

## **Overview of Quantum Technologies in the frame of Italian Space Agency activities**

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Advances in laser science (laser miniaturization, optical frequency combs, quantum cascade lasers, interband cascade lasers, etc.) have renewed several space applications that were previously based on different technology. Some examples may be found in several fields, such as: optical communications, that offer better performance in terms of bit rate, security and immunity to interference compared to radio communications; optical interferometry and velocimetry, for extremely precision distance measurement, that are renewing the classical radar in microwave region; optical clocks, that will replace microwave clocks in the next future and optical fiber and free space laser link for Time/Frequency (T/F) transfer, offering improved performance compared to microwave T/F.

In the last few years, the advent of quantum technologies (QTs) has paved the way to QTs for space-based systems (quantum enhanced interferometry, satellite quantum key distribution, cold atom interferometry-based gradiometers, quantum enhanced optical clocks, etc.).

In this rapidly changing scenario, the Italian Space Agency has both financed external institutions for projects in the field of Photonics, Optical Metrology and Quantum technology and, thanks to internal infrastructure (Matera Laser Ranging Observatory and Metrology/Quantum Technology laboratory), is actively working on projects funded by European Commission or other Italian Institutions.

Quantum communication projects, which were the first to be funded, are in more advanced stage and are producing an intense interaction with industrial world. These activities are mostly based on earth-satellite Quantum Key distribution (QKD) and optical fiber QKD. On the other side, more research-oriented projects on quantum sensing and simulation have been recently funded (quantum enhanced interferometry, quantum simulation of Quantum Cascade Laser dynamics using ultracold atoms in optical lattices, cold atom interferometry for gravity measurement, development of optical clock for relativistic geodesy).

At the same time, several research projects in the field of optical metrology and photonics (optical time/frequency transfer, transportable laser-spectroscopy gas sensors, classical free space optical communications, and Light Detection and Ranging), where ASI is actively involved, are producing promising results for space science.