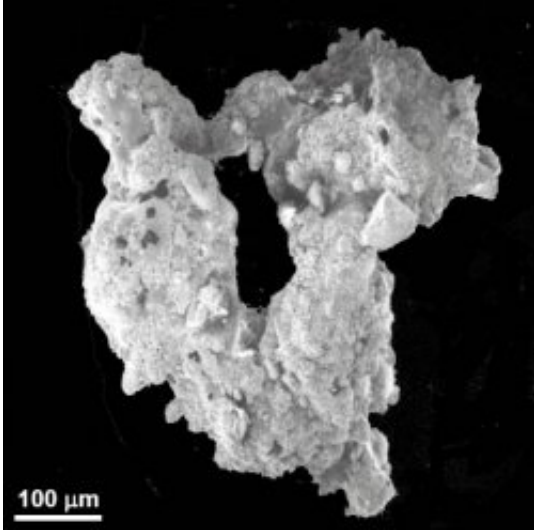


Lunar Dust Buster

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A tiny, jagged speck of moon dust. Micro-photograph courtesy of David McKay, NASA/JSC.

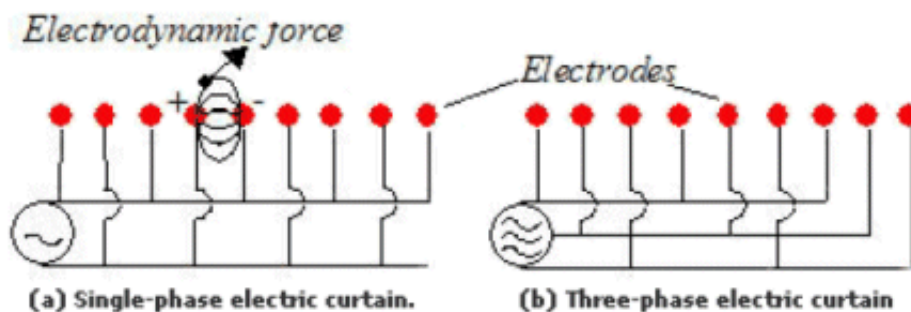
Ever get a fragile item packed in a box filled with Styrofoam peanuts? Plunge your hands into the foam peanuts to search for the item, and when you pull it out foam peanuts are clinging to your arms. Try to brush them off, and they won't fall off—instead, they seem to hop away, only to cling to your legs or elsewhere. The smaller the peanuts, the more tenacious they seem. In fact, if you break a foam peanut into bits, the tiny lightweight bits are almost impossible to brush off.

This behavior is classic static cling.

It's also the behavior of lunar—and possibly also Martian—dust.

The dozen Apollo astronauts who landed on the Moon between 1969 and 1972 found moondust to be an unexpected challenge. Not only was it so abrasive that it wore partially through the outer gloves of their space suits, but also it stuck to everything. The more they tried to brush it away, the more it worked its way into the space suits' fabric.

Part of the dust's tenacious clinging was due to the sharp, irregular shapes of individual dust grains, formed by millions of years of meteorite impacts that repeatedly melted rocks into glass and then broke the glassy rocks into powdered glass. The particles' jagged edges were almost like claws that hooked into things like microscopic burrs.



Prof. Senichi Masuda's diagram of the original "electric curtain," circa 1971.

But another reason was the dust's electrostatic charge. On the Moon, harsh, unshielded ultraviolet rays from the Sun have enough energy to kick electrons out of the upper layers of the regolith (soil), giving the surface of each dust particle a net positive charge. The smaller the particles, the less their mass and the greater their charged surface area, so the more they clung—just like Styrofoam peanuts broken into small

bits.

A team led by Carlos I. Calle (lead scientist at NASA's Electrostatics and Surface Physics Laboratory at Kennedy Space Center), however, has used a bit of intellectual judo to figure out a way to take advantage of the dust grains' electrostatic charge to repel them. In fact, they've come up with a new application of an old idea.

"In the 1970s, electrical engineering professor Senichi Masuda of the University of Tokyo—well-known as a pioneer in electrostatics—came up with the 'electric curtain'," Calle recalls.

Masuda, not even thinking about the Moon or Mars, was working on air pollution filters. Because smog particles are often charged, Masuda came up with a prototype of what he called the electric curtain.

Essentially, the electric curtain was a series of parallel electrodes—thin copper wires—spaced roughly a centimeter (half an inch) apart in a circuit board. To them, Masuda applied alternating current, such as that from an ordinary wall socket. The word "alternating" refers to the fact that the electrons in the wires are quickly—60 times a second in the United States, 50 times a second in Europe—made to move forward and backward along the wire, instead of just in one direction as in the direct current from a battery.

But instead of providing the same alternating current to all the parallel electrodes at once, Masuda did something ingenious. He slightly delayed the onset of the current to each successive electrode. That slight delay made the electromagnetic field of each electrode to be out of phase with its neighbors, creating an electromagnetic wave that rapidly traveled horizontally across the surface on which the electrodes lay. Moreover, any charged particles lying on the surface got lifted and moved by that traveling electromagnetic wave, as if they were surfers being pushed

along by an ocean wave.

Fast forward to the present: After seeing how Martian dust that collected on the solar panels of Mars Pathfinder deprived it of electric power and impaired performance, Calle and his collaborators began wondering if the electric curtain could be adapted to keep solar panels on the Moon and Mars dust-free. After all, he reasoned, "human and robot astronauts can't always be cleaning windows."

To let sunlight through, however, the device would need transparent electrodes. So instead of using copper wires, Calle and his colleagues made electrodes out of indium titanium oxide (ITO), transparent semiconducting oxides "that are now a mature technology, used in the touch screens of PDAs (personal digital assistants)," Calle explains. They also moved the electrodes closer together—just a few millimeters apart. The result was a transparent film that "is flexible, like a sheet of vinyl," that they call an electrodynamic dust shield.

When the transparent dust shield was covered with simulated lunar or Martian dust (which is mostly ground-up volcanic ash and cinders from terrestrial volcanoes) and put in a vacuum chamber that was then pumped down to the rarefied atmospheric pressure of Mars or the Moon, it worked like a champ. Most of the dust was thrown off to the side in seconds.



Calle's device rapidly throws off simulated martian dust in a laboratory test at the Kennedy Space Center.

None of the simulated lunar and Martian soils, however, contains either the pure iron or shards of glass found in real moon dust. This difference might affect the dust shield's effectiveness. "I'm hoping to try the experiment again with a vial of actual lunar dust," he says.

While Calle is optimistic about the dust shield's effectiveness for large flat or gently curved surfaces such as solar panels and the visors of astronauts' helmets, "folds in the fabric of a space suit are more challenging," he says. "ITO's are flexible, but after a point will break." He's also working to fine-tune the voltage, frequency, phase, and other electrical properties of the traveling electromagnetic wave to repel the greatest amount of dust. And he's curious to see how it would behave in lower gravity.

There's much work to be done, says Calle, but one day his device might draw the curtain on the troubles with moon dust.

Source: Science@NASA, by Trudy E. Bell

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