PhD project 2015-2018

Signal processing for Mars spectral data

Summary

The Planetary Fourier Spectrometer (PFS) instrument onboard the Mars Express mission (European Space Agency, ESA) recorded a very large dataset of spectra, thanks to 10 years of orbital observation around the Red Planet, at various places, local time and season, with unprecedented spectral resolution. Among other new detection, the PFS provided a very debated seasonal detection of atmospheric methane of several parts by billions. If true, this detection implies a large amount of methane released at present time, but also imply that methane is destructed very efficiently. Several candidate processes are proposed, including rocks alteration or life. This question has been considered at the top level by the ESA at the point to send the ExoMars Trace Gaz Orbiter mission (planed to launch in 2016 and arrive in 2017) to unravel this mystery. The main objective of this PhD program will be to correct the major limitation of the PFS instrument to have access to local atmospheric properties: the effect of micro-vibrations that can be corrected by blind deconvolution using complex variables.
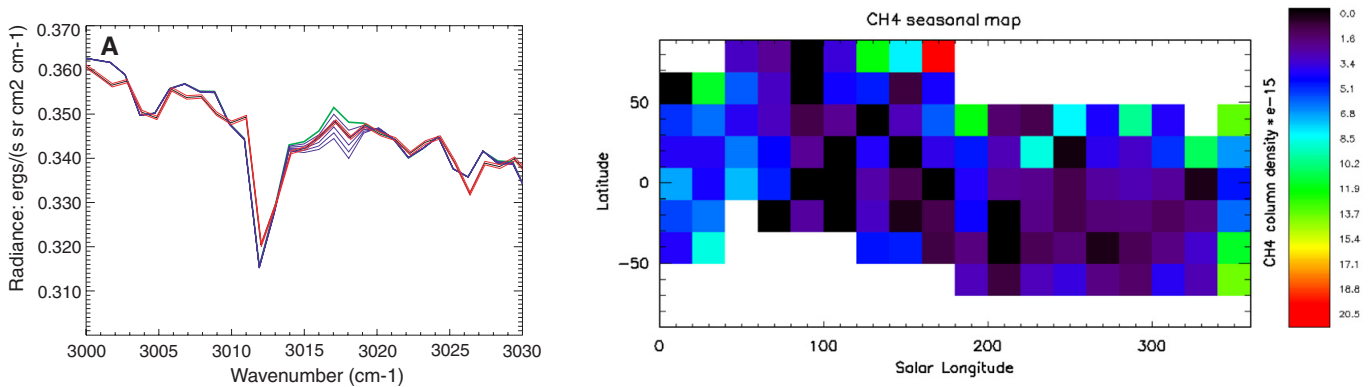
Figure 1: (Left) The detection of methane in the atmosphere of Mars. Synthetic spectra computed for 0 ppbv (green curve) and 10, 20, 30, 40, and 50 ppbv (violet curves) of methane, compared with the PFS average spectrum (black curve) (from Formisano et al, 2004). (Right) Seasonal map of methane at a spatial resolution of 20° latitude (all longitude are averaged) and 20°Ls (1/18 of the Martian season). The colors refer to the methane column density in unit of 10^{15}molecule/cm^2.

Among blind inverse problems, blind deconvolution is one of the much harder. Indeed, traditional mathematical priors such as sparsity inside dictionary of elementary atoms do not lead to satisfactory solution. However, a lot of advances have been made, especially when strong priors can be made on the convolution filter, such as in speech dereverberation. Even if the transfer between the signal processing community and some specific applied domain is successful, the PFS instrument has not benefited yet of such advanced signal processing techniques.

We plan to adapt and develop new deconvolution tools, and propose them as a end-user toolbox. Especially we will focus on the implementation on very parallelized architecture (GPU/Xeon Phi) to process very large dataset.
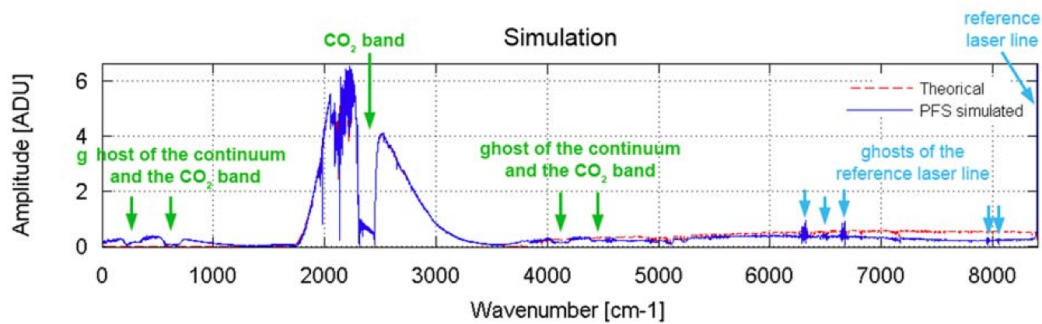

Figure 2: Simulated PFS data and the effect of micro-vibration (from Shatalina et al., 2014)

Team

The team around this PhD will be:
- Frédéric Schmidt (GEOPS, Paris) is Co-Investigator of the PFS instrument. He will be the official PhD advisor (Habilitation since January 2014). He is an expert in surface/atmosphere interactions in Planetary Science. He is also developing innovative signal treatment tools for remote sensing data.
- Mathieu Kowalski (L2S, Paris) is expert in signal processing and blind deconvolution.
- Nicolas Gac (L2S, Paris) is expert in signal processing and implementation on GPU.
- Marco Giuranna (IAPS, Roma) is Principal-Investigator of the PFS instrument since 2012. He is leading the calibration of the instrument, the technical and scientific operations and analysis.
- Bortolino Saggin (Politecnico di Milano) is expert in Fourier transform spectroscopy and space engineering.

Skills

The Phd candidate must have the following skills:
- High academic skills in at least two domains: signal processing, physics, programming, planetary science, remote sensing
- Language skills: good English level (if possible basic French level)

Condition

Phd funded for 3 year: from ~September 2015 to ~September 2018

Salary: 1400 €/month net (social security and taxes included)
Student with equivalent Master degree.
Location: GEOPS (University Paris Sud/CNRS)
                  Bâtiment 509
                  Université Paris Sud, ORSAY, FRANCE

Optional Master internship

Student in Master degree could spend their internship before the PhD program in our lab.
Duration: ~March 2015 to ~September 2015
Salary: 500 €/month net (social security and taxes included)

Contact

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