Internship proposal (Engineering or Master degree): Lunar oxygen production

Supervisors: Jack Robinot, Sylvain Rodat, Stéphane Abanades

Localization: PROMES-CNRS laboratory (Odeillo Solar Furnace) FRANCE

Acronym: ROAST: Regolith Only and Sunlight

Duration: 6 months

Gratification: ~600€/month

Keywords: concentrated solar energy, pyrolysis, regolith, oxygen extraction, moon exploration.

Subject overview:

The objective of the project is to explore an innovative method for producing oxygen on the Moon through concentrated solar pyrolysis of lunar regolith. This process involves heating lunar soil (regolith) to very high temperatures to extract various materials, including the oxygen essential for any lunar base project. A key advantage of this process is that it does not require any resources from Earth. Preliminary studies have been conducted by CNES/ESA, and a Ph.D. student is currently advancing the project at PROMES-CNRS. An initial thermodynamic study has been completed, and a test campaign is underway to gain a better understanding of the pyrolysis reaction. The work will focus on developing and conceptualizing a solar vacuum pyrolysis process to produce both oxygen and metals. This research is expected to open new perspectives for establishing a lunar base by utilizing in-situ resources, supporting further exploration of space.

Details of the internship proposal:

Based on initial experimental results and previous research in vacuum pyrolysis, this internship will focus on the design and conceptualization of a complete system for in-situ resource utilization (ISRU) on the Moon. The goal is to develop a process that begins with the extraction of lunar regolith and culminates in the production of oxygen for life support or fuel. This will involve designing and optimizing the system to leverage the Moon's unique environment, including solar irradiance, vacuum conditions, and reduced gravity. A continuous-mode reactor will be designed, with key features such as the feeding mechanism, metals condensation, oxygen recovery, and viewport positioning to allow concentrated energy to enter the reactor while avoiding metal deposition. A material and energy balance study will be conducted to evaluate the average oxygen production rate, the size of the solar concentrator, and the amount of regolith needed to achieve the desired outputs. A 3D CAD model of the process may also be developed.

If desired, participation in experiments involving the exposure of lunar regolith simulants to concentrated solar energy (10,000 suns) reaching temperatures up to 2000°C under primary vacuum conditions will be possible. Oxygen throughput will be quantified, and volatilized species analyzed using various techniques, such as XRD, XPS, Raman spectroscopy, and SEM/EDS.

The primary objective of the internship is to adapt a process that has only been tested on Earth to the unique conditions of space. The intern will have the freedom to guide the project and focus on areas of particular interest within the lunar ISRU framework. The work is both innovative and original, offering the opportunity to explore a wide range of scientific and engineering challenges, from vacuum pyrolysis to system integration in a lunar context.

Work context:

The position will be based at the PROMES Odeillo laboratory (CNRS 1MW solar furnace), located in the Pyrénées Orientales at an altitude of 1600 m, 100 km from Perpignan, 20 km from Spain, and 40 km from Andorra. The laboratory is easily accessible by night train from Paris. To achieve the project objectives, the intern will benefit from close collaboration with CNES (Centre National d'Études Spatiales) and ESA (European Space Agency). The intern will have access to the CNRS-PROMES solar infrastructure, including solar furnaces, solar reactors, gas analysis devices, and more, as well as the lab's extensive experience in materials and solar thermochemistry. The intern will join the Solar Fuels team at CNRS-PROMES in Odeillo and will be supervised by a Ph.D. student and two CNRS researchers.

Skills:

The candidate (Engineering or Master degree) should have a background in aerospace or chemical engineering. An interest in both modeling and experimental works would be an asset, as well as a good command of English.

Contact:

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