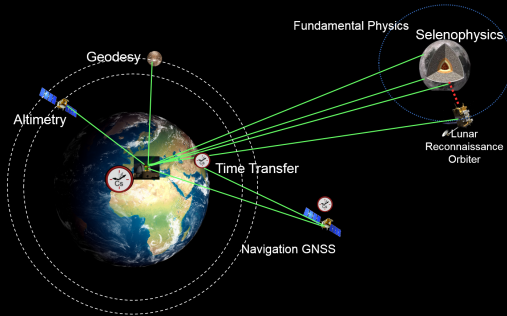


# Free Space Laser Links for Space Applications



## 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. Some lectures will focus on the effect of atmosphere on the propagation of a laser beam. At the end, the lecture will give an overview of the current scientific and technical challenges for ground to space laser links : geochronometry, spatial geodesy, time transfer, and some hot

topics for the space industry : optical communications, space debris monitoring and quantum key distribution. Student's projects will include practical sessions with the M&O telescope where data will be acquired on space targets.

## 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.
- General knowledge about: instrumentation for laser ranging (telescope, detectors, clocks, retroreflectors,...), metrology for laser ranging and time transfer applications, laser propagation in the atmosphere.

## PREREQUISITES

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

## THEORY AND APPLICATIONS

by JULIEN CHABÉ

- Principle of Satellite Laser Ranging and Time transfer
- 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,...

For personal project, each student will work on a 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 (free accommodation provided by OCA) and perform some data analysis.

## MAIN PROGRESSION STEPS AND EVALUATION

- Two thirds : Theoretical lectures and exercises.
- One third : Observations at **Calern Observatory**, data reductions
- Evaluation: Written final exam (general questions and case study): 30% ; Project (involvement, overall progress and small report): 30%, Final defense: 40%

## BIBLIOGRAPHY & RESSOURCES

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

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