Snippets of the Martian soundscape

For the first time, audible sounds have been recorded at the surface of Mars by two microphones aboard NASA’s Perseverance rover. Recordings across frequencies of 20 hertz to 20 kilohertz and above reveal the dynamics of the planet’s atmosphere and the distinctive sound-propagation properties of an atmosphere dominated by carbon dioxide.

The observation

The SuperCam instrument suite² on NASA’s Perseverance rover carries a microphone 2.1 metres above the ground to record air-pressure fluctuations in the audible frequency range and beyond, from 20 hertz to 50 kilohertz. This microphone was turned on periodically to record the turbulence of the planet’s atmosphere. Perseverance carries a second microphone as part of the Entry, Descent and Landing Camera, which is mounted on its port side. Both microphones are used to record artificial sounds. Some of these sounds help to inform operators about equipment health. Others come from well-localized sources: the robotic helicopter Ingenuity during its flights above Mars’s surface and the shock waves produced when the SuperCam laser vaporizes surface rocks to measure their chemical composition.

After the first 216 sols (Martian days) of the mission, we found that the wind- and turbulence-induced acoustic signal extends up to 600 Hz (Fig. 1). The data reveal a dissipative energy regime—a range of conditions for which the energy of turbulence is converted into heat—that extends across five orders of magnitude. The laser-induced signal lies at frequencies above 2 kHz, whereas the Ingenuity signal was caught at 84 Hz and 168 Hz. These recordings allowed us to study in situ sound-propagation properties. We obtained two distinct values for the speed of sound: the value at frequencies below 240 Hz was about 10 metres per second slower than that above 240 Hz. This is a distinguishing characteristic of a low-pressure CO₂-dominated atmosphere. The recordings of the laser-induced signal provided data on the acoustic attenuation with distance for frequencies above 2 kHz, allowing us to better understand how a process called vibrational relaxation in CO₂ molecules affects Mars’s acoustics in the audible range.

The implications

Acoustics offers a fresh way to explore Mars’s atmosphere. It extends the detection of infrasound (sound waves with frequencies lower than 20 Hz) and pressure fluctuations down to scales that are 1,000 times smaller than those probed in previous missions¹. The dissipative regime we uncovered will help us to understand thermal exchanges in the planet’s atmosphere. Moreover, the measurements of Mars’s acoustic attenuation provide in situ experimental data for the modelling of acoustic processes, which is crucial for many geophysical studies of CO₂-dominated atmospheres.

The Perseverance observations were facilitated by the implementation of the SuperCam microphone high above the ground, away from most sounds generated by wind flowing past the rover. By contrast, the microphone near the rover’s deck picked up more rover-induced sounds. The use of known artificial sound sources was crucial to the success of this study. At first, we were not sure whether we would hear Ingenuity’s flights, but the signal came through loud and clear even when Ingenuity was more than 100 m away.

These initial results show the potential for a new generation of acoustic sensors to study the dynamics of Mars’s atmosphere. The use of acoustics will be even more informative on planets with denser atmospheres, such as Venus, as well as on Saturn’s moon Titan³, where sound waves interact more strongly with the atmosphere and propagate for longer distances. The acoustic exploration of the Solar System has just started.

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Something as seemingly simple as putting a working microphone on Mars has eluded and vexed the planetary-science community for decades. Finally, the SuperCam team managed to get a microphone onto NASA’s Perseverance rover ... and it works! Even better, the microphone recorded both the passive acoustic environment and the impulsive shock waves generated when SuperCam’s laser blasted rocks to obtain chemical samples. At last, the team can explore sound propagation and atmospheric turbulence in Mars’s CO₂-dominated atmosphere.

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