ExoMars and the Molecular Traces of the Origins of Life

SUMMARY.
A decade ago, ESA's Rosetta mission had made spectators from all over the world dream: In 2014, the Rosetta mission tried to pose the little robot Philae on the nucleus of comet 67P/Churyumov-Gerasimenko. The Rosetta Space Probe collected information about the composition of the comet nucleus during its spectacular approach to the sun. Our gas chromatograph coupled to a mass spectrometer was on board and delivered precious data. Since 2008 our research group has been actively involved in an international team for the design and construction of the ExoMars mission of the European Space Agency (ESA). In particular, we are implied in the scientific team of the Mars Organic Molecule Analyzer (MOMA) instrument. Our work is particularly linked to the chirality of molecules that we intend to identify on the surface and sub-surface of Mars after landing planned for 2028/2029. The technique again will be a gas chromatograph coupled to a mass spectrometer. The lecture will briefly summarize the main successes of the cometary Rosetta mission and then focus on the ongoing development and evolution of ESA's ExoMars mission.

— OBJECTIVES

Students will learn how to design scientific instruments for space missions, how to accompany space missions with the help of laboratory experiments and how to treat space mission data. Gas chromatography, mass spectrometry and circular dichroism spectroscopy will be teached along with enantiomers, chirality, and concepts and theory of stereochemistry. History and evolution of planet Mars will be treated.

— PREREQUISITES

A bachelor degree in physics, astrophysics or chemistry.

— THEORY

by Uwe Meierhenrich

The aim of this Meteor is to better understand the molecular composition of the surface and subsurface of planet Mars. We are particularly interested in the concept of molecular chirality. Chirality and stereochemistry of molecules under investigation will be teached; they contain important hints on their formation pathway and chemical evolution.

— APPLICATIONS

by Uwe Meierhenrich

Based on current knowledge on the mineralogical and chemical composition of surface of planet Mars, students will experimentally and systematically investigate different samples of Mars analogues available in the laboratory. Gas chromatography coupled to mass spectrometry will be experimentally used to resolve enantiomers and to investigate the phenomena of chirality and stereochemistry. The identification of organic species in these mass spectra will be envisaged. The Mars Organic Molecule Analyzer (MOMA) instrument onboard ExoMars that we developed in an international partnership lead by the Max Planck Institute for Solar System Research, is an identical gas chromatograph using four stationary phases coupled with a mass spectrometer ion trap type. Data will be interpreted in view of the ExoMars mission and landing on Mars scheduled for 2028.

— MAIN PROGRESSION STEPS

- Week 1: Courses Mars and ExoMars
- Week 2: Courses Chirality
- Week 3: Courses GC-MS
- Week 4: Exercices
- Weeks 5-7: Project

— EVALUATION

- Theory grade [30%] including theoretical understanding of lectures, critical spirit in discussions, and scientific thoughts and insight during exchange.
- Practice grade [30%] based on laboratory experiments, technical skills, initiative, progress of the project, data analyses.
- Defense grade [40%]
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

— BIBLIOGRAPHY & RESOURCES

- JL Vago, UJ Meierhenrich et al. Habitability on early Mars and the search for biosignatures with the ExoMars Rover. Astrobiology 17 (2017), 471-510.
- ExoMars website

— CONTACT

☎ +33 489 150146
✉ Uwe.Meierhenrich@unice.fr