Laser-Induced Breakdown Spectroscopy Payload Design for Lunar Resource Detection

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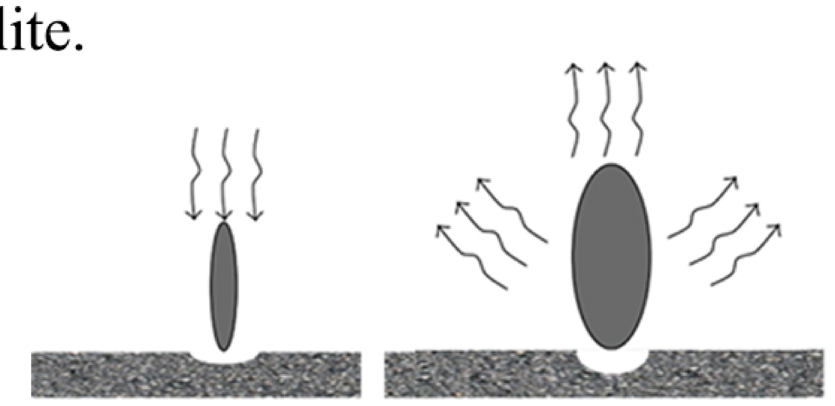
I. Introduction

The Pegasus Space Program is a student-run small satellite group based in Minnesota. The goal of the program is to create a six unit cubesat that will scan the surface of the Moon for an isotope of helium called Helium-3. This isotope can be used in fusion and is one of the most powerful fusion fuel sources. By using laser-induced breakdown spectroscopy, we hope to analyze the surface of the moon and gather definitive data on where Helium-3 deposits are located.

II. What is Laser-Induced Breakdown Spectroscopy

Laser-Induced Breakdown Spectroscopy (LIBS) is a material sampling method where a laser pulses light at a selected sample area, creating a plasma and ionizing a localized part of the sample matter. The light emitted from the plasma can then be analyzed through a spectrometer, measuring the sample's spectral emission signature to determine the make-up of the sample matter. Using a LIBS system, the chemical composition of material can be studied in-situ without the need to collect samples physically. This can reduce a large task, such as studying the surface makeup of hundreds of sites across the Moon's surface, into a task that can be handled by a single satellite.

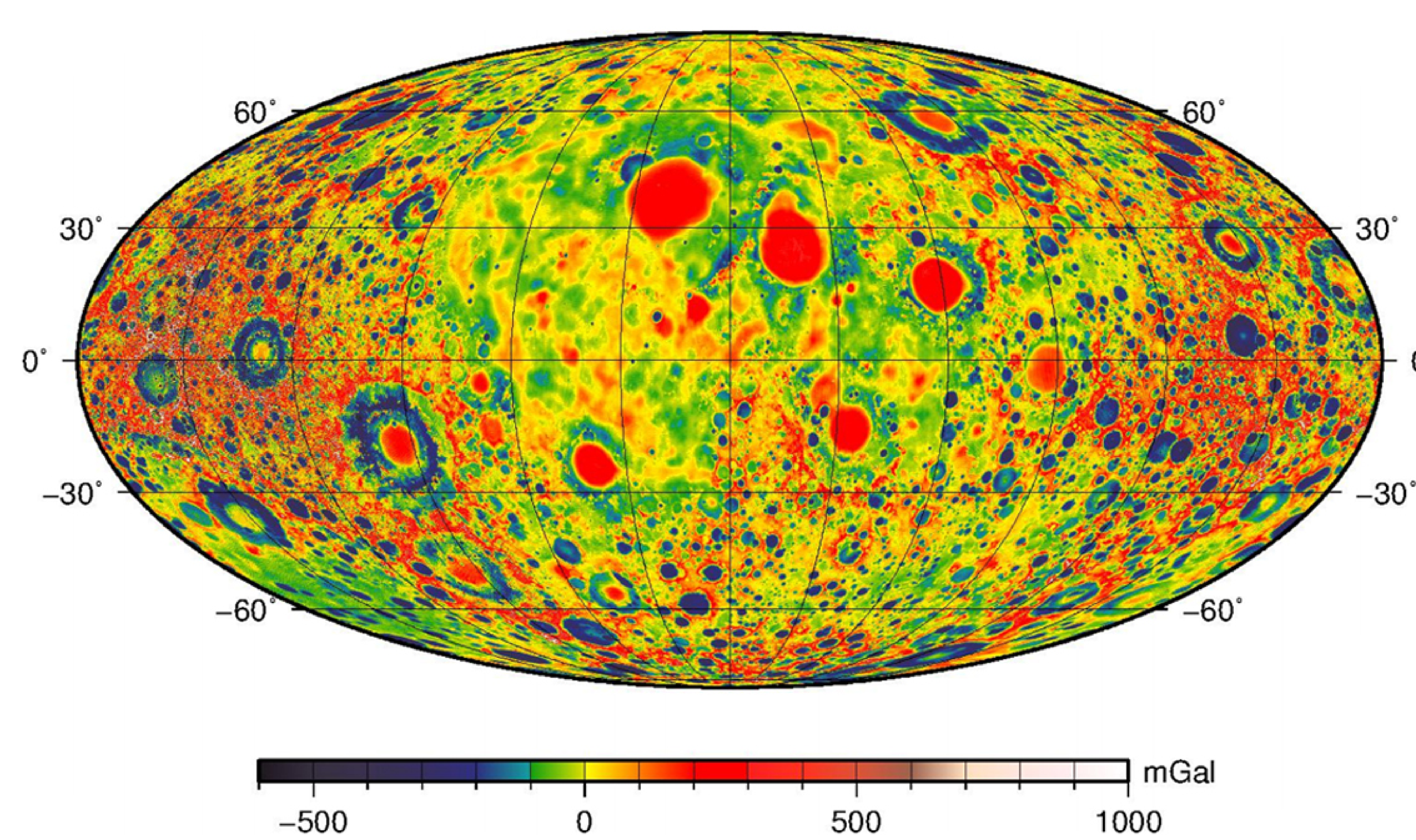


(plasma creation) (plasma emission and detection)

Abstract

A laser-induced breakdown spectroscopy system uses a laser to turn a sample into plasma composed of ionized matter. The specified wavelength emitted from the plasma can be detected using emission spectroscopy, and data can be collected specifying the type of material and concentration. Helium-3 found within the lunar regolith has the potential to be a fuel source used in fusion energy and is, therefore, an economic factor that could lead humanity one step closer to becoming a true space-faring civilization. Understanding the quantity and scale of these Helium-3 deposits would be beneficial knowledge for use in powering future lunar colonies and industries. A satellite-based laser-induced breakdown spectroscopy system, flying close to the lunar surface in a highly elliptical orbit, could be used to detect such pockets of Helium-3 and could be applied to any number of other elements.

Lunar Gravitational Field Map[3]



III. Helium-3 on the Moon

In a study on rare gases found in Apollo 11 rock and regolith samples, Helium-3 was found to be contained within the samples chemical composition. The theorized origin of lunar Helium-3 is solar wind bombarding the surface of the Moon, embedding the isotope within the soil and rocks.

IV. Orbital Lifetime

Due to large mass concentrations in the Moon's gravity field, frequent orbital perturbations affect satellite orbiting at a low altitude or outside the relative safety of frozen orbits, causing many to crash into the surface. To avoid these orbital perturbations, a highly elliptical orbit can be used to reduce the gravitational effects of the mass concentrations. This not only extends the expected lifetime of the mission, but also assists with reducing the distance between the laser-induced breakdown spectroscopy system and the surface of the Moon. These two positives are balanced with the negatives of having a unique orbit in a place most launch companies are just reaching, causing payload to be highly-priced.

V. References

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