Coherent One Way (COW) QKD Protocol

INSTITUIÇÕES ASSOCIADAS

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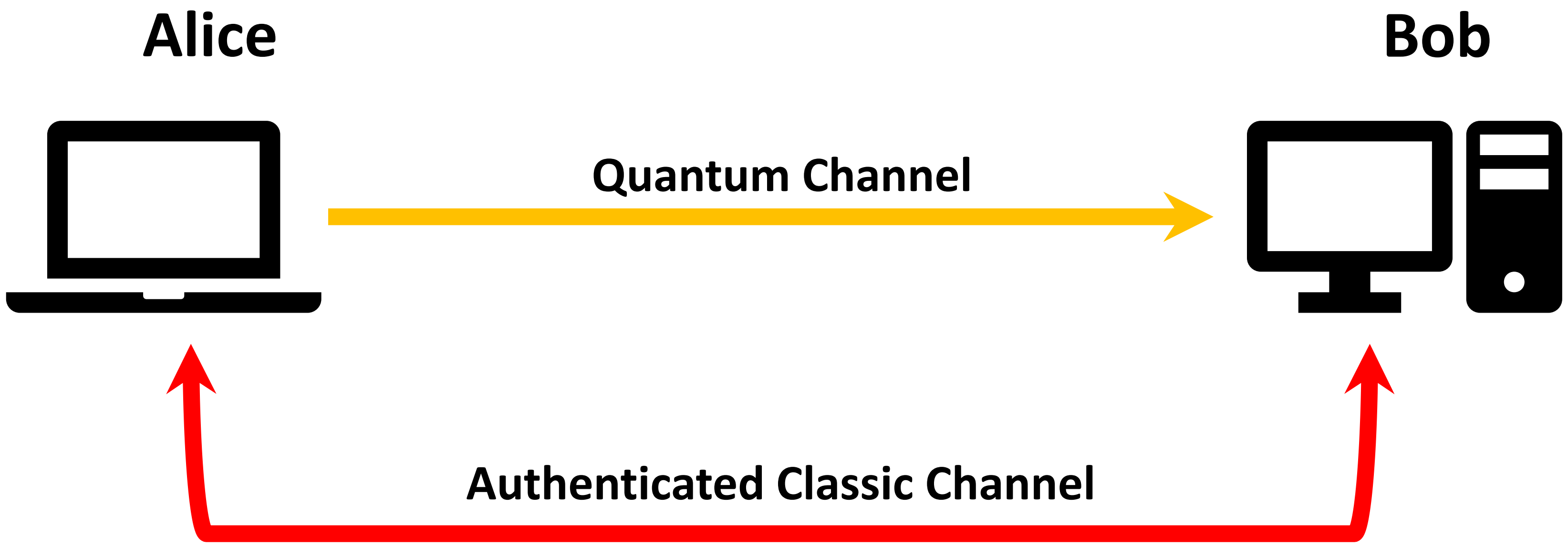
Quantum Key Distribution

Quantum Key Distribution (QKD) is a secure way of sharing a unique random key (composed of 0 and 1) between two parties spatially distant. They later use this symmetric key to encrypt and decrypt messages between them.

To share/create the random key, they use two channels, one quantum channel and one Authenticated classic channel (can be eavesdropped but can't be modified).

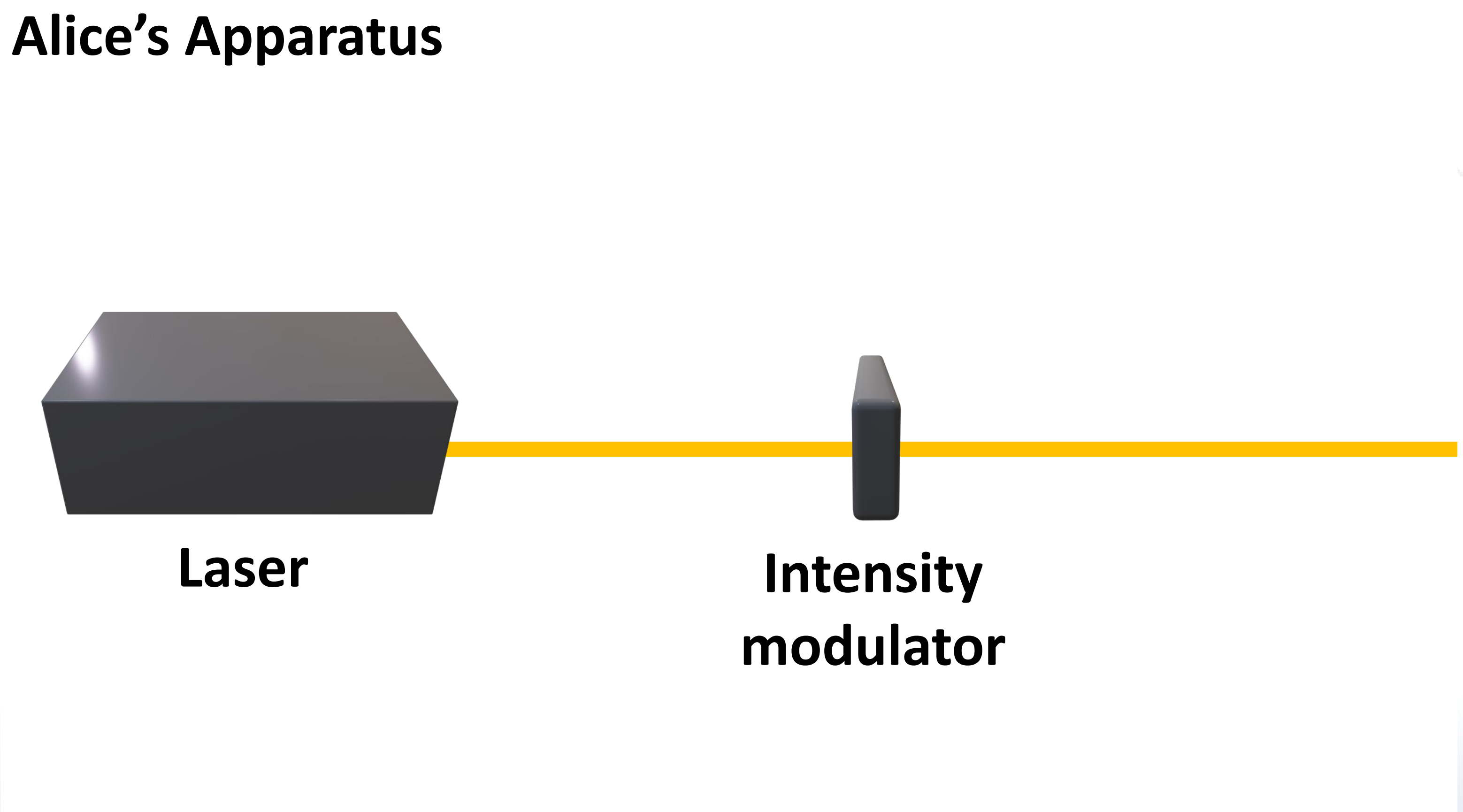


Quantum Key Distribution

The two main types of QKD are Polarization protocols and Time Bin protocols.

The Coherent One Way (COW) protocol was elaborated by Nicolas Gisin et al in 2004 [1]. Uses time bin properties.

It is also characterized by having a very simple experimental setup since Bob's apparatus is passive.



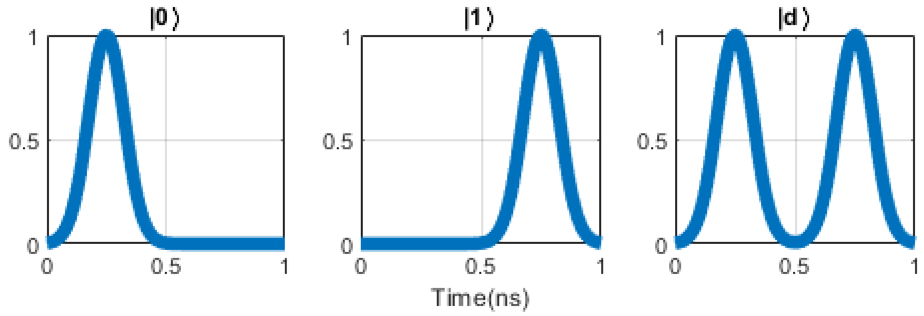
[1] Gisin, Nicolas, et al. "Towards practical and fast quantum cryptography." arXiv preprint quant-ph/0411022 (2004).

COW - Protocol

Step 1 Alice creates a random key using:

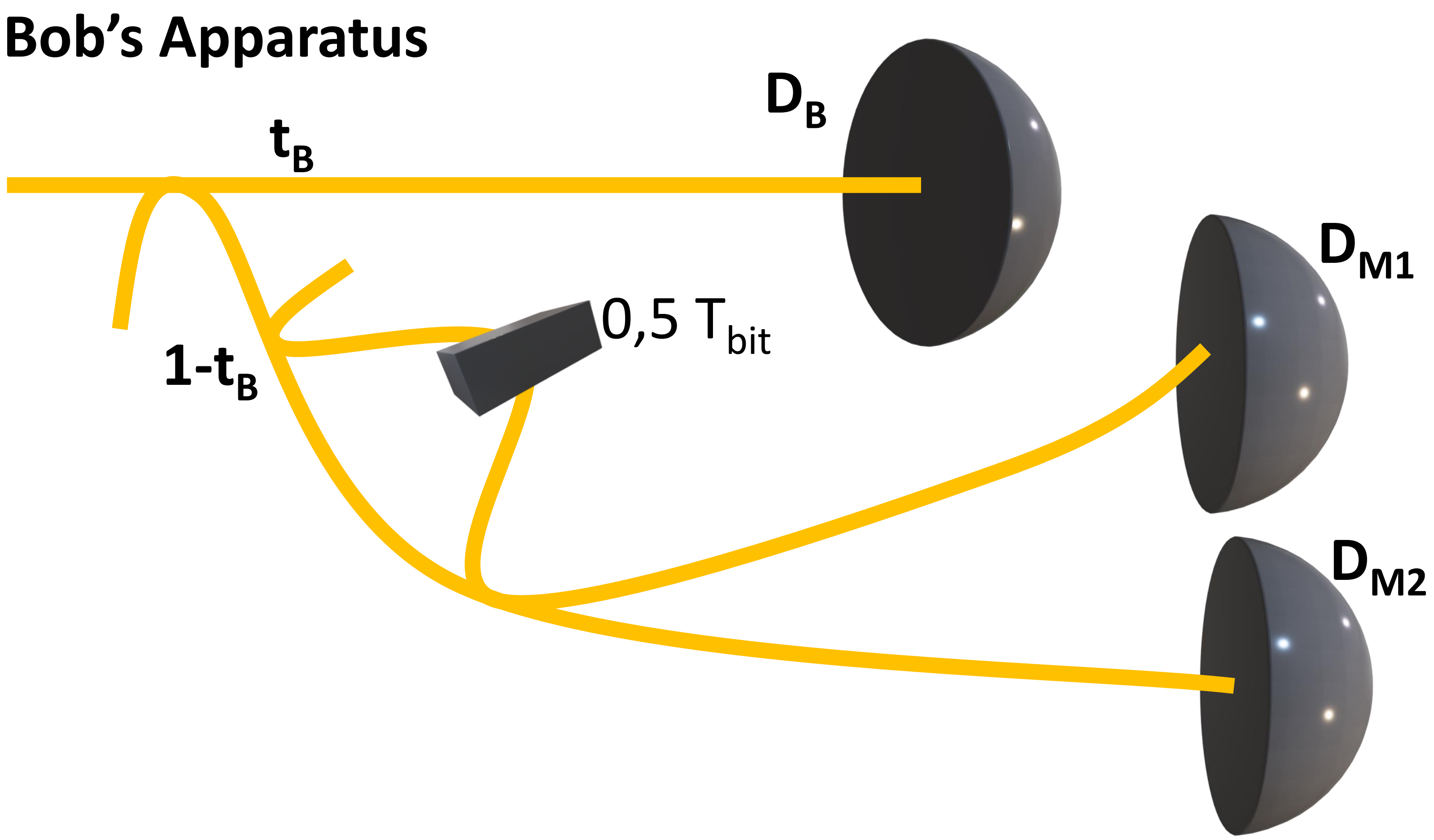
$$|0\rangle = |\alpha\rangle|\emptyset\rangle$$
$$|1\rangle = |\emptyset\rangle|\alpha\rangle$$
$$|d\rangle = |\alpha\rangle|\alpha\rangle$$

Where $|\emptyset\rangle$ is the vacuum state and $|\alpha\rangle$ is a coherent state of light with intensity $\mu = |\alpha|^2$ and spreads a few random decoy states ($|d\rangle$) in random locations during the creation of the key.



COW - Protocol

Step 2 Bob's detection is completely passive. An asymmetric coupler sends a fraction t_B of the photons into the data line. That consist of a single photon counter D_B, where the bits are discriminated by the time of arrival.



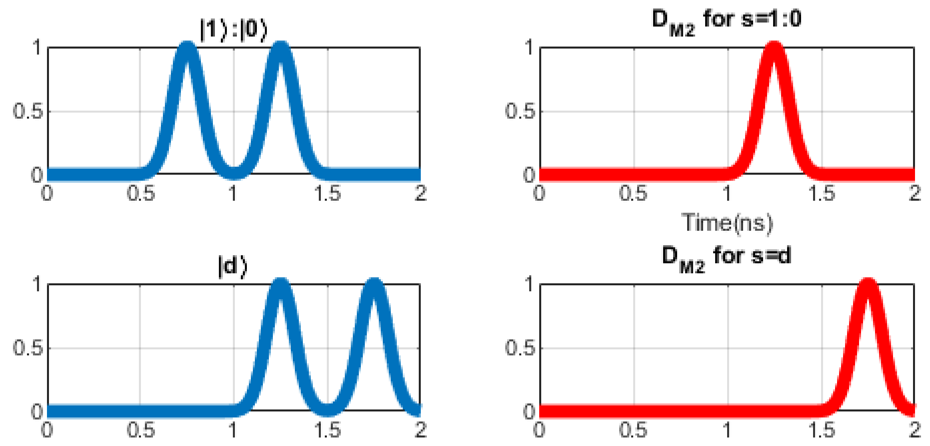
In the other line half of each pulse interacts with the half of the previous pulse (delayed by 0.5 T_{bit}).

COW - Protocol

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

- A logical bit 1 followed by a logical bit 0 where the coherence is across the bit separation (s=1:0);
- Decoy state where the coherence is within the bit sequence (s=d);

All the other photons should click the D_{M1}.



COW - Protocol

Step 3 Alice tell Bob the times of the decoy sequences ($2k_d$ & $2k_d - 1$). Bob also checks if the D_{M2} has ever fired during a $2k_d$ time. Thus they estimate the break of coherence of decoy pulses.

Step 4 Bob reveals the times that he had a detection in D_{M2}, Alice verifies if they belong to a $|1\rangle : |0\rangle$, thus, Alice and Bob estimate the break of coherence across the bit separation.

Step 5 Finally, Bob reveals the items that he has detected in the data line. Alice and Bob run error correction and privacy amplification on these bits and end up with a secret key.

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- 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.
- Roberts, George L., et al. "Modulator-Free Coherent-One-Way Quantum Key Distribution." Laser & Photonics Reviews 11.4 (2017): 1700067.