Verification of Particle Image Velocimeter for Study of Martian and Lunar Regoliths

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We would like to thank Dr. Brent Bos from NASA's Goddard Space Flight Center for providing us with the PIV device, as well as processing collected data
We would like to thank Dr. Carl Allen from NASA's Johnson Space Center for providing us with Johnson Space Center-Mars 1 soil simulant
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Abstract
The behavior of dust, or regolith, on Mars and the moon is critical to our understanding of the Martian and lunar environments. The dust interaction with space suits and other equipment is a major concern for long term space missions. Dust on the moon greatly deteriorated the space suits in NASA's Apollo program. We have developed a test enclosure for the study of dust motion. NASA's Goddard Space Flight Center has developed a Particle Image Velocimeter (PIV) to measure the velocity and size of thousands of moving particles. The PIV was developed as a demonstration project for use on possible future NASA missions to Mars, the moon, or even asteroids. A controllable and stable simulation environment accommodating this PIV device was needed to collect data on the PIV performance. The “Dust Box” is designed to contain the PIV, provide the ability to collect stable and accurate data, and have flexibility to run many different experimental configurations. These configurations involve applying an electric field to deflect charged dust particles by using two biased copper plates, changing the dust flow patterns, and controlling the dust flow rates. We are currently studying particle velocity and charged particle behavior. Lunar and Martian soil simulants (JSC-1/JSC Mars-1) along with standard sand are used in this experiment in order to get the most precise results possible. These experiments will provide a better understanding of regolith behavior and will help verify the ability of the PIV to measure accurately the size and velocity of thousands of dust particles.

Keywords
regolith, particle, image, velocimeter, dust, algorithm

Disciplines
Other Electrical and Computer Engineering

Comments
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Validation of PIV System for Regolith Study
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Objective:
Test operation of NASA's Particle Image Velocimeter (PIV) to study dust motion. This will provide a better understanding of regolith behavior and will help verify the ability of the PIV to measure accurately the size and velocity of thousands of dust particles.

Background:
• Dust interaction with equipment is a major concern for long term space missions
• Human exploration of asteroids, the Moon, and Mars will require understanding and mitigating the dust contamination environment

PIV:
• NASA's Goddard Space Flight Center developed PIV to measure velocity and size of particles
• Instrument detects particles as small as 5-8 µm

Data Collection:
• Martian regolith simulant is used**
• High speed camera records general flow trends
• NASA PIV algorithm processes the video image files

- Particle count and size distribution are collected for small sample sizes
- Particle size distribution is found from images of dropped particles using Matlab

Future Tasks:
• Determine particle’s charge-to-mass ratio
• Determine particle’s acceleration due to varying plate and charging configurations

Particle Count Results

<table>
<thead>
<tr>
<th></th>
<th>Particle Count 1</th>
<th>Particle Count 2</th>
<th>% Difference</th>
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<tbody>
<tr>
<td>Unprocessed PIV video</td>
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<td>77</td>
<td>3.9</td>
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<tr>
<td>Microscope Count</td>
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<tr>
<td>Matlab Threshold Count</td>
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</tbody>
</table>

Before PIV algorithm
After PIV algorithm

Particle Size Distribution

No electric field applied
Electric field applied (1 kV/cm)

Charged Particle Path of Travel from PIV

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*Images courtesy of Dr. Brent Bos, NASA's Goddard Space Flight Center
**JSC Mars 1 simulant provided by Dr. Carlton C. Allen, NASA's Johnson Space Center