

Quantum Optics Experiments in Space

Presentation of the proposed research program

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DI PADOVA

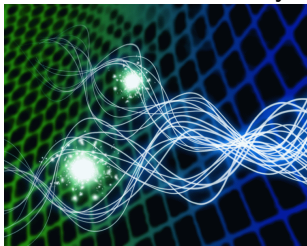


Quantum Optics Experiments in Space

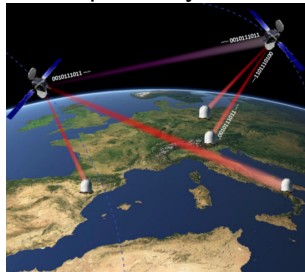
Research Project Goal

Study the feasibility of different experiments involving **Quantum Optics in Space** with multiple purposes and applications

Fundamental tests combining
Quantum Mechanics
and General Relativity



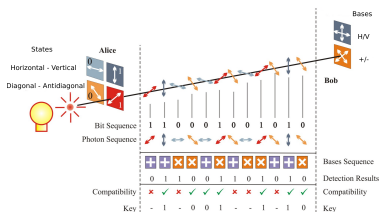
Secure communications
on planetary scale



Quantum Key Distribution

QKD: a Quantum Communication protocol

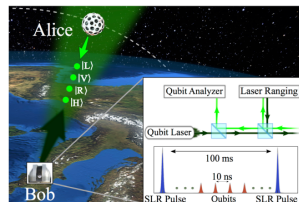
It allows establishing a secure communication between two parties by exchanging quantum states



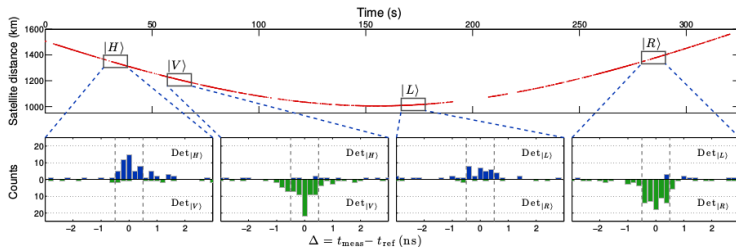
- Already realized in **commercial products**
- **Fiber based QKD** is limited within few hundreds of kilometers
- **Free space optical links** are more suitable for long-distance QKD
- Global network for QKD requires **space channels**

Space Quantum Communications: state of the art

- Single-photon exchange exploiting LEO satellites: $\mu_{sat} \approx 1$
- First satellite quantum communication using **polarization encoding**
- **ASI** and private aerospace companies interested in developing this technology also with **dedicated payloads**

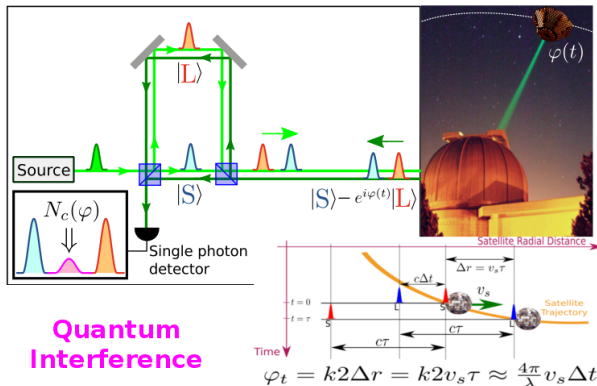


G. Vallone, PRL 115 (2015)



Quantum interference along Space channels

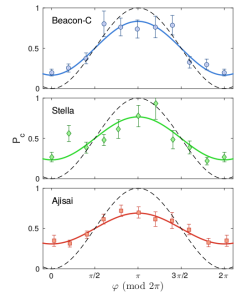
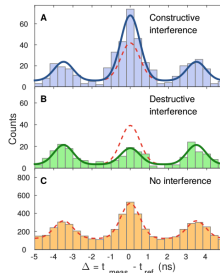
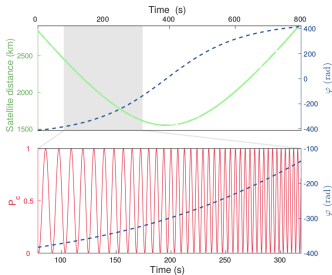
- Quantum information encapsulated in the photon **phase**
- More difficult to be implemented in free space long links
- **Atmospheric turbulence** is **not** detrimental for **time-bin** technique



Quantum
Interference

Experimental results

- Trajectory reconstruction and phase estimation
- Returns histogram with phase selection
- Interference with **three different satellites** and visibility up to 67%



Research project: framework and objectives

Framework

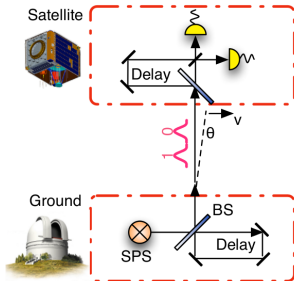
Characterization of the Earth-satellite quantum channel and its exploitation to realize quantum communications and quantum experiments in Space

Objectives

- Designing and testing a **new interferometry setup** to achieve a greater value of the interference visibility
- Studying the **combined use of photon** degrees of freedom given by **polarization and phase** to enlarge the transmissivity of the quantum channel
- Observing interference with high visibility is the starting point to realize **Quantum Optics experiments in Space**

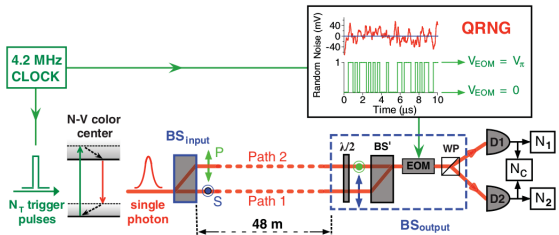
For example...

Optical COW experiment



Rideout et al.,
arXiv:1206.4949 (2012)

Satellite based *delayed-choice* experiment



Jacques et al., Science, 315 5814 966-968 (2007)

Gantt Chart

Level	Activity description and events
Event	Presentation for approval of research
WP100	Design and test of the interferometry setup
WP200	Study of combined use of photon polarization and phase
Event	Admission to II year
WP300	Research activity abroad
Event	Admission to III year
WP400	Quantum experiments in Space: feasibility studies
Event	Admission to final examination
WP500	Writing thesis and reports

