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Wake-induced pressure fluctuations on the Mars2020/SuperCam microphone inform on Martian wind properties

Studying the Martian Winds using the Influence of the SuperCam Wake Flow Regimes on the Mars2020 Microphone

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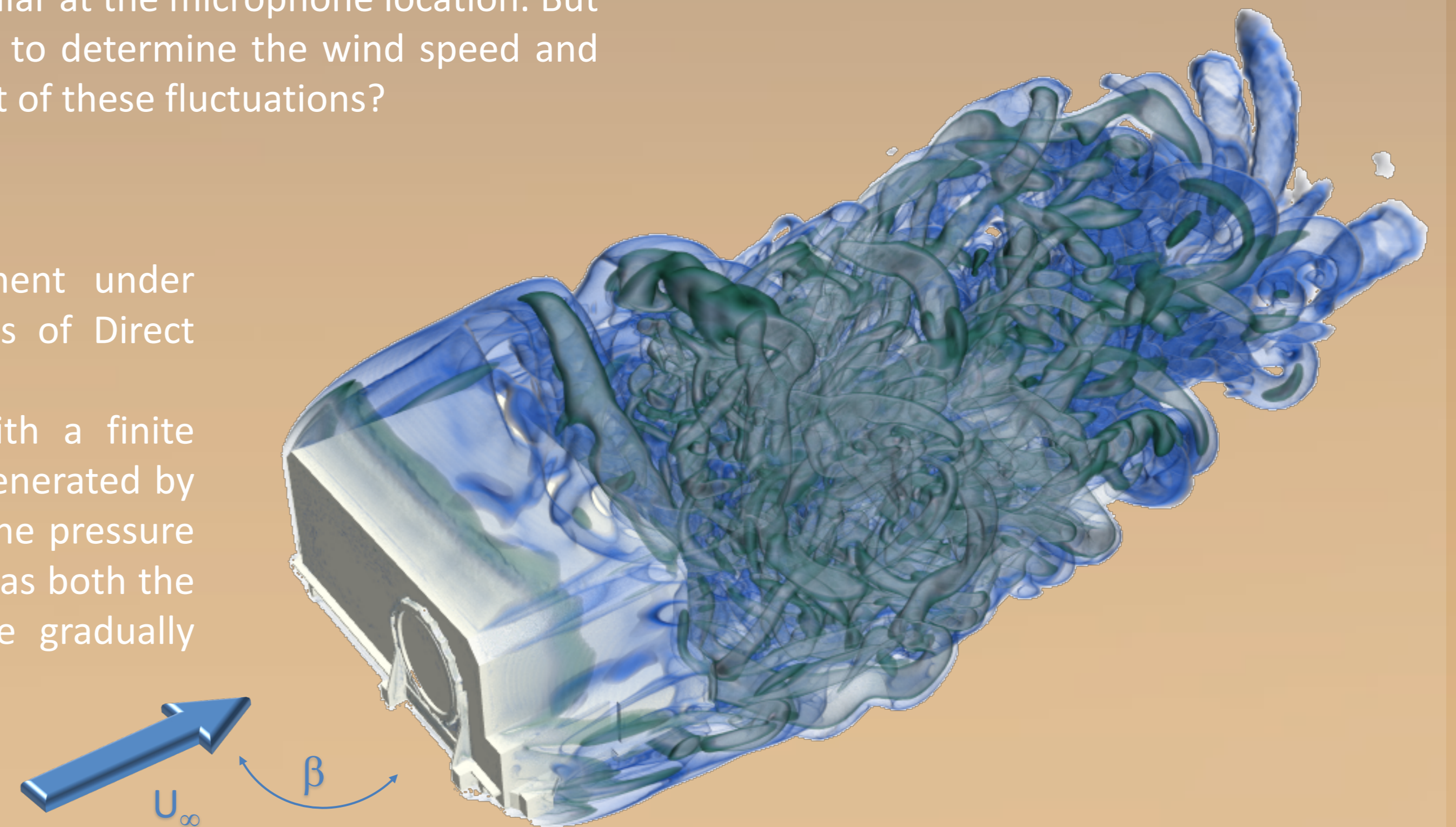
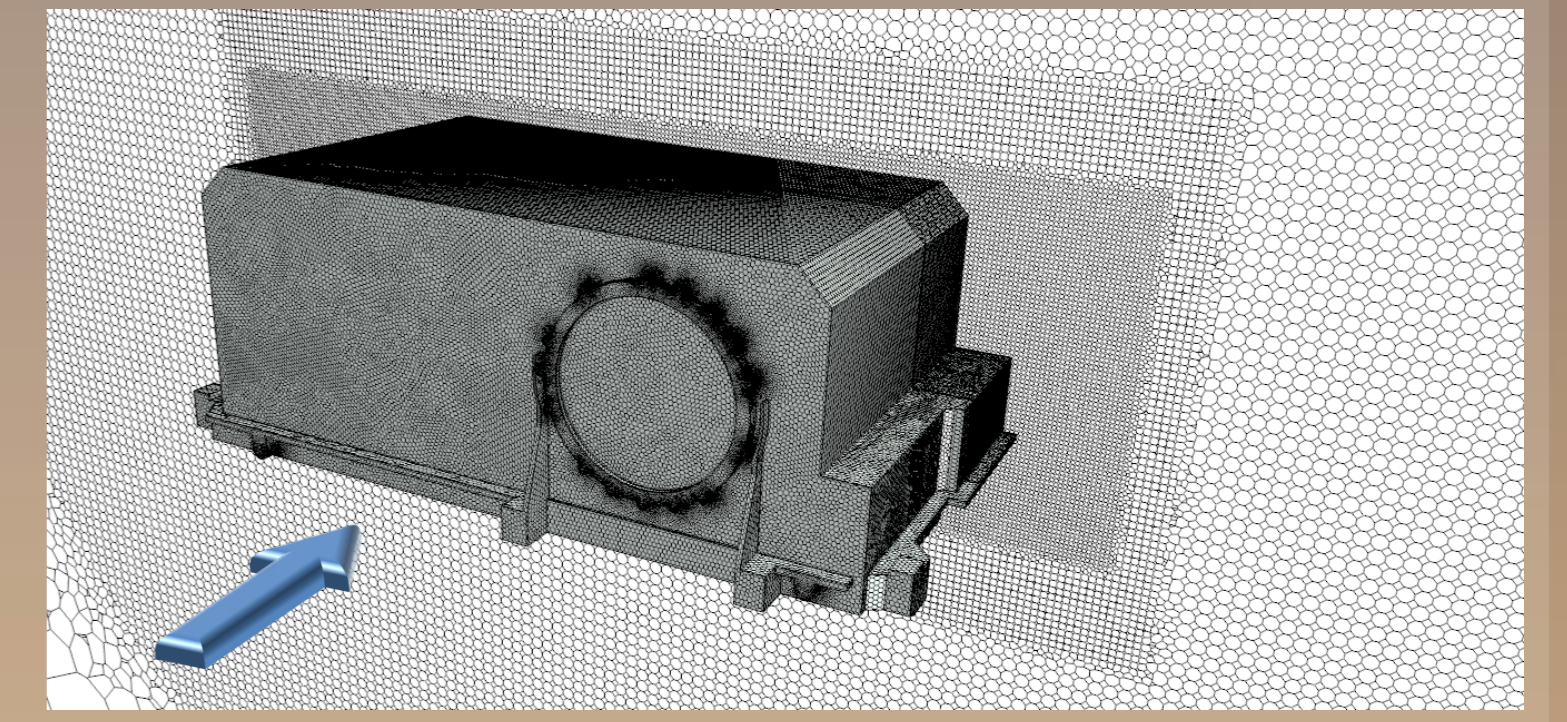


Numerical approach

When the Martian wind flows around the SuperCam instrument, it will generate a wind-dependent wake, made of varieties of vortices. These vortices will promote local pressure fluctuations, in particular at the microphone location. But can we use the SuperCam Mars Microphone to determine the wind speed and direction on Mars, based on the measurement of these fluctuations?

We analyze the flow around the instrument under Martian environmental conditions by means of Direct Numerical Simulations (DNS).

The Navier-Stokes equations are solved with a finite volume approach [3]. Flow Instabilities are generated by the SuperCam instrument. Their impact on the pressure field exerted on the microphone is evaluated as both the direction and the velocity of the wind are gradually varied.



Wake structure and pressure fluctuations

The numerical results reveal the occurrence of complex instability modes in the close wake of SuperCam, depending on the direction of the wind. Fig.1 depicts the vortical structures in the wake of SuperCam for a 5 m/s Martian wind. The wake features very different shapes and different spreading of the size of the vortices as the instrument is progressively rotated 360°.

The analysis of the time histories of the pressure signal measured at the location of the Mars Microphone (Fig.2) highlights different trends as a function of the direction of the wind. These trends are confirmed whatever the velocity of the wind.

The direction of the wind impacts both the mean and fluctuating values of the pressure signal at the location of the microphone: from maximum when the Mars microphone is facing the wind ($\beta = 0^\circ$), the mean value reaches a minimum when the flow is facing either the lateral left face ($\beta = 270^\circ$) or the back face ($\beta = 180^\circ$) of SuperCam, since the microphone is immersed in a massively separated region of the flow. Interestingly enough, the *r.m.s.* value provides more detailed information on both the wind direction and speed. It is minimum when $\beta = 0^\circ$, but reaches a maximum value when $\beta = 90^\circ$. For this direction of the wind, and to a lesser extent for $\beta = 270^\circ$, the PSD of pressure fluctuations (Fig.3) is fueled on a larger band and depicts a peak, related to the wind speed. This peak highlights the vortex shedding process promoted by the SuperCam instrument.

The identification of both the minimum and maximum values of the pressure fluctuations and of the vortex shedding frequency peak as the SuperCam is rotated is thus the solution to determine *in situ* the Martian wind speed and direction.

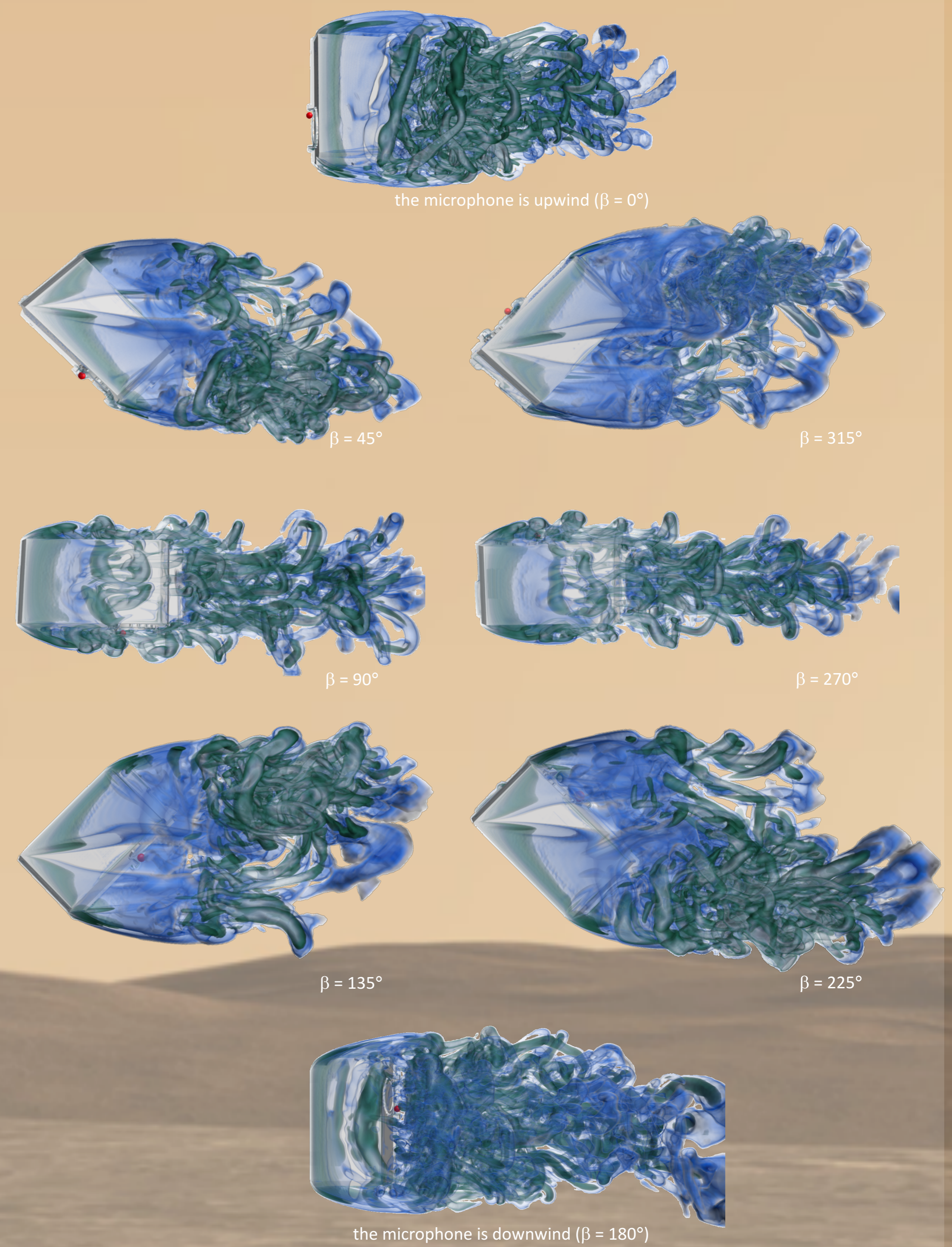


Fig.1: Iso-surfaces of Q-criterion [3], revealing the vortical structures in the wake of the SuperCam instrument (upper view), for a 5m/s wind (96 % CO₂, density 0.02 kg/m³, pressure 600 Pa, temperature 210 K) flowing from left to right, as the SuperCam is rotated 360°. The different colors correspond to more or less (dark green to light blue) intense vortices. The red dot illustrates the Mars Microphone location.

Background

Mars Microphone:

- Add-on to SuperCam [1]
- Records from 100 Hz to 10 kHz
- Three operating modes: microphone only, laser continuous and laser synchronized

Sound Propagation:

- ~240 m/s
- High frequency sounds are absorbed by the CO₂

Objectives

- Support the Laser-Induced Breakdown Spectroscopy (LIBS) investigation by determining rock physical properties and laser induced crater depth [2]
- Contribute to basic atmospheric science by recording the noise of the wind flowing past the instrument
- Listening to the rover mechanical noise

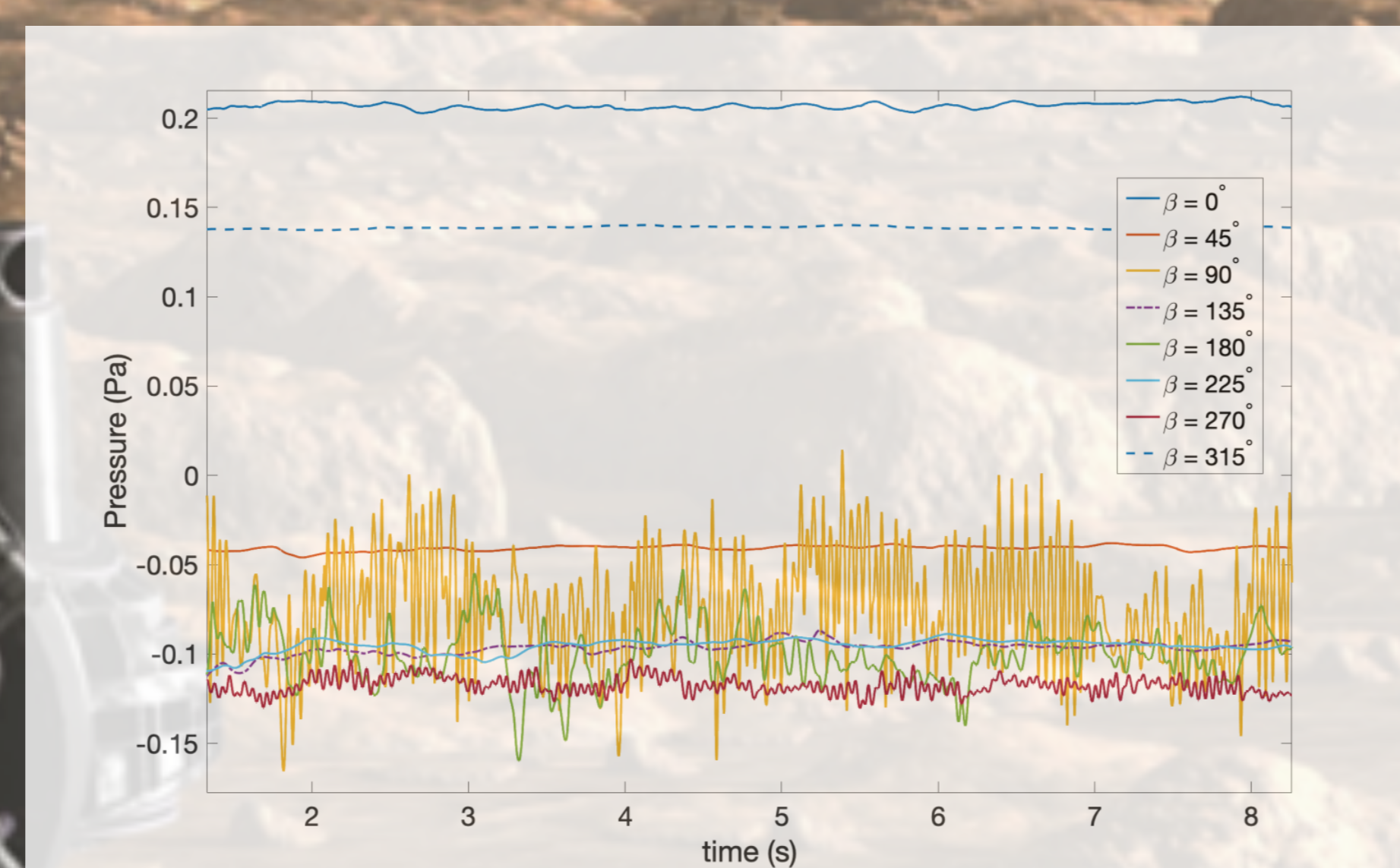


Fig.2: (left) Time histories of the pressure signals (relative to ambient pressure) and (right) polar plots of the time-averaged (upper) and *r.m.s.* (lower) pressure at the location of the microphone, for a 5 m/s wind velocity coming from various directions.

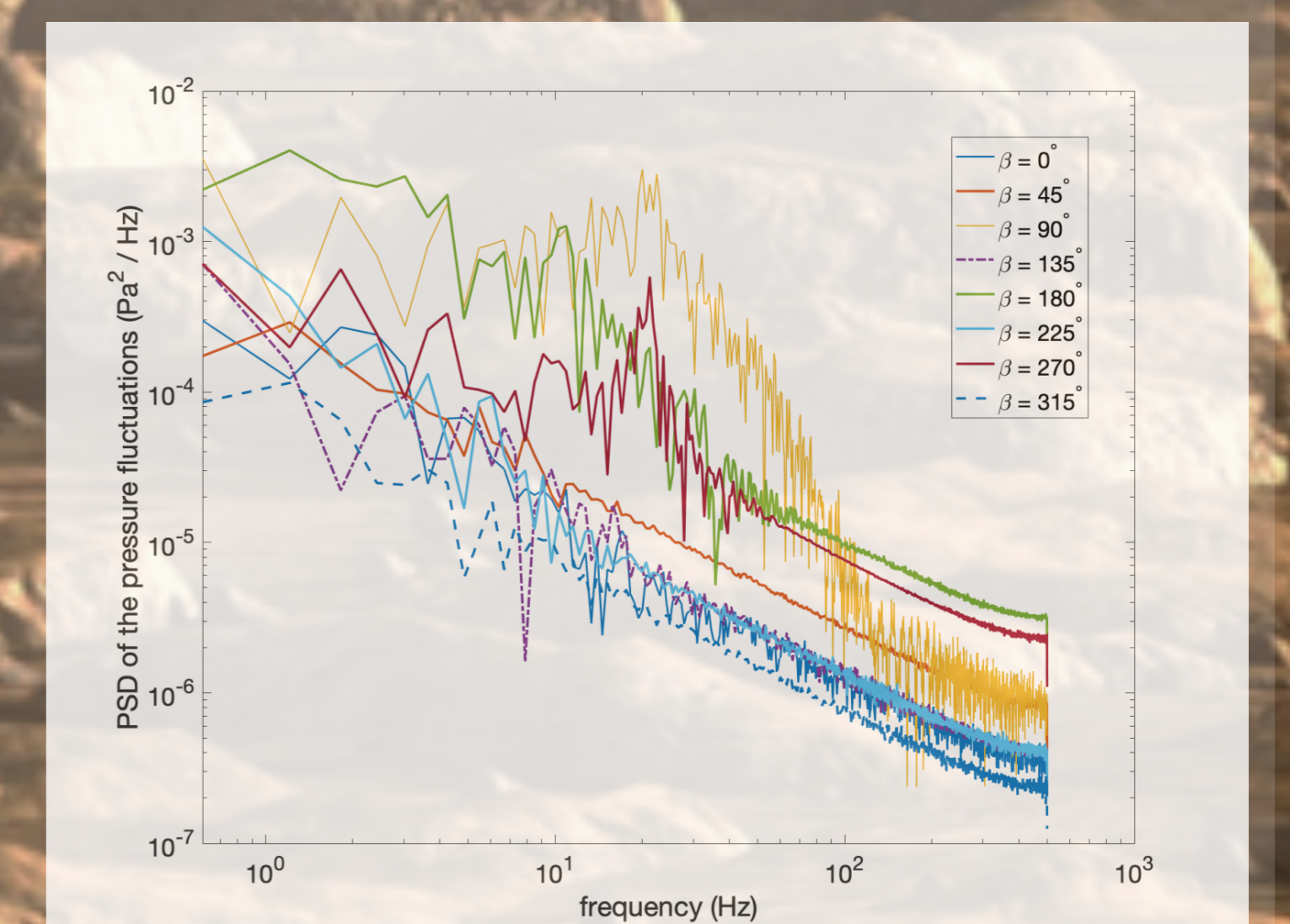


Fig.3: PSD of the pressure fluctuations at the location of the microphone, for a 5 m/s wind velocity coming from various directions.

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[1] R.C. Wiens, S. Maurice, F.R. Perez, The SuperCam remote sensing instrument suite for the mars 2020 rover mission: a preview, Spectroscopy 32 (2017), [2] Chide B. et al. (2019) Spectro. Chem. Acta B., [3] Bury Y. and Jardin T. Transitions to chaos in the wake of an axisymmetric bluff body. Phys. Lett. A.