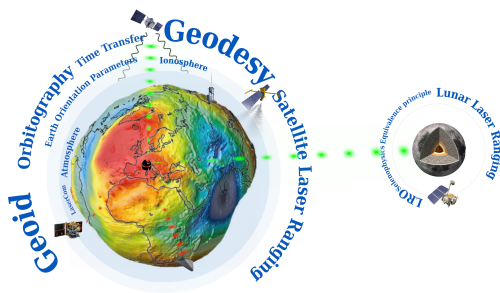


# Ground to Space Laser Links for Space Applications



## SUMMARY.

Have you ever dreamed of shooting lasers into space for science? The aim of this METEOR is to provide a comprehensive introduction to techniques for establishing laser links between the ground and space targets. After an introduction to the scientific context surrounding laser links to space (Space Geodesy, Lunar Science, Fundamental Physics), we'll look in detail at the satellite laser ranging technique. The course will detail the ground and space technologies and physics required to establish highly precise distance measurements (mm) between the ground and a space target hundreds of thousands of km away. We will also look at the emerging topics of classical and quantum laser communications and space debris tracking. A part of this METEOR will be carried out at the Calern observatory for projects involving sky-based experimentation.

## — OBJECTIVES —

Understand the general instrumentation and physical concepts needed to perform free space laser links (laser ranging, optical communication,...) between Earth and an orbiting target. Be able to design an experiment for laser ranging or optical communication

- **Knowledge:** Lasers, telescope, detectors, space target,...
- **Skills:** Optical calculation, data analysis, extract information from ground to space laser experiment (target shape, attitude, link budget,...)
- **Project:** Define and run your own project, including observation, data acquisition and processing

## — PREREQUISITES —

- ☒ S1. Fourier Optics
- ☒ S1. Numerical methods
- ☒ S2. Imaging through turbulence

## — THEORY —

by JULIEN CHABÉ

- Introduction to Space Geodesy
- Principle of Satellite Laser Ranging and Time transfer
- Time and distance Metrology
- Laser propagation through the atmosphere
- Laser Communication and Quantum keys distribution to Space

## — APPLICATIONS —

by JULIEN CHABÉ

- Evaluation of budget links for laser experiments
- Error budget in laser ranging experiment
- Observations with the MéO telescope (Moon, geodetic satellite, space debris)
- Data processing and analysis



The MéO telescope in action

## — MAIN PROGRESSION STEPS —

- **Week 1:** MéO telescope visit - Introduction to Space Geodesy - Laser Ranging
- **Week 2:** Laser and Gaussian Optics - exercices
- **Week 3:** Laser through the atmosphere - project

- **Week 4:** Metrology of time and Time Transfer to Space - project
- **Weeks 5-7:** project

## — EVALUATION —

- **Theory grade [30%]**
  - Written exam (50%): theoretical questions
  - Case study (50%): exercise based calculation
- **Practice grade [30%]**
  - Project (60%): thought-process and results
  - Project report (40%): presentation of your results
- **Defense grade [40%]**
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

## — BIBLIOGRAPHY & RESOURCES —

During the METEOR free accommodation to the Calern observatory is provided by OCA.

- Degnan, J. Millimeter Accuracy Satellite Laser Ranging: A Review
- Learn to make a better Lunar Laser Ranging Experiment than this
- Join us here

## — CONTACT —

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