Space Weather on Mars

Future human explorers of Mars can leave their umbrellas back on Earth, but perhaps they shouldn't forget their Geiger counters! A NASA experiment *en route* to the Red Planet aims to find out.

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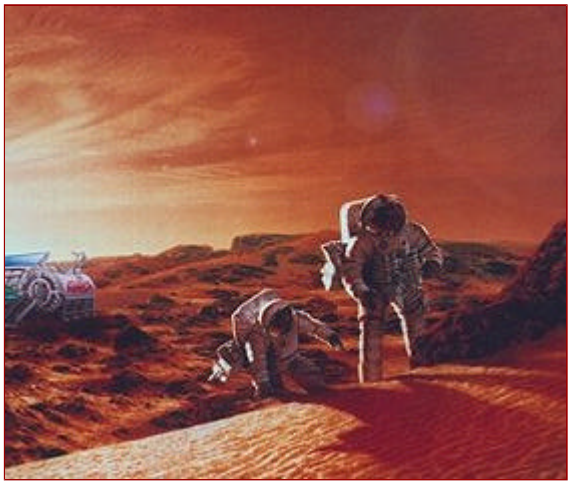
May 1, 2001 -- Alien planets have alien weather.



Take Mars, for example. A morning weather report on the Red Planet might sound like this:

"Good morning, Martians! It looks like another solar storm heading our way. An X-class solar flare exploded this morning and proton counts have soared 1000-fold. More of the deadly particles are *en route*, so don't leave shelter today without your radiation suit!"

"Coming up next, the sunspot report, right after this word from our sponsor: *Levi's Relaxed Fit LeadPants*."

Above: Composite art showing AFE (Aeroassisted Flight Experiment) and CELSS (Closed Environment Life Support System). Background art courtesy of Boeing.; Photographer: Digital artwork by Jae Park; Date: Nov 30, 1994

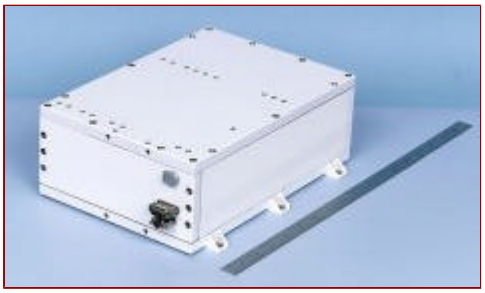
It doesn't sound much like the forecasts we hear on Earth, which feature rain and the daily pollen count. On Mars -- a world that's desert-dry, Antarctic-cold, and possibly lifeless -- human colonists will have a different set of weather concerns.

The Red Planet is substantially exposed to the harshest elements of *space weather*. Unlike Earth, which sits inside a protective magnetic bubble called the magnetosphere, Mars does not have a global magnetic field to shield it from solar flares and cosmic rays. Scientists aren't sure why, but Mars' internal magnetic dynamo turned off about 4 billion years ago. After that, the solar wind gradually eroded the martian atmosphere until, today, it is less than 1% as thick as Earth's.

No global magnetic field and a very thin atmosphere -- those are the two factors that render Mars vulnerable to space radiation.

Does such exposure mean Mars is lifeless? Not necessarily, say scientists. Indigenous life forms could be radiation resistant, like the terrestrial microbe *Deinococcus radiodurans*. Tiny Martians might also live in rocks or soil, substances that provide natural protection against radiation.

Nor is Mars necessarily uninhabitable for humans. If we learn how to shelter ourselves from the planet's unique brand of weather, humans can explore and perhaps even live on Mars. That's why NASA is sending a radiation monitor to the Red Planet ... to find out how much protection we humans might require.



MARIE, the Mars Radiation Environment Experiment, blasted off April 7th with the 2001 Mars Odyssey spacecraft. MARIE is one of three scientific instruments on board -- the other two will search for signs of water and interesting minerals on Mars. If all goes as planned, MARIE (along with the rest of Odyssey) will arrive in October and spend at least two years circling the Red Planet.

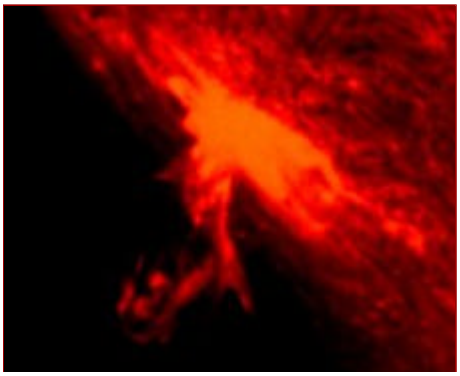
Above: MARIE, which spans less than 12 inches down its longest side, weighs 7.3 pounds and uses 7 watts of power.

"MARIE can detect charged particles -- electrons, protons, and atomic nuclei -- with energies between 15 MeV and 500 MeV," says Gautam Badhwar, the experiment's principal investigator at the Johnson Space Center. "There have never been any measurements of this kind from Mars orbit," he added. (Note: 1 MeV equals one million electron volts.)

Space radiation can be electromagnetic, like x-rays and gamma-rays, or particulate, like protons and electrons. Particulate radiation poses the greater threat to humans.

Most charged particles in our solar system come from two sources: solar flares, which produce a rain of dangerous protons, and distant supernova explosions, which accelerate atomic nuclei --called "cosmic rays"-- to nearly light speed.

"Both can be hazardous, but from the standpoint of crew health, solar flares are the greater concern," says Badhwar. Solar flares produce particles with relatively low energies (~70 MeV). "Such protons lose energy in tissue at a much higher rate than faster-moving particles like cosmic rays" he added. Cosmic ray nuclei, carrying typically 300 to 500 MeV per nucleon, zip through the human body so quickly there's not enough time to dump their energy into the surrounding tissue.



Right: Solar flares --the most powerful explosions in the solar system-- accelerate protons to relativistic energies. This 4.2 MB mpeg movie shows a solar flare in action, blasting hot gas away from the limb of the Sun. [more information]

Solar protons passing through humans ionize molecules along their tracks. "The ionization creates free radicals," explains Badhwar, "which can be very damaging." Sometimes protons will modify or even break DNA strands within cells. If the cell survives it can become cancerous -- a long-term health risk of radiation exposure.

Mars' thin atmosphere does little to protect the planet from energetic protons. The air density at martian "sea level" is roughly equivalent to that of Earth's atmosphere at 70,000 feet altitude! Fortunately, astronauts can find the protection they need indoors; shelter walls made of lightweight materials provide adequate shielding. But future explorers won't want to spend all their time inside shelters. They'll need to know how to handle radiation levels outdoors in the "martian wilderness" -- an environment MARIE will probe from Mars orbit.

Above: Explorers on Mars won't want to stay inside all the time. Artist Paul Hudson created this scene depicting humans striding across the Red Planet. [click to enlarge]

Although MARIE won't reach Mars for another six months, the instrument is already hard at work.

"We turned it on last week," says Badhwar. "All the engineering data look good."

By monitoring radiation levels during Odyssey's cruise phase, Badhwar and colleagues will discover what sorts of hazards await travelers in transit from Earth to Mars.

Radiation hazards ... tissue damage ... broken DNA. Space sounds like a dangerous place! Nevertheless, MARIE is an optimistic experiment. Its underlying assumption is that humans will eventually cross the divide between our planet and Mars. Thanks to MARIE and future experiments like it, Mars explorers will know how to survive and prosper when they get there.

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Web Links

2001 Mars Odyssey -- home page at the NASA Jet Propulsion Laboratory

MARIE -- The Mars Radiation Environment Experiment is designed to characterize aspects of the radiation environment both on the way to Mars and in the Martian orbit.

Human Exploration and Development of Space -- The goal of NASA's Human Exploration and Development of Space (HEDS) Enterprise is to open the space frontier by exploring, using and enabling the development of space

Radiation and Long-term Space Flight -- an overview of space radiation and its effects on humans, from the National Space Biomedical Research Institute

The Solar Wind at Mars -- ***Science@NASA article***: The solar wind has slowly eroded the Martian atmosphere for billions of years -- transforming the planet into a barren desert.

Digging in and Taking Cover -- ***Science@NASA article***: Lunar and Martian dirt could provide radiation shielding for crews on future missions.

The Accidental Space Tourist -- ***Science@NASA article***: Deinococcus radiodurans beats most of the constraints for survival of life on Mars - radiation, cold, vacuum, dormancy, oxidative damage, and other factors.

SpaceWeather.com -- read the latest space weather report for our own planet.

Ballooning for Cosmic Rays -- ***Science@NASA article***: Astronomers have long thought that supernovas are the source of cosmic rays, but there's a troubling discrepancy between theory and measurements.

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