Is there lightning on Mars?

Daniel Mitchard

The Perseverance rover on Mars has serendipitously recorded sounds and electromagnetic signals that are characteristic of lightning in dust storms.

David Bowie famously asked if there is life on Mars, but an equally vexing question is whether lightning exists on the red planet and, if so, whether it is similar to the lightning on Earth. Lightning is known to occur on other planets: it was detected on Jupiter [1,2] in 1979 by the Voyager I spacecraft, and has since been detected on Saturn, and possibly also on Uranus and Neptune [3]. But surprisingly, the lightning question has remained unanswered for Earth's nearest planetary neighbours, Mars and Venus. Writing in Nature, Chide et al.[4] now report bursts of sound and associated electromagnetic interference recorded by a microphone on top of Perseverance — one of NASA's Mars rovers — as dust storms passed overhead. The authors attribute these signals to Martian lightning.

The existence and type of lightning on Mars has been debated since NASA's Viking landers first analysed the planet's thin carbon dioxide atmosphere in the 1970s. Researchers proposed that Martian lightning could only occur near the planet's surface where the atmospheric pressure is just high enough for small electrical discharges to form [5] , but that there would need to be a mechanism to initiate it.

On Earth, lightning is typically triggered when different forms of ice in storm clouds accumulate electrical charge as they move past each other, much like how a balloon gains a static charge when rubbed. A similar process has long been theorized to occur on Mars, whereby the material blown around in dust storms would accumulate charge through a process called triboelectrification [5]. However, unlike the kilometre-long, highly explosive lightning on Earth, the thin Martian atmosphere would probably result in weak, millimetre-long, spark-like discharges [6] — similar to those that cause a static shock when a person touches something conductive.

Apart from visible light, lightning on Earth produces a wide range of distinctive electromagnetic radiation, from X-rays to microwaves and radio waves. Such electromagnetic radiation would also be expected to be produced by lightning on Mars, albeit to a lesser extent than on Earth because of the relatively weak electrical discharges. In 2006, microwave signals thought to be indicative of Martian lightning were detected by an Earth-based radio telescope [7]. However, an almost five-year-long study completed in 2010 using radar on the Mars Express — a spacecraft in Martian orbit, which was launched by the European Space Agency (ESA) — did not detect any radio signals that would be characteristic of lightning8 . In 2016, the ExoMars mission, run jointly by ESA and Russia's space agency Roscosmos, attempted to send an instrument to the surface of Mars to measure any electrical activity in the atmosphere during dust storms, but it crash-landed. A second planned ExoMars mission with a similar instrument was suspended in 2022.

The arrival of rovers on Mars has opened up opportunities to search for evidence of lightning directly on the planet. Although Perseverance was not specifically intended to conduct such a search, it carries a microphone that has periodically recorded sounds near the surface of the planet to help characterize wind and atmospheric turbulence. Chide et al. realized that the microphone might have serendipitously recorded sounds of electrical discharges in the atmosphere.

The authors' analysis showed that, in some of the recorded data, there were indeed distinctive audible features. However, there were also signals caused by the interference of electromagnetic radiation with the microphone. The combination of sound and electromagnetic radiation observed in the data was potentially characteristic of what would be expected from an electrical discharge in the atmosphere of Mars.

Of the 55 distinctive bursts of sound identified by the authors, seven coincided with electromagnetic interference. These mostly occurred during windy weather and dust storms or as short-lived whirlwinds known as dust devils (Fig. 1) passed directly over Perseverance. The coincidence of recorded sounds with electromagnetic interference for seven events, and the similarity of the 48 other bursts to the signals recorded during those events, led the researchers to conclude that the bursts were caused by electrical discharges in the atmosphere.

Chide et al. used the time difference between audio signals and associated interference to calculate the location of the lightning, which was typically just a few centimetres away from the microphone. The researchers also calculated the electrical energy of six of the events, finding them to be in the range of 0.1 to 150 nanojoules, with an estimated discharge length of up to 1 cm. The authors noted that lower-energy or more-distant electrical discharges might have gone undetected because the microphone would be sensitive to sounds within just a couple of metres of the rover, at most. One recording differed in that it suggested that a more-energetic discharge (40 millijoules) had occurred across a distance of about 40 cm to the surface, but the authors could not rule out the possibility that this discharge originated from the rover itself.

The recordings provide persuasive evidence of dust-induced discharges that fit with scientists' understanding of how such events would occur on Mars. However, the discharges were only heard and not seen, and no visible evidence of such activity has ever been recorded, despite the presence of several cameras on Mars over the years. This is understandable, because the light produced from such small discharges would be transient and dim, and would probably be obscured by the surrounding dust clouds. Even so, given the history of this field, some doubt will inevitably remain as to whether this really was Martian lightning. The debate is likely to continue for some time.

Nevertheless, the findings are compelling enough to open fresh avenues of research. In the future, new instruments for measuring atmospheric discharges, with more-sensitive cameras than were used in previous missions, could be sent to Mars to try to confirm the findings and to delve into the characteristics and consequences of such events. For example, complex chemical reactions are known to take place in the Martian atmosphere, such as those involved in cycling chlorine between the land and air9 .Could atmospheric electrical discharges drive that chemistry?

Atmospheric discharges might also pose a hazard for future human missions. Although the current evidence suggests it is extremely unlikely that the first person to walk on Mars could, as they plant a flag on the surface, be struck down by a bolt of lightning, the existence of small and frequent static-like discharges could prove problematic for sensitive equipment.

Daniel Mitchard is at the Lightning Laboratory, Advanced High Voltage Research Centre, Cardiff School of Engineering, Cardiff University, Cardiff CF10 4AW, UK.

e-mail: mitcharddr@cardiff.ac.uk.

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Figure 1 | A Martian dust devil viewed from above. Chide et al.4 report evidence of electrical discharges in the Martian atmosphere, including some associated with short-lived whirlwinds known as dust devils.