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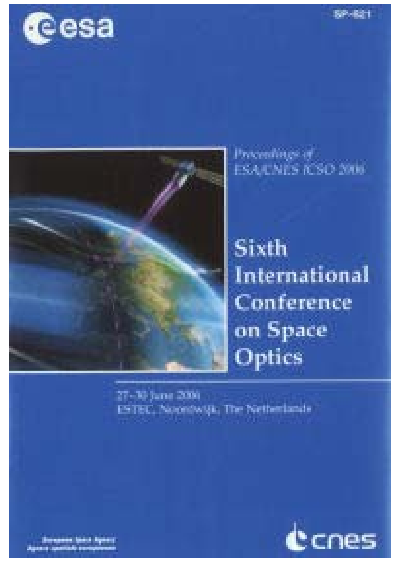

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APPLICATIONS OF QUANTUM ENTANGLEMENT ON A ISS-SPACEPLATFORM

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ABSTRACT

We proposed tests of quantum communication in space, whereby an entangled photon Source is placed onboard the ISS, and two entangled photons are transmitted via a simultaneous down link and received at two distant ground stations

1. GENERAL SPECIFICATIONS

Quantum entanglement [1] is at the heart of quantum physics. At the same time it is the basis for novel quantum communication schemes, such as quantum cryptography [2,3,4]. Bringing quantum entanglement to the space environment will open a new range of fundamental physics experiments, and will provide unique opportunities for quantum communication applications over long distances. We proposed tests of quantum communication in space, whereby an entangled photon Source is placed onboard the ISS, and two entangled photons are transmitted via a simultaneous down link and received at two distant ground stations [5,6], see fig 1. Furthermore, performing a series of consecutive single down links with separate ground stations will enable a test of establishing quantum cryptography even on a global scale. This Space-QUEST proposal was submitted within ESA's OA-2004 and was rated as 'outstanding' because of both, a novel and imaginative scientific content and for technological applications of quantum cryptography respectively.
We intend to explore the possibilities to send, receive and manipulate single entangled photon pairs using telescopes, reflectors and high-power lasers over a distance of some tens of kilometers up to 100 kilometers experimentally [8], see fig 2. A distance of approx. 10 kilometer would already correspond to one atmospheric equivalent and would thus imply the feasibility of installing a ground to satellite link [6]. We are already collaborating with European Space Agency ESA and partners from industry (Contraves, Tesat), to investigate and outline the accommodation of a quantum communication terminal in existing optical terminals for satellite communication. We are also investigating the experimental requirements for an optical ground station as a receiver or transmitter in quantum communication schemes to and from satellites.
Free-space quantum communication has recently become an intensively studied field [9, 10, 11, 12] promising fundamental tests of quantum entanglement over increasing distances as well as the secure exchange of cryptographic keys. The experiments carried out so far are terrestrial free-space quantum communication links with fixed transmitter and receivers, and have successfully increased their working distances up to 144 km [13], between the canary island La Palma and Tenerife usinf the optical ground station (OGS) of European Space Agency (ESA).

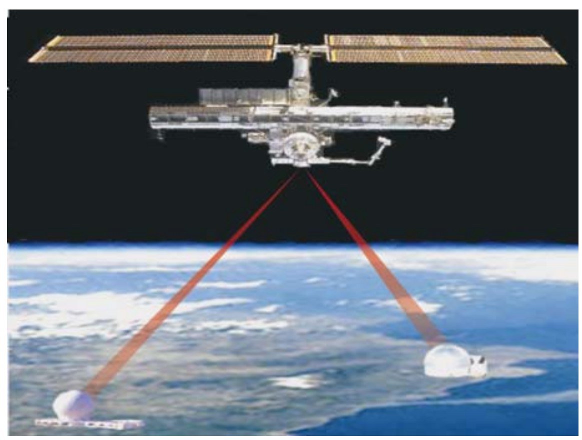

Fig. 1. Our proposed quantum communication experiment involves the ISS and two optical ground stations. Entangled photon pairs are simultaneously distributed to two earth-bound locations thus enabling both fundamental quantum physics experiments and novel applications such as quantum cryptography.

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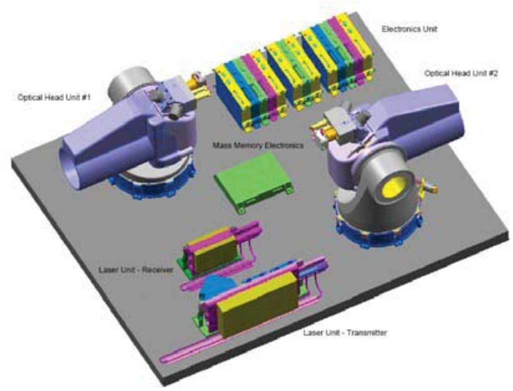

Fig. 2. Entangled photon pair experimental payload. The sourc of entangled photons together with the two telescopes and the electronics unit is shown here.

2. REFERENCES

1. A. Einstein, B. Podolsky and N. Rosen, Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?, Phys. Rev. 47, 777 (1935)

2. Ekert, A. K. Quantum Cryptography Based on Bell's Theorem. Phys. Rev. Lett. 67, 661-663 (1991).

3. Bennett, C. H. & Brassard, G. Quantum cryptography: Public Key Distribution and coin-tossing. Proceedings of IEEE International Conference on Computers, Systems and Signal Processing, Bangalore, India, 175-179 (1984).

4. T. Jennewein, C. Simon, G. Weihs, H. Weinfurter and A. Zeilinger, Quantum Cryptography with Entangled Photons, Phys. Rev. Lett. 84, 4729 (2000)

5. Quantum Communications in Space, ESA contract 16358/02 and 16441/02

6. M. Aspelmeyer, T. Jennewein, M. Pfennigbauer, W. Leeb, A. Zeilinger, Long Distance Quantum Communications with Entangled Photons Using Satellites, IEEE Journal of Selected Topics in Quantum Electronics, special issue on "Quantum Internet Technologies"; quant-ph/0305105

7. R. Kaltenbaek, M. Aspelmeyer, T. Jennewein, C. Brukner, M. Pfennigbauer, W. Leeb and A. Zeilinger, Proof-of-concept experiments for quantum physics in space, SPIE Proceedings on Quantum Communications and Quantum Imaging; quant-ph/0308174

8. Pfennigbauer, M. et al. Satellite-based quantum communication terminal employing state-of-the-art technology. J. Opt. Netw. 4, 549-560 (2005).

9. Kurtsiefer, C. et al. Quantum cryptography: A step towards global key distribution. Nature 419, 450 (2002).

10. M. Aspelmeyer, H. R. Böhm, T. Gyatso, T. Jennewein, R. Kaltenbaek, M. Lindenthal, G. Molina-Terriza, A. Poppe, K. Resch, M. Taraba, R. Ursin, P. Walther, A. Zeilinger, Free-Space Distribution of Quantum Entanglement, Science 301, 621 (2003)

11. Resch, K. J. et al. Distributing entanglement and single photons through an intra-city, free-space quantum channel. Opt. Express 13, 202-209 (2005).

12. Peng, C.-Z. et al. Experimental Free-Space Distribution of Entangled Photon Pairs over a Noisy Ground Atmosphere of 13km. Phys. Rev. Lett. 94, 150501 (2005).

13. R. Ursin, F. Tiefenbacher, T. Schmitt-Manderbach, H. Weier, T. Scheidl, M. Lindenthal, B. Blauensteiner, T. Jennewein, J. Perdigues, P. Trojek, B. Ömer, M. Fürst, M. Meyenburg, J. Rarity, Z. Sodnik, C. Barbieri, H. Weinfurter, A. Zeilinger, Free-Space distribution of entanglement and single photons over 144 km (to be published).