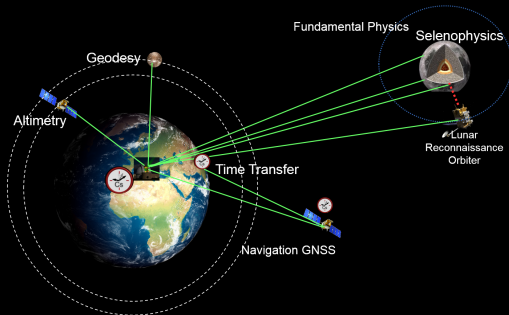


# Free Space Laser Links for Space Applications



**SUMMARY.**

The METEOR will provide an introduction to the principle of Satellite and Lunar Laser Ranging. We will see how we can measure the distance from the ground to an Earth orbiting object such as a geodetic satellite or the Moon with a sub-centimetric precision. After an introduction about the scientific applications of these free space laser links for geodesy, time transfer, and fundamental physics, the lectures will cover the needed equipments and instrumentation to perform such links, both for the ground segment (telescope, detectors, clocks) and for the space segment. Some lectures will focus on the effect of atmosphere on the propagation of a laser beam, including attenuation, refraction and turbulence. At the end, the lecture will give an overview of the current

scientific and technical challenges for ground to space laser links (geochronometry, space debris monitoring, quantum key distribution,...) with a focus on optical communications, a hot topic for the space industry. A practical session will be organized at the M&O telescope where data will be acquired on real targets (geodetic satellites and Moon).

**OBJECTIVES**

- Understand the general instrumentation needed to perform free space laser links (laser ranging, optical communication,...) between the ground and an orbiting target
- Evaluate the performances of each subsystems for each application.
- The students will acquire knowledge about: the key instrumentation for laser ranging (telescope, detectors, clocks, retroreflectors,...), metrology for laser ranging and time transfer applications and about laser propagation in the atmosphere.

- Metrology: Accuracy, precision, stability
- Ground and Space : The laser Ranging Station & its components
- Laser propagation through atmosphere
- Future challenges : Optical communications, Quantum key distribution, Space debris,...

**APPLICATIONS**

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The students will work on different scenario of applications and will evaluate the performances of the laser link. They will perform some laser ranging measurements on different targets with the M&O telescope at Calern Observatory and perform some data analysis.



**MAIN PROGRESSION STEPS AND EVALUATION**

- Two thirds : theoretical courses and exercises.
- One third : observations, data reductions.
- Written final exam (general questions and case study)

**BIBLIOGRAPHY & RESSOURCES**

Degnan, J. Millimeter Accuracy Satellite Laser Ranging: A Review  
 Lunar Laser Ranging Experiment

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**PREREQUISITES**

Fourier optics, Atmospheric turbulence, Image Formation, Adaptive Optics, Quantum mechanics.

**THEORY**

by JULIEN CHABÉ

- Principle of Satellite Laser Ranging and Time transfer