The Planetary Fourier Spectrometer (PFS) onboard the European Mars Express Mission

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ABSTRACT. *The Planetary Fourier Spectrometer (P.F.S.) for the Mars Express mission is an infrared spectrometer optimised for atmospheric studies able to cover the wavelength range from 1.2 to 5 µm and from 5.5 to 45 microns . The spectral resolution is 1.5 cm^{-1},while the sampling is 1 cm-1. The instrument field of view FOV is about 1.6 deg. for the Short Wavelength channel (SW) and 2.8 deg for the Long Wavelength channel (LW)(FWHM figures are given) which corresponds to a spatial resolution of 7 and 12 km when Mars is observed from an height of 250 km (nominal height of the pericentreat the starting of the mission). P.F.S. can give unique data necessary to improve our knowledge not only of the atmosphere properties but also about mineralogical composition of the surface and the surface-atmosphere interaction.*

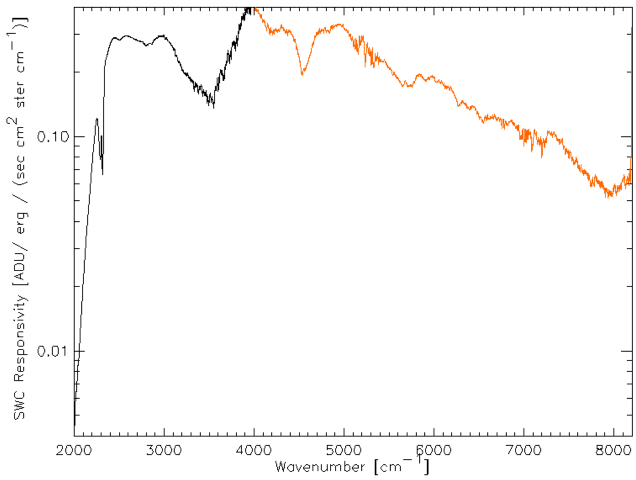
The scientific objectives of the P.F.S. experiment can be summarised as it follows:

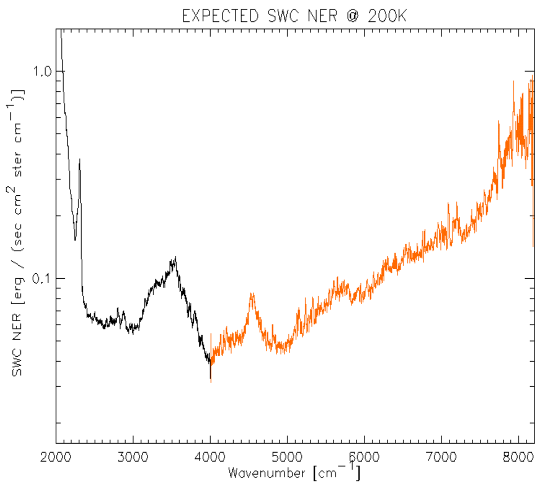
1) Atmospheric studies: a) global long time monitoring of the three-dimensional temperature field in the lower atmosphere (from the surface up to 40-60 km); b) measurements of the minor constituents variations (water vapour and carbon monoxide); c) search for possible other small components of the atmosphere; d) new determination of the D/H ratio; e) study of the optical properties of the atmospheric aerosols: dust clouds ice clouds hazes; determination of the size distribution and chemical composition; f) investigation of radiance balance of the atmosphere and the influence of aerosols on energetics of the atmosphere; g) Study of global circulation, mesoscale dynamics and wave phoenomena.

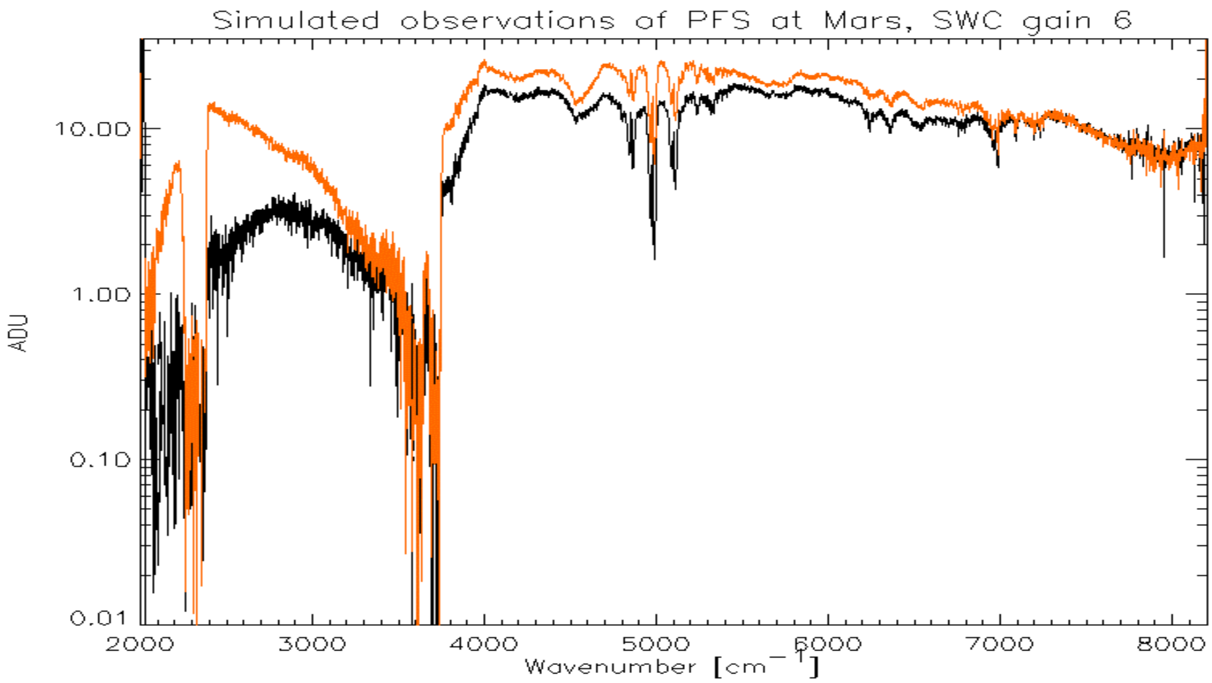
2) Surface studies: a) monitoring of the surface temperature; b) determination of the thermal inertia obtained from the daily surface temperature variations; c) determination of the restrictions on the mineralogical composition of the surface layer; d) determination of the nature of the surface condensate and seasonal variations of its composition; e) measurements of the scattering phase function for selected places of the surface; f) pressure and height local determination (CO_2 altimetry) for selected regions; g) surface-atmosphere exchange processes.

The experiment has real time FFT on board to be able to select the spectral range of interest for data transmission to ground. Measurement of the 15 micron CO_2 band is very

important. Its profile gives, by means of a complex temperature profile retrieval technique, the vertical pressure temperature relation, basis of the global atmospheric study. The SW channel uses a PbSe detector cooled to 200-220 K while the LW channel is based on a pyroelectric ($L_i T_a O_3$) working at room temperature. The intensity of the interferogram of Martian light is measured every 150 nm of physical mirrors displacement, corresponding to 600 nm optical path difference, by using a laser diode monochromatic light interferogram (a sine wave), whose zero crossings control the double pendulum motion. PFS will be working around the pericentre of the orbit. Being the repetition time of the measurements 1 every 10 sec, and the working time being roughly 90 minutes around pericentre, a total of more than 540 measurements per orbit will be acquired plus 60 calibration measurements. PFS will ***measure at all local times*** *in order to have the atmospheric vertical temperature profiles also in the night side, furthermore the inertial spacecraft attitudes will be used for limb viewing measurements.*

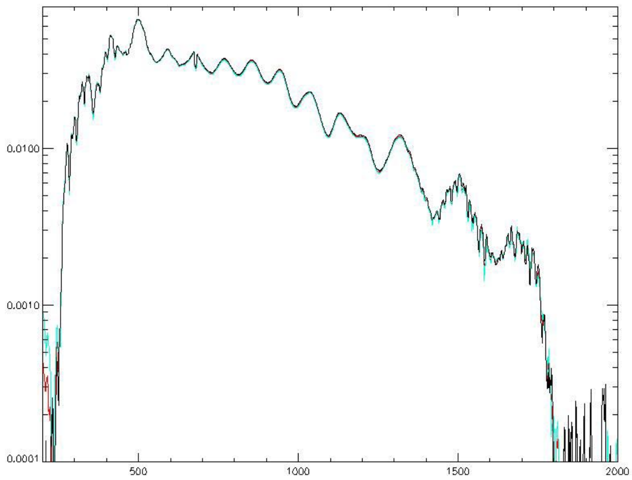


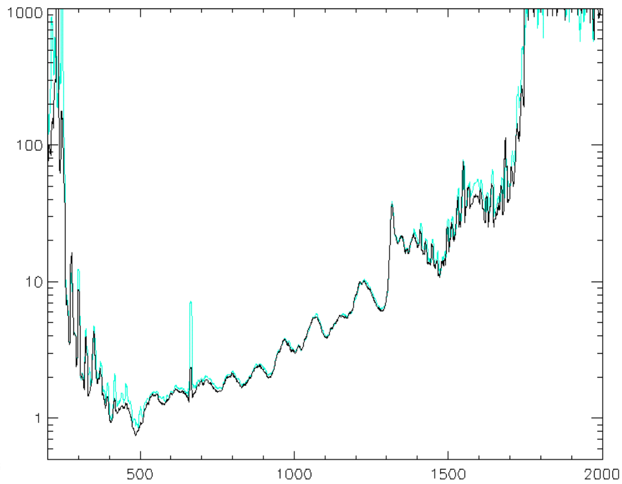


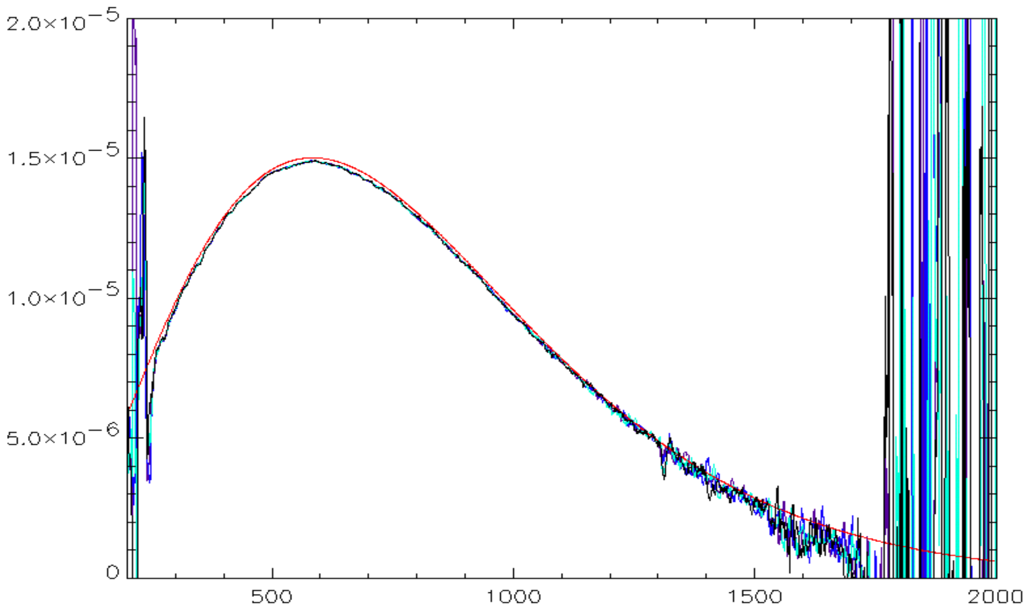


Estensive calibration measurements have given us the responsivity of the instrument , which for the SWC is given above in the first panel. The second panel gives the SWC NER. The third panel gives a two simulated Martian spectra complete with the instrument noise measured at room temperature and using gain 6 . The instrument noise has been shown to be ADC limited , therefore its importance decreases by increasing gain , and by decreasing detector temperature the instrument responsivity increases by factors up to 7. It is clear , then, that by using the appropriate gain , and at the working temperature of 200 K a SNR of 100 is expected. The two spectra above are for

equatorial region of Mars (colored one) and for polar region (black one) .Note the CO2 bands at 2350 cm-1 (useful for non LTE emission studies) , at 3700 cm-1 (useful for dust opacity studies) , at 5000 cm-1 useful for ground pressure measurements) .
Responsivity and NER for the LW channel are given in the next two panels . Note that most of the

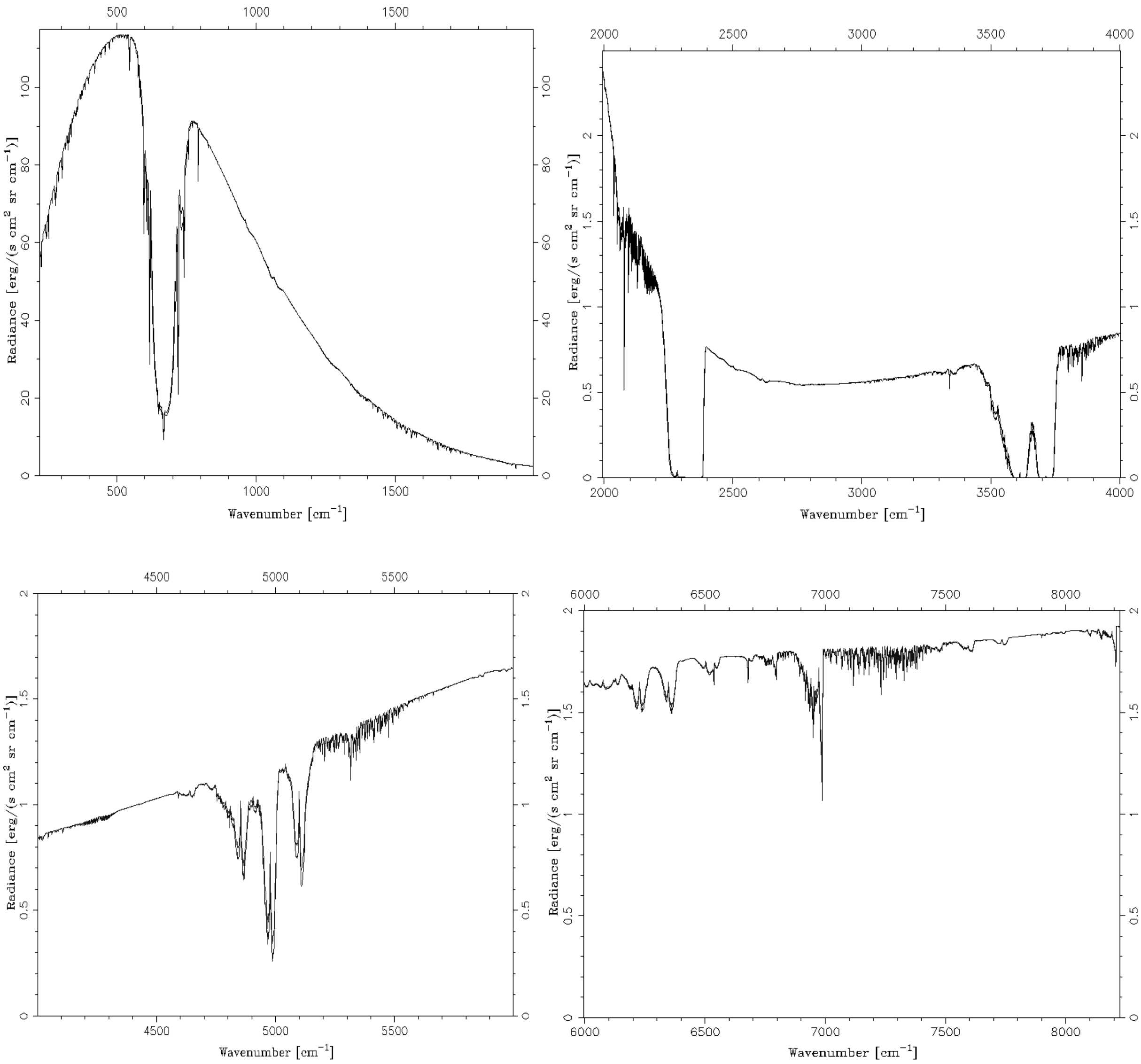






calibrations were made in air , therefore some atmospheric features are still present.
For the LW channel it is important to know well the internal Black body that PFS is carrying along: the third panel above gives the radiance measured from this internal black body and expressed in radiance intensity (MKS) using the measured responsivity . The red curve is the computed Planckian with the same temperature (only 7 degrees different from the LWC detector).Four measurements are overplotted for different gain factors. Above 1800 cm-1 the responsivity decreases to very small values, and only noise appears.
Above it is given the main characteristics of the PFS hardware as it has been calibrated in the laboratory. It is important to complement this information with a synthetic spectrum showing the basic features (absorption bands) of the Martian atmosphere in the wavenumber range covered by PFS with its spectral resolution. This is done in the next four panels for the 200 – 2000 cm-1 , 2000 – 4000 , 4000 – 6000 , and 6000 – 8000 cm-1. While the 15 microns band is used for the temperature profile retrieval, the 3700 cm-1 CO2 band is used for the aerosols opacity , and the 2

microns band is used for the measurements of the ground pressure. The 2350 cm-1 CO2 band shall be used for the study of non LTE emission of the upper atmosphere. Furthermore measurements on the nightside of Mars shall provide thermal inertia information , specially if within few days the same areas can be covered on the dayside by other measurements.
Finally the SW channel with the high spectral resolution that PFS provides , and the highly inclined spacecraft orbit , will allow polar cup ices studies of composition aspects and time variation and of water and dust seasonal cycle.



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