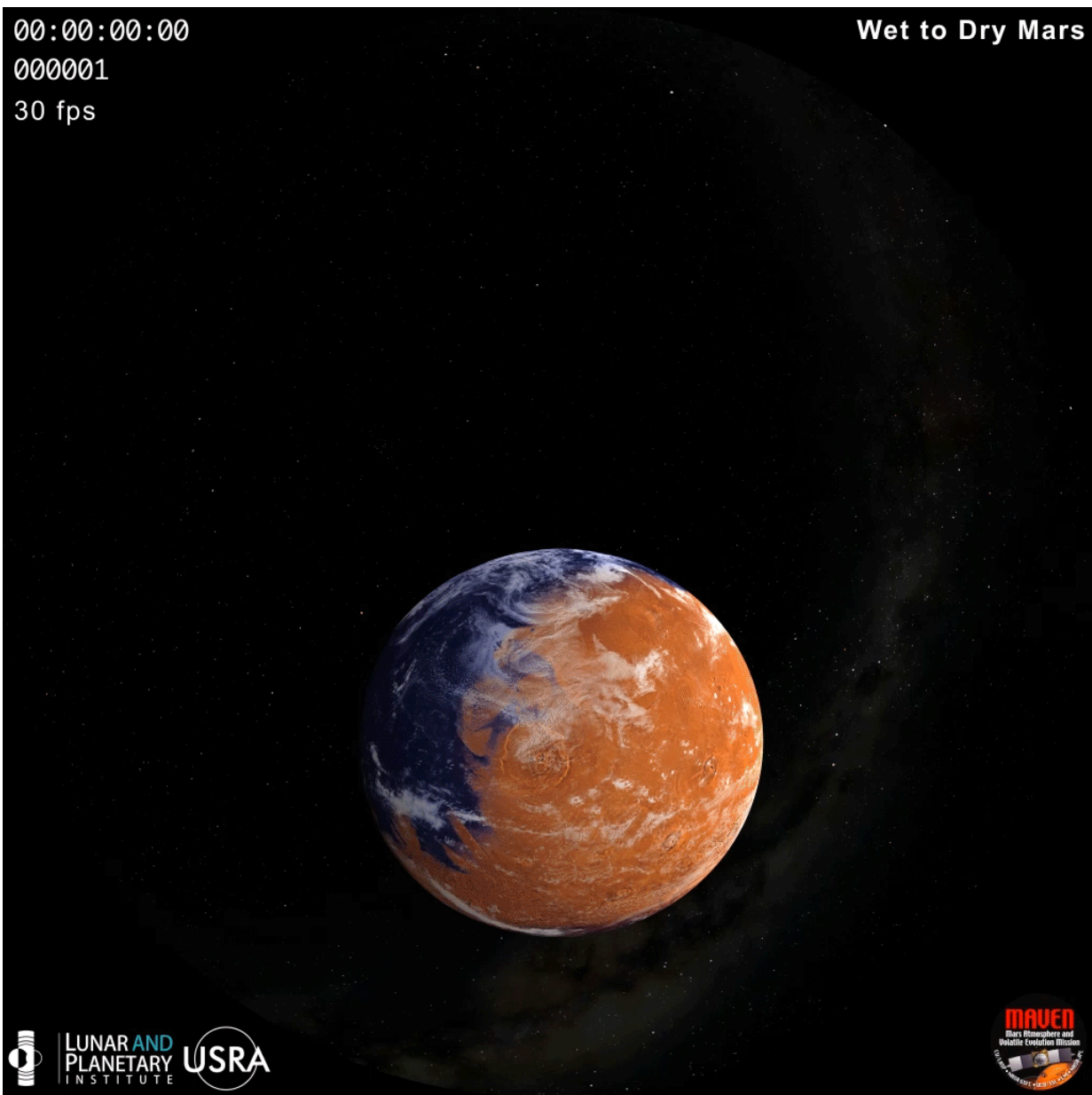


New MAVEN findings reveal how Mars' atmosphere was lost to space

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New results from the MAVEN mission reveal that substantial loss of atmosphere is what dramatically changed the climate of Mars. Credit: The Lunar and Planetary Institute NASA's MAVEN mission

Solar wind and radiation are responsible for stripping the Martian atmosphere, transforming Mars from a planet that could have supported life billions of years ago into a frigid desert world, according to new results from NASA's MAVEN (Mars Atmosphere and Volatile Evolution Mission) spacecraft led by the University of Colorado Boulder.

"We've determined that most of the gas ever present in the Mars atmosphere has been lost to space," said Bruce Jakosky, principal investigator for MAVEN and a professor at the Laboratory for Atmospheric and Space Physics (LASP). "The team made this determination from the latest result, which reveals that about 65 percent of the argon that was ever in the atmosphere has been lost to space."

Jakosky is lead author of a paper on this research to be published in *Science* on Friday. Marek Slipski, a LASP graduate student, co-authored the study.

MAVEN team members had previously announced measurements showing that [atmospheric gas](#) was being lost to space and that described the processes by which atmosphere was being stripped away. The present analysis uses measurements of today's atmosphere to give the first estimate of how much gas has been removed through time.

Liquid water, essential for life, is not stable on Mars' surface today because the atmosphere is too cold and thin to support it. However, evidence such as features resembling dry riverbeds and minerals that

only form in the presence of liquid water indicates the ancient Martian climate was much different - warm enough for water to flow on the surface for extended periods.

There are many ways a planet can lose some of its atmosphere. For example, chemical reactions can lock gas away in surface rocks or an atmosphere can be eroded by radiation and wind from the planet's parent star. The new result reveals that [solar wind](#) and radiation were responsible for most of the atmospheric loss on Mars and that the depletion was enough to transform the Martian climate. The solar wind is a thin stream of electrically conducting gas constantly blowing from the surface of the sun.

Young stars have far more intense ultraviolet radiation and winds, so atmospheric loss by these processes was likely much greater early in Mars' history, and these processes may have been the dominant ones controlling the planet's climate and habitability, according to the team. It's possible that microbial life could have existed at the surface early in Mars' history. As the planet cooled off and dried up, any life could have been driven underground or forced into occasional or rare surface oases.

Jakosky and his team got the result by measuring the atmospheric abundance of two different isotopes of argon gas. Isotopes are atoms of the same element with different masses. Because the lighter of the two isotopes escapes to space more readily, it will leave the gas remaining behind enriched in the heavier isotope. The team used this enrichment together with how it varied with altitude in the atmosphere to estimate what fraction of the atmospheric gas has been lost to space.

As a "noble gas" argon cannot react chemically with anything so it won't get sequestered in rocks, and the only process that can remove it to space is a physical process called "sputtering" by the solar wind. In sputtering, ions picked up by the solar wind impact Mars at high speeds and

physically knock atmospheric gas into space. The team tracked argon because it can be removed only by sputtering. Once they determined the amount of argon lost by sputtering, they could use the efficiency of sputtering to determine the sputtering loss of other atoms and molecules, including carbon dioxide (CO₂).

CO₂ is of interest because it is the major constituent of Mars' atmosphere and because it's an efficient greenhouse gas that can retain heat and warm the planet.

"We determined that the majority of the planet's CO₂ also has been lost to space by sputtering," said Jakosky. "There are other processes that can remove CO₂, so this gives the minimum amount of CO₂ that's been lost to space."

The team made its estimate using data on the Martian upper [atmosphere](#) from MAVEN's Neutral Gas and Ion Mass Spectrometer (NGIMS) instrument supported by measurements from the Martian surface made by NASA's Sample Analysis at Mars (SAM) instrument on board the Curiosity rover.

"The combined measurements enable a better determination of how much Martian argon has been lost to [space](#) over billions of years," said Paul Mahaffy of NASA's Goddard Space Flight Center in Greenbelt, Maryland. Mahaffy, a co-author of the paper, is principal investigator on the SAM instrument and lead on the NGIMS instrument, both of which were developed at NASA Goddard.

"Using measurements from both platforms points to the value of having multiple missions that make complementary measurements," said Mahaffy.

NASA Goddard manages the MAVEN project and MSL/Curiosity is

managed by NASA's Jet Propulsion Laboratory in Pasadena, California.

More information: "Mars' atmospheric history derived from upper-atmosphere measurements of $^{38}\text{Ar}/^{36}\text{Ar}$," *Science*, [science.sciencemag.org/cgi/doi ... 1126/science.aai7721](https://science.sciencemag.org/cgi/doi/10.1126/science.aai7721)

Provided by University of Colorado at Boulder

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