Testing of influence of polarization perturbation on dark channel in the system of entangled photons QKD (EPR Quelle, AIT)

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The objective of the present report is to summarize the results of stability testing of the EPR Quelle system (Austrian Institute of Technology - AIT) with respect to various types of optical fibers, adjustable output (by piezo-electric control) of the system and to assess feasibility of practical utilization of this system in commercial communication networks.

As the test indicator testing cards generated by piezo-electric control of the system have been used, allowing for quick estimation of stability of system operation. The quantitative measure is quantum bit error (QBER) which displays the summarized level of communication perturbations. QBER is an effective resultant parameter summarizing all imperfections of the system including detector errors, optical elements mismatch and optical fibre decoherence. Comparison of QBER for various configurations of optical fibers for dark channel allowed, however, to disclose the net factor caused by polarization decoherence of photons in the quantum communication link.

The AIT EPR Quelle systems are equipped with telescopic setups design for achieving long distance QKD (up to 3 km) in open air dark channel, where the satisfactory level of compensation of polarization of flying qubits is provided.

In the system EPR Quelle (AIT) for QKD on entangled photons employing protocol E91 the polarization of photons is treated as flying qubit, which is connected with manufacturing of entanglement by parametric down conversion II in BBO crystal applied in this setup. Nevertheless, it is obvious that any perturbation in the optical fiber link between Alice and Bob would modify polarization of transferred entangled photon state and effectively blur the key distribution. The good example is presented in the figure 13. The points in this figure are accurately distributed (between 250 to 320) with extremely high amplitude. The figures 14 and 15 show that the considerable perturbations strongly influence the system and change its functionality in a qualitative manner. Two adjustment procedures were necessary to restore the system functionality. The first one corresponds to mechanical adjustments of fixing of optical elements preserving alignment of optical fibers and without dark channel modification (ca. every 5 mm in comparison to 30 mm for net systems) for the system with dark channel with higher level of polarization mismatch. Application of automatic piezo-electric control of the correction mirror would be thus recommended. The second adjustment procedure concerns the direct correction of polarization in order to repair its drift. Each modification of the quantum channel results in some polarization drift which requires the feedback polarization correction. This adjustment must be performed up to achievement the optimal value of observed data.

Conclusions:

Quelle system works efficiently for quantum communication using ca. 800 nm wave length photons. Application of optical fiber with ca. 1550 nm transmission window considerably diminishes efficiency to the level of almost preclusion the key distribution. Moreover, one can observe that the process of key generation is not stable, i.e., the corresponding QBER does not have a normal distribution. The good example is presented in the figure 13. The points in this figure are accurately distributed (between 250 to 320) with extremely high amplitude. The figures 14 and 15 show that the considerable perturbations strongly influence the system and change its functionality in a qualitative manner. Two adjustment procedures were necessary to restore the system functionality. The first one corresponds to mechanical adjustments of fixing of optical elements preserving alignment of optical fibers and without dark channel modification (ca. every 5 mm in comparison to 30 mm for net systems) for the system with dark channel with higher level of polarization mismatch. Application of automatic piezo-electric control of the correction mirror would be thus recommended. The second adjustment procedure concerns the direct correction of polarization in order to repair its drift. Each modification of the quantum channel results in some polarization drift which requires the feedback polarization correction. This adjustment must be performed up to achievement the optimal value of observed data. With this regard one can recommend development of the system towards automatic self-adjustment of polarization. Both mentioned here improvements would enhance the feasibility level of usage of Quelle system for QKD in real commercial metropolitan telecommunication networks.