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Wind shelter development for broadband seismic observation on Mars

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Abstract

Japan Mars Exploration project (Mars Exploration with Lander-Orbiter Synergy) is now under consideration and it includes seismic observation. Our plan is to install broadband and high sensitivity seismometer. I will report our development of broadband seismic observations on Mars, especially focusing on the performance test by using wind tunnel and numerical simulations to evaluate and reduce effects of surface wind on the seismometer.

1. Mars' free oscillation

To infer gross view of interior of Mars from surface to core free oscillation data is indispensable, particularly in the situations of restricted operation. There exist two major problems to be overcome.;1) availability of suitable seismometer to detect planetary free oscillation under severe environments, 2) excitation of free oscillations in Mars. As for the excitation problem we consider the possibility of atmospheric continuous excitation induced by wind (range 20 to 50m/s). The expected level is shown in **Figure 1.** As for 1) we are developing wide band high sensitivity Laser interferometry seismometer which well covers the free oscillation band and the amplitudes.

So, we need a broadband and high sensitivity seismometer (range 50hz to 1000s : **Figure 2**).

2. Mars environmental problems

To performe seismometer observation on Mars, there still exist several difficult problems. They are mostly due to the severe environments of Mars such as extreme variation of temperature, high radiation and strong surface wind. Particularly strong surface wind may be the most troublesome since we have bitter lessons from Viking Landers. In this presentation we report our trials to reduce the effect of wind.

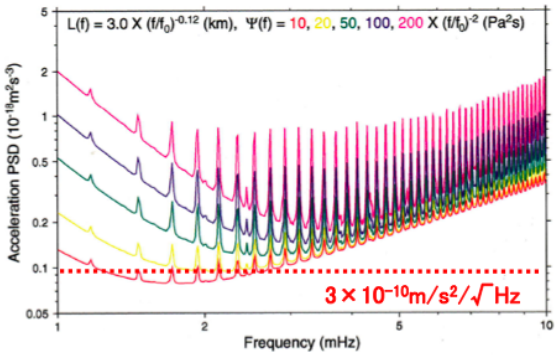

Figure 1: Mars free oscillation spectrum (N. Kobayashi 2008)

3. How to make a wind shelter?

Our development is composed of two different approaches. One is performance test of wind shelter by using wind tunnel. Another is numerical simulations to evaluate interaction between wind and seismometer for better design of seismometer shape. By combing two methods, we will devise suitable shaped shelter.

3.1. Wind tunnel test

We conducted wind tunnel test by changing atmospheric pressure from 0.1 to 0.3 atm, and wind velocities from 13 to 27 m/s. We test two typical shapes for the shelter ; semispherical and cylidrical one. We focus on flotation force and rotational moment induced by the wind, because large flotation force and rotational moment can slide and roll over the wind shelter. We determine the relationship between flotation force,rotational moment , wind velocity and atmospheric pressure.

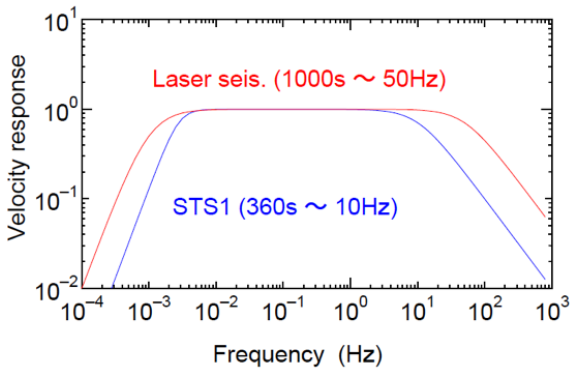

Figure 2: Laser interference broadband seismometer (A. Araya et al,. 2007)

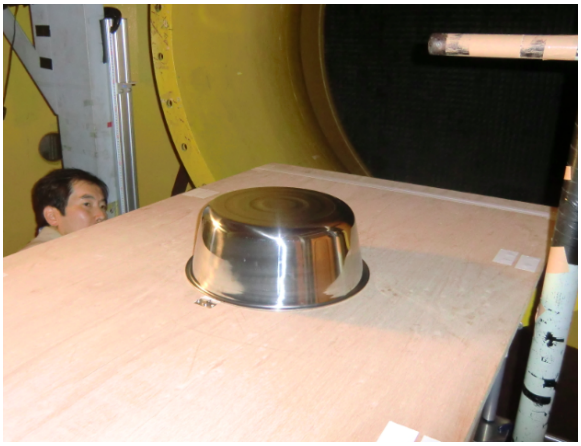

Figure 3: Wind tunnel test (JAXA/ISAS, Sagamihara, Japan)

3.2. Numerical simulation

We simulate the effect of wind shelters. We solve imcompressible and inviscid flow with finite volume method using OPENFOAM.

4. Results

We can evaluate the flotation force and rotational moment by the wind tunnel test results. Both flotation force and rotational moment are proportional to the atmospheric pressure and square of the wind velocity (**Figure 5**). We will compare the wind tunnel test with the simulation.

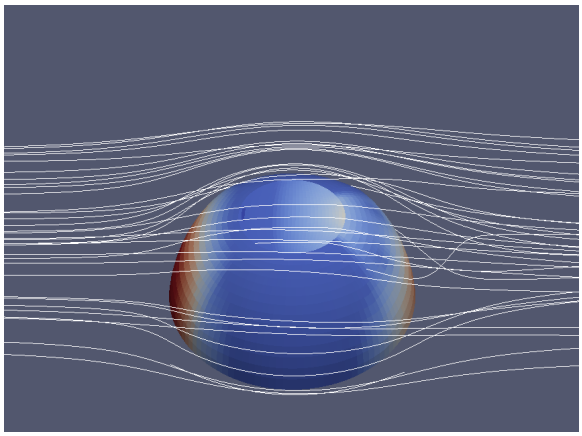

Figure 4: Semispherical shelter's numerical simulation result. (pressure and flowlines)

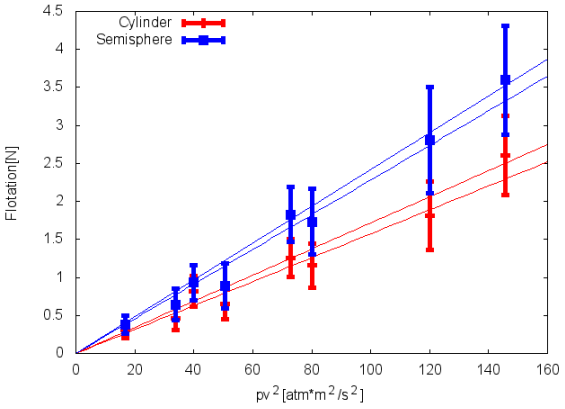

Figure 5: Flotation force vs atm and square of the wind velocity (wind tunnel test result)

References

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