Experimental verification of acoustic characteristics under simulated Martian surface environment

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Introduction: In 2020s, launches of Mars explorers is planned, and realization of the series-like Mars explorations is expected. As of 2016, the sonic wave observation in Martian atmosphere has never been carried out. Not only measuring Martian atmospheric sound with the dust events but also sensing of physical parameters in Martian atmosphere could be realized if a few small microphones are equipped on a Rover for the exploration based on an appropriate design and development.

Purpose: We aim to measure the sound attenuation and the sound velocity experimentally under the Martian atmospheric condition in the large science space chamber excluding the temperature control with operating the microphone evaluation model to be mounted on Mars probe.

Experiment outline: As a Martian surface atmosphere condition, nighttime temperature of -120 degree Celsius operation and calibration tests including infrasound detection in an environment simulating the harsh environment of CO_2 component occupying 95%, ground surface pressure of 7 hPa and the similar environment were carried out at Chiba Institute of Technology, Kochi University of Technology and ISAS/JAXA. We measured sound propagation characteristics in Martian atmosphere in ISAS/JAXA large-scale science space chamber using microphones arrays that had been confirmed under the simulated Martian conditions. Air, argon, and carbon dioxide were set to 7 hPa and 70 hPa, respectively, as the experimental conditions, and measurements were made including only atmospheric pressure of air. This chamber was about 2 m in diameter and 4.5 m in length, with a moving arm inside. Measurement was also carried out by installing a speaker at the terminal end of the arm, outputting a certain frequency, and moving it laterally within the movable 3 m range of the arm by 0.25 m step. The sound speed was calculated from the standing wave of half wavelength generated in the chamber. Also, attenuation was calculated by comparing amplitudes under different pressures by the same method.

Experimental result: In the experiment of this time, since it was found that it is difficult to calculate the measurement of the sound velocity, by the spaced microphones the sound speed is calculated from the data acquired to confirm the position of the antinode and the node of the standing wave. Because the number of data was too small to calculate accurate values. However, when the interior of the chamber was set to 7 hPa with carbon dioxide, the theoretical value of sound velocity was 269.7 m/s, whereas the experimental result was 280 m/s. For argon, the theoretical value was 322.1 m/s,experimental one was 350 m/s. For the air, 350 m/s was measured with respect to the theoretical 326.4 m/s. From this result it was possible to obtain the sound speed with an error within 8% of the theoretical value. In addition, when comparing sound intensities at 70 hPa and 7 hPa with argon, an amplitude difference of 10.41 times on average was obtained if the pressure difference was 10 times. Moreover, with the air, the amplitude difference of 8.9 times was obtained under the same condition.

Discussion: Since the value of sound velocity under the simulated Martian surface condition was measured and values close to the theoretical ones were obtained for three species of CO_2, Ar, and Air. It is considered that it is possible to derive a more accurate value by increasing the number of observation points by the same method. Also, regarding sound attenuation, when the sound velocity, gas and temperature are the same as the dynamic viscosity = absolute viscosity / density, since the pressure is a function of density, it is consistent with the idea that the attenuation becomes large when the pressure is small, so the result seems roughly to be correct.

Conclusion: Sonic speed and sound attenuation were measured under simulated Mars environment using an evaluation model of the microphone array. Since the speed of sound is close to the theoretical value, the sound speed in the Martian atmosphere can be considered to be almost the same as the theoretical equation. In the future we will have microphone arrays on the balloon and will conduct an experiment in the stratosphere comparatively close to the Martian atmosphere without a boundary surface at ESRANGE in Sweden in October, 2017.

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