Coherent One Way (COW) QKD Protocol

João António, Daniel Pereira, Armando N. Pinto

Department of Electronics, Telecommunications and Informatics,
University of Aveiro, Aveiro, Portugal
Instituto de Telecomunicações, Aveiro, Portugal

INSTITUIÇÕES ASSOCIADAS:

INSTITUTO SUPERIOR TÉCNICO

Faculdade de Ciências e Tecnologia da Universidade de Coimbra

universidade de aveiro

PT Inovação

SIEMENS Communications

it

instituto de
telecomunicações

creating and sharing knowledge for telecommunications

COW - Protocol

Step 1 Alice produces:

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

where $|0\rangle$ is the vacuum state and $|\alpha\rangle$ is a coherent state of light with intensity $\mu = |\alpha|^2$.

Alice produces $|d\rangle$ with probability f and the quantum signal cannot be divided bitwise (coherence of the laser).

$$|...0d10...\rangle = |... : 0\alpha : \alpha\alpha : \alpha 0 : 0\alpha...\rangle$$

COW - Protocol

Step 2 Alice uses an attenuator to around 0.1 photons per pulse and then transmits through a quantum channel.

Step 3 Bob uses a 90:10 beamsplitter making 90% of the photons into the SPD_1 to arrival time measurements, the remaining 10% are used to measure phase coherence.
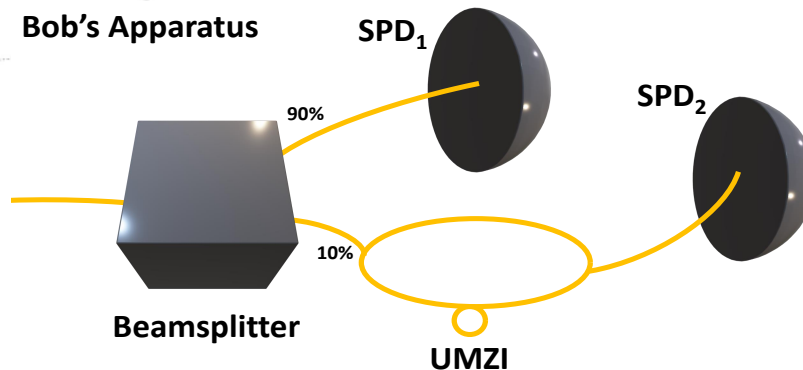
COW - Protocol

In the UMZI (Unbalanced Mach-Zehnder Interferometer) the delayed half of each pulse is recombined in the non-delayed half the next pulse.
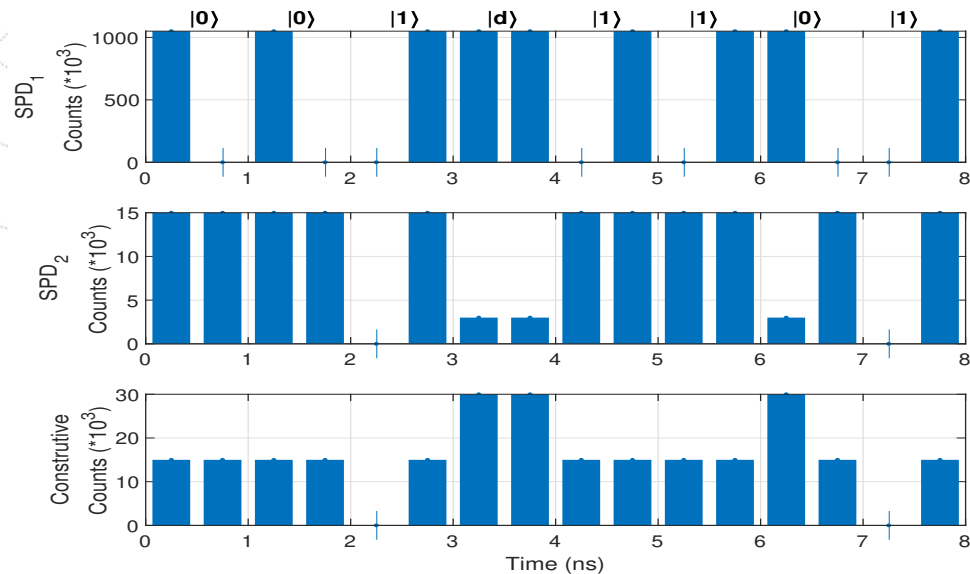

Image based on the article 2017 - Roberts - Modulator-free coherent-one-way quantum key distribution

COW - Protocol

Step 4 Alice informs Bob when she sent a decoy pulse.

Step 5 They calculate the visibility (V) and the QBER (Q) of the key.

$$V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

where the I_{max} and I_{min} are the average pulse intensities for constructive and destructive interference respectively.

They also share a small part of the key in a public channel, to see if there are errors in the message.

A loss of coherence and therefore a reduction of the visibility reveal the presence of an eavesdropper, in which case the key is simply discarded
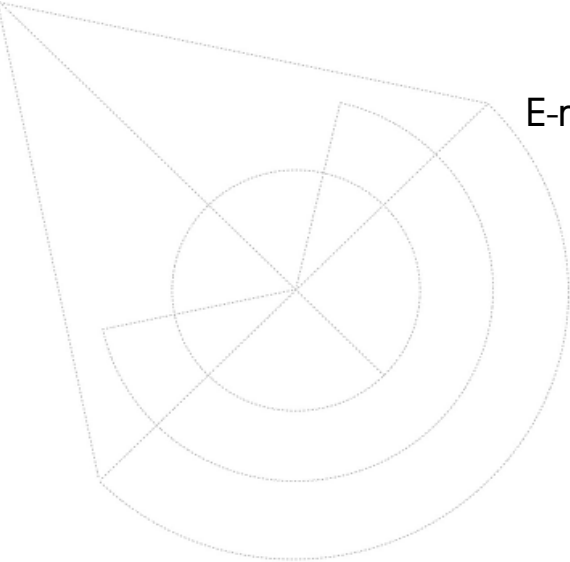
COW - Protocol - Attacks

- Beam-splitting attack - Eve removes a small part from the intensity of the original message and send the rest to bob in a no-losses channel (symbolized by a red line). Eve introduces additional errors in order to make her information equal to the Bob information.

- Active beam-splitting attack - Eve removes smaller intensities of the message and can make individual measurements and block some of it.
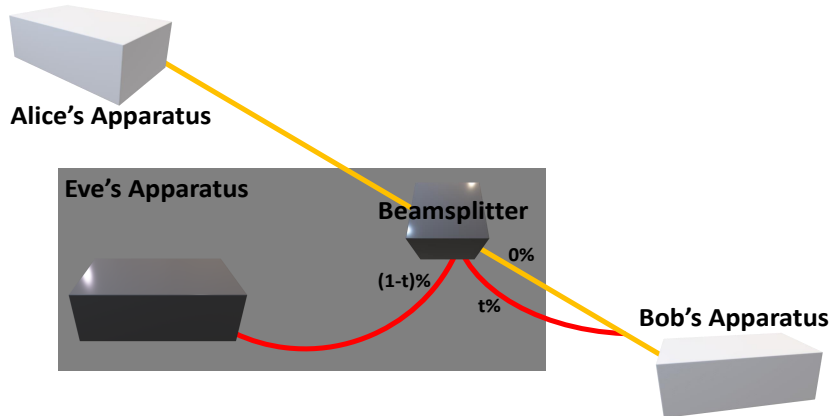
COW - Protocol - Attacks

- Unambiguous state discrimination (USD) - Alice and Bob only check for coherence in two successive pulses. d So if Eve attacks while they don't check the coherence, she can do an unnoticed attack. But if systematically, they notice that no decoy is detected.

Name	Discriminating
USD3	$|0\rangle|\alpha\rangle|0\rangle$
USD4a	$|0\rangle|\alpha\rangle : |\alpha\rangle|0\rangle$
USD4b	$|0\rangle : |\alpha\rangle|\alpha\rangle : |0\rangle$

E-mail: joaoantonio@ua.pt