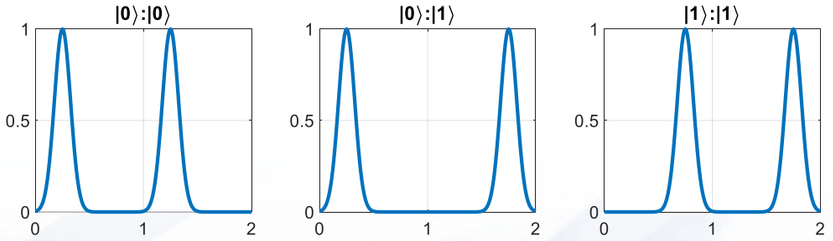


Monitoring line - COW protocol

The D_{M2} (constructive photon counter) should only click when:



All the other combinations of photons should click the D_{M1}:

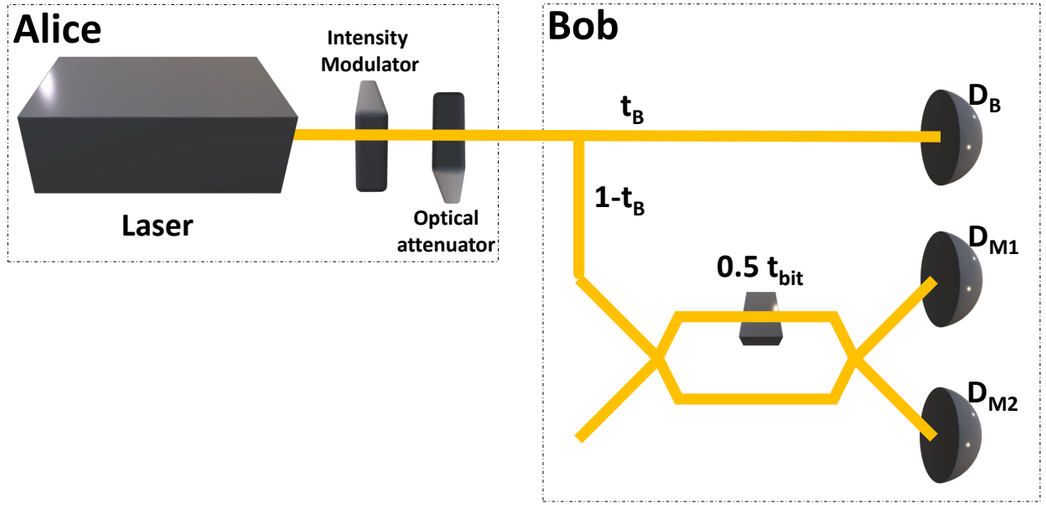


Testing Visibility and Errors - COW protocol

Step 3 Alice tell the times of the decoy. Bob checks if the D_{M2} has fired during a decoy time.

Step 4 Bob reveals the other times that he had a detection in D_{M2}, Alice verifies if they belong to a $|1\rangle : |0\rangle$.

Step 5 Bob reveals some part of the key. Alice and Bob run error correction and privacy amplification on these bits and end up with a secret key.



Intercept-Resend Attack - COW protocol

- Eve detects the pulse flying to Bob (probability μt), and if the detector fires, she prepares a single-photon in the good time-bin and forwards it to Bob.
- Eve breaks coherence everywhere with this attack.

The size of the key is the sum of:

- Eve and Bob detected
- Eve detected and Bob had a dark count
- Eve has not detected and Bob had a dark count

$$V_{d|IR} = V_{10|IR} = 0$$

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- Ouellette, Jennifer. "Quantum key distribution." Industrial Physicist 10.6 (2004): 22-25.
- Gisin, Nicolas, et al. "Towards practical and fast quantum cryptography." arXiv preprint quant-ph/0411022 (2004).
- Branciard, Cyril, et al. "Zero-error attacks and detection statistics in the coherent one-way protocol for quantum cryptography." arXiv preprint quant-ph/0609090 (2006).
- Kronberg, Dmitry Anatol'evich, et al. "Analysis of coherent quantum cryptography protocol vulnerability to an active beam-splitting attack." Quantum Electronics 47.2 (2017): 163.