A WHEEL ELECTROMETER TO MEASURE ELECTROSTATIC FIELDS ON THE MARTIAN SURFACE.
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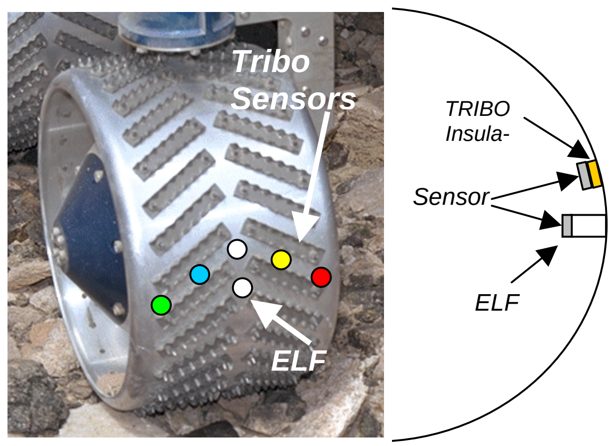
Introduction: Surface sand and dust electrification is a highly probable phenomenon in the low pressure, low humidity environment of Mars. Surface soil and dust particles on Mars may become electrostatically charged due to incident UV radiation reaching the surface. Recent experiments have shown [1] that this process can electrify the soil and provide a photoelectron sheath that levitates charged particles about one meter above the surface, a phenomenon which was possibly seen on the Moon and that may also exist on Mars [2]. Contact charging may also occur due to collisions between wind-blown dust particles and stationary surface particulate matter. It has been suggested that the formation of soil agglomerates and sand dune formation may be attributed to the electrostatic properties of the Martian soil [3]. To date, there has been no experiment on the surface of Mars to directly measure the amount of charge contained on the surface dust and soil particles [4].

A system of embedded sensors that can be incorporated into the wheel of any future mission rover would provide for a simple and fairly unobtrusive way to measure the distribution of electrostatic fields on the Martian surface and to measure variations in soil electrostatic response. This technology could perhaps be applied to different types of sensors that require the mobility provided by a rover's wheel.

Instrument Design: The Wheel Electrometer Sensor (WES) will consist of two types of sensor modules. These sensors will be attached just beneath the rover wheel in such a way that each sensor will be exposed to the Martian regolith either by line of sight through a small amount of Martian atmosphere or by direct contact with the regolith. For purposes of visualization, we will describe how the WES might be incorporated into one of the wheels of the Field Integrated Design & Operations (FIDO) rover (Figure 1(a)). FIDO is an advanced vehicle that is used in technology definition and field tests for future NASA Mars Program.

There will be two basic types of sensors. The first type of sensor is the Electric Field sensor (ELF) that will measure the regolith surface charge density as the rover wheel rolls over the Martian surface. The second type of sensor is the Triboelectric sensor (TRIBO) which will measure the amount of electrical charge that develops on a wheel-mounted insulator material through frictional contact as the rover wheel rolls over the Martian regolith.



(a) **(b)**

Figure 1. The Wheel Electrometer System (WES) shown on the FIDO wheel. (b) Cross-sectional view of the ELF and TRIBO modules. The ELF is recessed to allow measurement of an undisturbed soil plug that has not been compressed or rubbed by the wheel rim.

Figure 1 (a) shows the FIDO wheel with the both the ELF and TRIBO sensor modules. The five TRIBO sensors utilize a different insulator material and are backed by independent miniature electrometers while the ELF is a bare sensor recessed back from the wheel surface. The ELF and TRIBO sensors are actually based on the same technology. Each type of sensor simply measures the amount of charge that is induced on a metal electrode that has been exposed to some external distribution of electrostatic charge and has sensitivities that are achieved by adjusting circuit component values and the sensor area (Figure 1(b)).

In the case of the ELF sensor, the source of the charge would be any charged soil particles that may be present on the Martian surface at the time the rover wheel rolls over it. The ELF sensor electrode will be recessed several centimeters radially inward from the outer surface of the wheel through a hole in the wheel. This will ensure that the ELF directly measures any naturally occurring charge that may be present on a small patch of undisturbed Martian regolith as the wheel rolls forward. The ELF will provide an output voltage that is directly proportional to the amount of charged regolith that the sensor "sees" through the hole. The regolith's surface charge density will be determined using the charge measurement and the known hole area. As the rover travels across the Martian surface, the local surface charge density will be mapped using the ELF measurements. These data will provide direct measurements of the presence of electrically charged particles on the Martian surface.

The TRIBO sensor module will have five independent sensors. The electronic circuitry for each sensor is identical, but a different insulator material will cover the electrometer sensor electrode of each sensor. Our studies of the electrostatic properties of Martian regolith simulant JSC Mars-1 at NASA KSC indicate that the electrometer response to rubbing an insulator over the simulant is significantly different for different insulators [5]. As the rover wheel rolls over the Martian regolith, each of the five different insulators will make contact with the surface. The electrostatic response to contact charging of each insulator with the regolith will provide data regarding how the regolith fits into the triboelectric series.

Preliminary Results: A prototype of the WES with four TRIBO sensors was built in our laboratory to test the concept in a simulated Martian environment using JSC Mars-1 simulant soil [6] (Figure 2). The prototype wheel is 12.7 cm in diameter and has a length of 10.3 cm. The four TRIBO sensors have a diameter of 1.84 cm with a concentric guard and a shield. The sensors are capped with Teflon, Lucite, Fiberglass/G-10, and Lexan disks of 2.0 cm in diameter and 0.7 cm thick.

Figure 3 shows preliminary data obtained with the prototype WES in dry air at 9% relative humidity and at atmospheric pressure. The prototype wheel was rolled along a 60 cm tray containing JSC Mars-1 Simulant. The four insulators acquire different electrostatic charges when in contact with this simulant. The sharp peaks observed in the graph are due to the initial contact with the soil. Repeated contacts show an increase in the charge exchanged between simulant and insulator. Several runs were taken prior to the one generating the data presented here. The insulators and simulant were exposed to an ionizer to neutralize their surface charges before this run but no cleaning was performed. Thus, this procedure is fairly close to an actual procedure that could be used on a flight instrument. Atmospheric ions would neutralize the insulators during long periods of rover inactivity.

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Figure 2. Prototype Wheel Electrometer System.

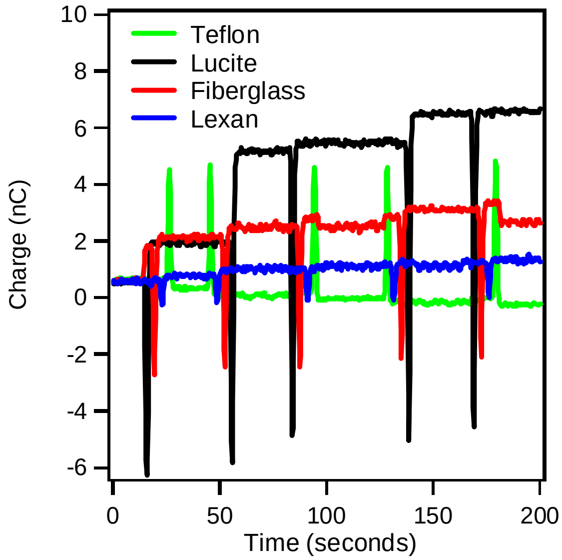

Figure 3. Charge generated on the four polymers capping the electrometer sensors on the prototype WES.

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