Laboratory characterisation of the Radiation Explorer in the Far-Infrared Breadboard (REFIR/BB) for the atmospheric emission measurement in the 100-1100 cm^{-1} spectral range

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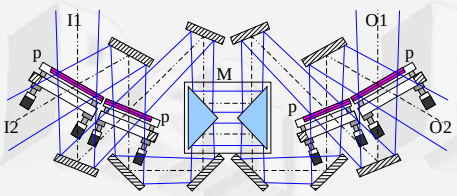
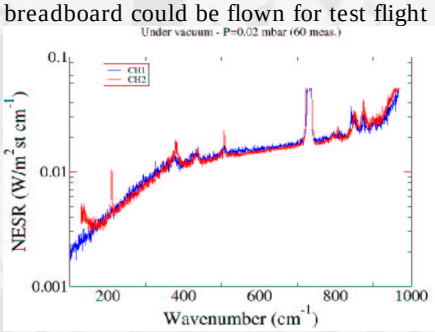
A spectrometer named Radiation Explorer in the Far InfraRed (REFIR) is being proposed for a future space mission aimed at the spectral measurement in the far infrared of the Earth outgoing emission from 100 to 1100 cm-1 wavenumber, with particular attention at the spectral regions that are not covered by any current or planned space mission. In preparation for a possible space mission, a BreadBoard version (REFIR/BB) of the Fourier transform spectrometer has been built.

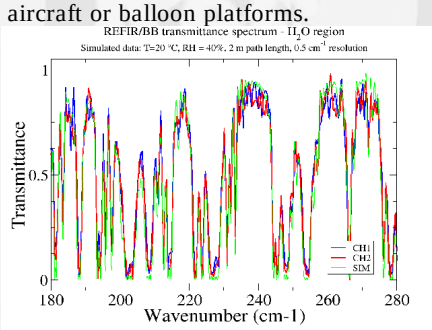
REFIR/BB will allow us to study the trade-off between all instrument parameters, to test the optical layout and to optimise the data acquisition strategy. This work describes the laboratory results on REFIR/BB with particular attention to the instrument characterisation. Tests were performed both in air, at ground level, and under a vacuum chamber. In perspective the breadboard could be flown for test flight on aircraft or balloon platforms.

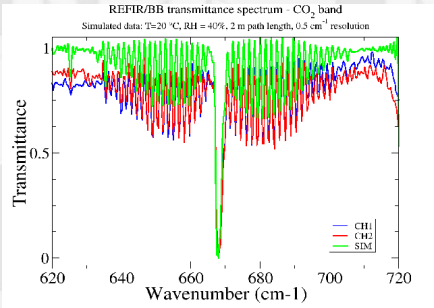


Optical layout of the REFIR/BB instrument
2-input (I1, I2), 2-output (O1, O2) ports polarizing Fourier transform spectrometer. M-Moving retroreflector, P- Photolithographic polarizers



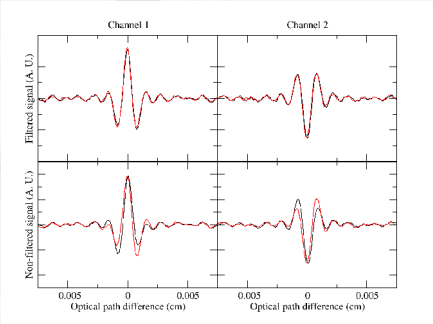
Noise Equivalent Spectral Radiance measured under vacuum conditions. Spectral features are due to beam splitter substrate (mylar) absorption.



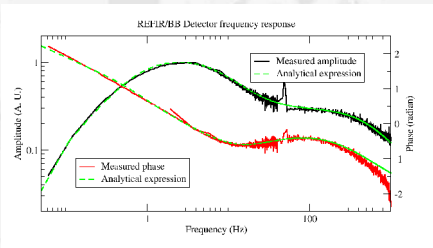


Air transmittance measured as the ratio between the signal acquired in air and the signal acquired under vacuum. Rotational water vapor band is shown in the left-side panel while the CO_2 vibrational ν2 mode is shown in the right-side panel. The results are compared with the transmittance simulated under the same laboratory conditions of the measurements. The differences in the baseline in the right-side panel are a residual calibration error due to the absorption features of the BS mylar substrate.

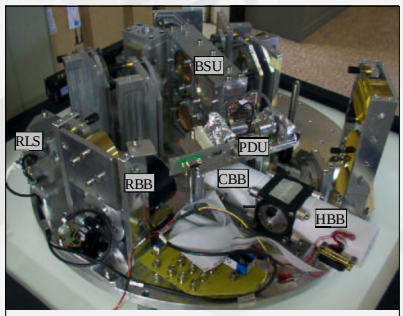
Detector response analysis



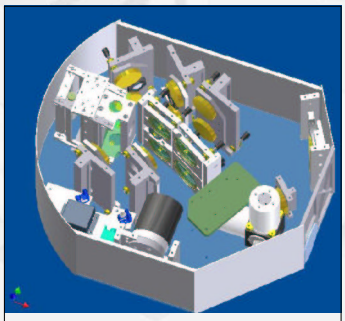
Interferogram phase correction is performed through a frequency filtering in the time domain in order to compensate for the effects of the detector and preamplifier. In the upper panel are shown the interferograms after resampling on equal space intervals for both detectors with and without filtering. In the panel below is shown the measured system response and the analytical expression used for implementing the filtering algorithm.



Interferometer type	Polarising interferometer with double input/output
Spectral bandwidth	100-1000 cm^{-1}
Spectral resolution (max)	0.25 cm^{-1} double-sided interferogram
Optical throughput	0.0097 cm^{2}sr
Internal pupil diameter	20.95 mm
Field-of-view	±30 mrad
Input optics	Off-axis parabolic mirror (f=300mm)
Output optics	Off-axis parabolic mirror (f=150mm) + Winston cone concentrator 1.4 mm output diameter
Beam Splitter	Photolithographic Au grids (0.7µm wide, 2.5µm pitch) on 2.5µm mylar
Detectors	2 DLATGS pyroelectrics, 2mm diam.
Reference laser	Single-mode laser diode, λ=780 nm, temperature stabilised
Power	75 W
Weight	55 Kg (including electronics)
Dimensions	Optics Module: 500x615mm^2, height = 256mm Electronics: 220x220x360mm^3



REFIR/BreanBoard PDU-Pyroeledric Detector Unit, BSU-Beam Splitter Unit, RLS-Reference Laser System, HBB-Hot Black Body, CBB-Cold Black Body, RBB



REFIR/Balloon Schematic of the REFIR optics module in the balloon-borne configuration.

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Project info
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