New data analysis methods applied to Mars' ground vibrations and the imaging of its internal structure

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InSight (NASA mission) landed on the Mars' surface on Nov. 26th, 2018. Since the beginning of Feb. 2019, the SEIS experiment – composed by a broad-band and a short-period seismometers – is fully operating. The detection and the localisation of seismic events are of first importance i) to quantify the internal energy that still remain inside the red planet and ii) to constrain the physical properties of Mars' interior (1D seismic tomography). Although as of today more than 550 events are detected, very few transient signals that can be undoubtedly associated with marsquakes are identified. As a consequence, a large part of this catalog can be related to external sources (such as wind or pressure drops) but it is however possible that some events are unexpected transient signals from Mars's interior. Event detections are mostly based so far on arrivals of extra-energy in the background continuous signal which prevents moreover any detection during the noisy part of the day.
A new approach based on a statistical redundancies of waveforms in the signal can bring a different kind of observations. This can be done through seismic auto-correlations but also using cross-correlations between pressure sensor and SEIS. The lander is supposed to be a redundant source due to the atmosphere excitation and then can be used as reference in order to detect out layer phases that are no necessarily visible in terms of amplitude. This is an innovative way to detect and to characterize seismic waves buried in noise or scattered, allowing to better use the seismic information. It will be interpreted in terms of Mars' internal structure by using the seismic inversion methods already developed by the team.
On Earth, the instantaneous phase redundancy can be used to detect persistent sources (eg. Gaudot et al., 2016) but more mathematical developments such as multivariate statistics can be done to give a new look on the continuous seismic signal. They can be associate with clustering and/or machine learning algorithm to classify the observations.

This new and unconventional approaches need strong mathematical skills with a clear affinity to the signal processing technics. Seismology knowledge would be appreciated but not required. The position will be located at LPG, in Nantes (France), but the project will be in strong collaboration with ISAE-Supaero in Toulouse. The PhD funding is guarantee through the French ANR MAGIS project. Given the international nature of the project, some workshops and meetings in North America and Europe are expected.
Master 2 degree in Science (mathematics, physics, Earth's sciences) is required. Candidates must fill the application form available on the EGAAL doctoral school **before June 12, 2020**.

Reference: Gaudot, I., É. Beucler, A. Mocquet, M. Schimmel & M. Le Feuvre (2016). "Statistical redundancy of instantaneous phases : theory and application to the seismic ambient wavefield". *Geophys. J. Int.* 204(2), 1159–1163.

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