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QUANTUM MEASUREMENTS OF SIGNALS FROM THE ALPHASAT TDP1 LASER COMMUNICATION TERMINAL

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I. INTRODUCTION

Quantum optics [1] can be harnessed to implement cryptographic protocols that are verifiably immune against any conceivable attack [2]. Even quantum computers, that will break most current public keys [3, 4], cannot harm quantum encryption. Based on these intriguing quantum features, metropolitan quantum networks have been implemented around the world [5-15]. However, the long-haul link between metropolitan networks is currently missing [16]. Existing fiber infrastructure is not suitable for this purpose since classical telecom repeaters cannot relay quantum states [2]. Therefore, optical satellite-to-ground communication [17-22] lends itself to bridge intercontinental distances for quantum communication [23-40].

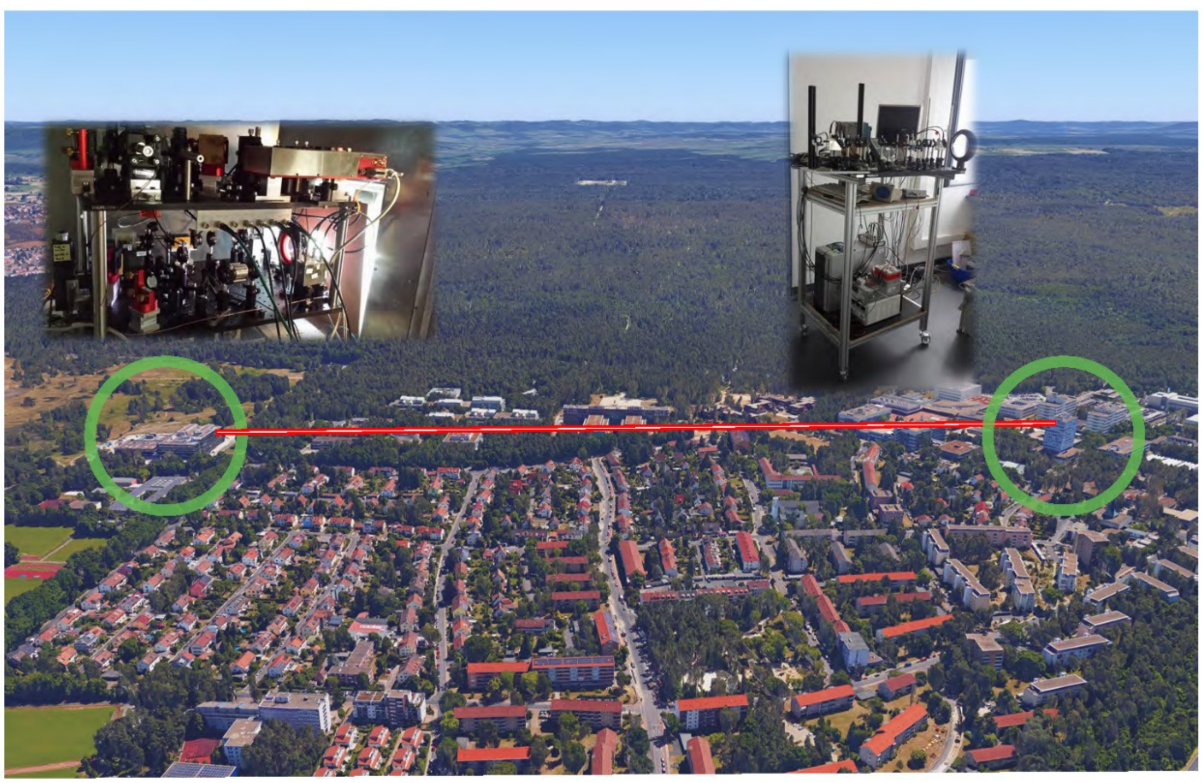

Fig. 1. Free space continuous variable quantum link between the new building of the Max Planck Institute for the Science of Light (sender) and the computer science tower of the Friedrich-Alexander University Erlangen (receiver). (Picture of Erlangen: Google)

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A. Laser Communication Terminal for Quantum Key Distribution

A space borne Laser Communication Terminal (LCT) is capable to relay quantum key distribution (QKD) between a large number of hubs on ground. In contrast to other satellite-to-ground communication scenarios, QKD does not require real-time availability. Keys can be produced at any convenient time in advance and stored until used.

B. Continuous Variable Quantum Communication

Standard telecommunication components allow for an efficient implementation of quantum communication using continuous variables (CV) of light [41-45]. MPL Erlangen implements free space CV quantum communication (see Fig. 1) based on binary phase-shift keying of coherent states and homodyne detection of the optical field quadratures [46-50]. This operating principle is equal to the one of the TESAT/DLR LCTs [51-53]. Therefore, we have a unique shortcut to implement space borne quantum communication at lower cost than other ambitious programs around the world.

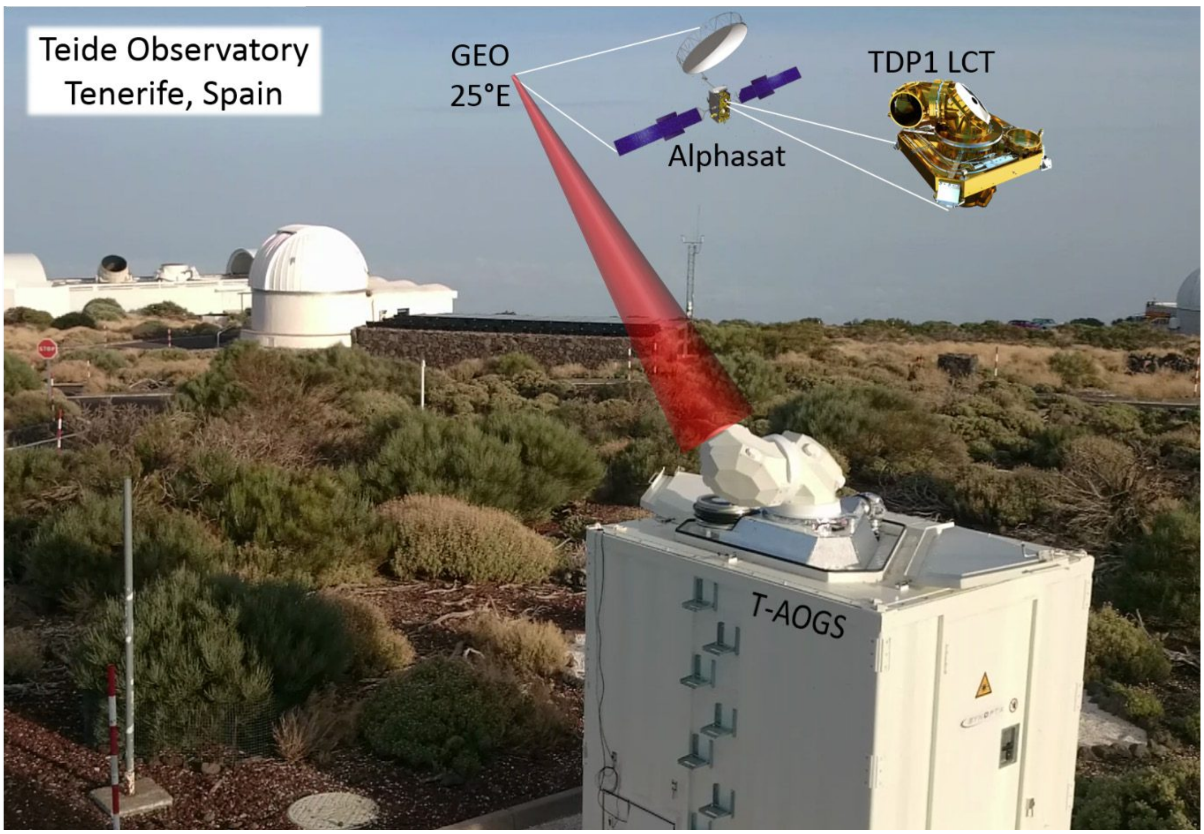

Fig. 2. Space-to-ground link setup: A Laser Communication Terminal (LCT) is embarked as Technology Demonstration Payload (TDP) on Alphasat in geostationary Earth orbit (GEO). The LCT links to the Transportable Adaptive Optical Ground Station (TAOGS), currently located at the Teide Observatory on Tenerife, Spain. By using homodyne detection for quantum signal acquisition, daylight operation is possible without any constraints. (Picture of Alphasat: ESA)

III. QKD FEASIBILITY VERFICATION

We have tested the feasibility of this proposal by quantum-limited measurements of signals from the Alphasat TDP1 LCT in geostationary Earth orbit (GEO). The Transportable Adaptive Optical Ground Station (TAOGS) [54, 21], currently located at the Teide observatory on Tenerife, is capable of establishing bi-directional communication links with the Alphasat TDP1 LCT (see Fig. 2). We utilize the downlink by extending the TAOGS with equipment for quantum-limited measurements. Our measurement results [55] show that coherence is well preserved after propagation over more than 38 000 km and through Earth's atmosphere. By using a low-noise phase-locking mechanism based on homodyne detection, phase-encoded quantum communication protocols become feasible.

III. CONCLUSION

Our results underpin the feasibility of satellite quantum communication using existing hardware. In order to optimize the system for quantum communication, our next step is the adaptation of the sender and receiver for applied QKD. Furthermore, on the fundamental research side, the large gravitational potential difference between GEO and ground allows to investigate gravitational effects on quantum states [56-60].

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