

A proposal of Martian dust devil observation by combination with electromagnetic and acoustic wave measurements

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Mars 2020 rover is planned to launch by NASA in 2020, as the almost same package of the Mars Science Laboratory (named Curiosity after its successful landing in August 2012). The announcement of opportunity (AO) for scientific/technology payloads to be onboard the NASA Mars 2020 rover was called for to the scientists community in world wide in September 2013. Here, we introduce our proposed instrument designed for electromagnetic (EM) and acoustic wave (AW) measurements that have never been operated on Mars.

Low-frequency EM and AW are important for monitoring atmospheric events because of their long-distant propagating characteristics more than 1000 km. Electrical discharges could be a hazard for instruments and future human activities on Mars, hence it should be treated as one of the strategic knowledge gaps (SKGs) for future missions. Our concept is that combining EM and AW measurements, precise distance information of dust storms and/or dust devils can be obtained by using two independent velocities of light (c) and sound (Cs) because discharges could be generated by electro-static processes in low-pressure dusty atmosphere and the process also generates shock waves in acoustic/infrasonic pressure wave range. Moreover, wind roaring sound, shock waves by meteors entries, and operational sounds by rover itself will be recorded as the world first "Martian sound."

Our EM and AW detection system consists of antennae, microphones, and common receiver circuits with on-board software. For E-field detection, a legacy monopole of 10 cm will be used as a vertical antenna. Two orthogonal loop antennae should be applied for B-field with direction-finding system. However, instead of pop-up devices, these 3 antennae will be compressed into a fixed 10 cm cubic antenna to be equipped on rover surface. Although a legacy receiver circuit can be used, we can minimize it into a postcard size by applying a newly-developed chip device. Analyses of EM and AW for monitoring discharges can be operated by on-board software to reduce data volume. Similar software is used in GLIMS operated on JEM-Kibo/ISS, where only the most significant events will be sent to the Earth in priority basis.

EM sensing in the Martian atmosphere is significant for the future human exploration on Mars. Although the environment on Martian surface is too severe to survive even in fair climate condition, human activities on Mars is obviously dangerous especially when it is under the storm-like condition. Thus, dust devils on Martian surface are significant for the future human exploration, especially, electrostatic discharge events could be serious hazards for astronauts as well as for Martian base facilities. However, the EM condition on the Martian surface has never been measured in detail. Hence, we consider the remote-sensing of the dust devils and discharge events from a single site on Mars with simple sensors could be a potential instrumentation.

Here, as a proposal to the NASA 2020 AO, we introduce one of the most promising remote-sensing methods for dust devils and discharge events by using a combination of EM and AW. According to its rarefied atmospheric pressure condition on Martian surface, about 1/100 of the Earth's surface, dust particles can easily be flown up by surface wind then could effectively produce charged particles by convection. Based on previous studies on the Earth, such charged particles possibly produce discharge events. Drastic changes in EM fields can be observed even at far-distant observatory, more than 1000 km away from the exact coordinates of discharges. AW also could be a remote-sensing method when there exists the atmosphere. Especially, low frequency AW less than 1 Hz can propagate for long distance more than 100 km even in the rarefied atmosphere. If we use two independent velocities of light (for EM) and sound (for AW), we can identify source coordinates of every discharge events within a few tenth km.

Keywords: Mars, electromagnetic wave, acoustic wave, discharge, dust devil, lander