

# Atmosphere channel for “last mile problem” in quantum communication

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**Abstract.** The work is devoted to the creation of a telescopic transceiver system that organizes an atmospheric point-to-point communication channel, and its use for quantum communication at sideband frequencies as the “last mile” for data protection in a geographically distributed data centre

## 1 Introduction

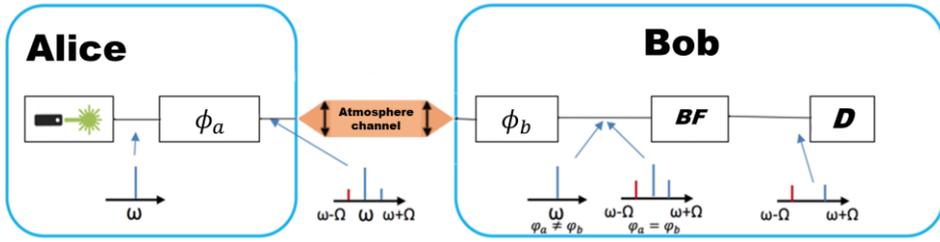
Atmosphere communication lines are actively developing both in the field of classical communication for realization of specific tasks in laying Internet networks, and in the field of quantum cryptography. Atmospheric laser communication lines are successfully used at short and medium distances (up to 1 km), where the laying of a fiber line or radio frequency channel is unprofitable for technical reasons.

Actual atmospheric systems of quantum communication are usually developed long distances (from 50 to 150 km) on the basis of the earth-satellite, or earth-satellite-earth. This paper presents a quantum communication system that operates on a universal “hybrid” protocol that generates a quantum key simultaneously in a fiber channel and in the atmosphere channel. The relevance of such a scheme is associated with the feature of building quantum telecommunication networks in urban conditions. As a rule, there are areas where the laying of the fiber is impossible or unprofitable.

This problem is called the “last mile” problem. This scheme is possible in cases where objects are in direct line of sight from each other. Systems of quantum communication at the sideband frequencies of modulated radiation [1-2] use a different approach to the coding of quantum states, the use of which will avoid problems that arise for systems with polarization coding.

## 2 Quantum communication protocol

The scheme of quantum communication shown in Figure 1 at the lateral frequencies of modulated radiation is implemented for the distribution of binary bit sequences through an atmospheric communication channel.



**Fig. 1.** Principal scheme of a quantum communication system on sideband frequencies with an atmospheric communication channel

The sender (Alice) generates continuous laser radiation at a wavelength of  $\lambda = 1550$  nm. Then, the radiation undergoes phase modulation on an electro-optical modulator ( $\phi_a$ ). As a result of phase modulation, in the signal spectrum appear two side components, separated from the center frequency of the laser signal by the value of the frequency of the modulating radio frequency signal and having a phase detuning  $\Omega$  specified for the  $\phi_a$ . Further, the modulated signal is attenuated in the attenuator (not shown in the figure) in such a way that, in total, on two side components, the signal power corresponds to the average number of photons in the time count  $\mu = 1$  and enters the atmospheric communication channel. After passing through the atmospheric quantum channel, the signal enters the receiving module (Bob) and follows the phase modulation unit. In it, the signal is divided into two orthogonal components, each of which is modulated on a separate phase modulator (not shown in the figure). The phase shift  $\phi_b$  is introduced in this system in the same way as it does in the sender unit. If the phases  $\phi_a$  and  $\phi_b$  coincide, the signal at the side frequencies is amplified, otherwise it is suppressed. Next, the signal is followed by an optical spectral filter (BF). The signal at the central frequency is reflected from the SF. A quantum signal at side frequencies passes through a filter (BF) and is then recorded by a single photon detector (D).

Table 1 presents the main results of an experimental study of the transmission of quantum bits at the lateral frequency of modulated radiation through an atmospheric communication channel.

**Table 1.** Key rate generation in atmosphere channel.

Distance	Optical losses in atmosphere channel	Key rate	QBER
25 meters	$6,3 \pm 0,5$ dB	1,45 Kb/s	$6 \pm 0,4\%$
40 meters	$6,6 \pm 0,5$ dB	1,42 Kb/s	$6 \pm 0,4\%$
50 meters	$6,5 \pm 0,5$ dB	1,43 Kb/s	$6 \pm 0,4\%$

Thus, a telescopic transceiver system with an active tracking system was developed that was successfully used to organize an atmospheric communication channel for a quantum communication system at the lateral frequencies of modulated radiation.

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## References

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