Panchromatic Fourier Transform Spectrometer (PanFTS)

Overview

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Jet Propulsion Laboratory, California Institute of Technology

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Panspectral Measurements Improve Retrievals

Panspectral (UV → IR) enables:

- Retrievals of multiple chemical families:
  - $\text{O}_2$, $\text{O}_3$, $\text{O}_4$, $\text{H}_2\text{O}$, $\text{HDO}$
  - $\text{NO}_2$, $\text{NH}_3$, $\text{N}_2\text{O}$
  - $\text{CO}$, $\text{CO}_2$, $\text{HCHO}$, $\text{CH}_4$, $\text{CH}_3\text{OH}$, $(\text{CHO})_2$
  - $\text{SO}_2$, $\text{BrO}$, AOD, SSA, AAOD, Temp.

- Passive vertical profiling:
  - $\text{O}_3$ uncertainties

TES+OMI joint retrieval (D. Fu)

PanFTS has the measurement capabilities of several satellite instruments combined

Wide spectral coverage and high spectral resolution enables tropospheric profiling of multiple species with boundary layer visibility
From geostationary orbit PanFTS can map all of North and South America hourly with high resolution measurements (temporal, spatial, and spectral) that capture rapidly evolving tropospheric chemistry with planetary boundary layer sensitivity.
PanFTS Instrument Concept Overview:

Notional Flight Instrument and Subsystem Heritage

- Modular instrument design options:
  - UV-Vis only (0.28-0.76 microns)
  - Thermal IR only (8-15 microns)
  - UV-Vis-IR (0.28-15 microns)
PanFTS IR + Vis Interferometer Breadboard

- Infrared focal plane array
- UV-Vis focal plane array
- Optical path difference mechanism (OPDM) with dynamic alignment
Near-IR image of tungsten lamp filament imaged through PanFTS interferometer: high resolution spectra of atmospheric water vapor.

High resolution spectrum from each pixel

4x4 sub-image

Successful acquisition of a hyperspectral image is equivalent to a scene captured by PanFTS from geo when viewing reflected sunlight and thermal emission from Earth’s atmosphere.
Simultaneous IR and Visible Spectra of NO$_2$ Using PanFTS Breadboard

PanFTS

HITRAN

PanFTS Visible NO$_2$ Spectrum
• 128 x 128 Readout Integrated Circuit (ROIC) – designed by JPL
• Charge integration, digitizer located within each pixel
• High resolution (14 bits), Fast snapshot readout (16 kHz frame rate)
• Can be adapted for UV-Vis (silicon) or IR (HgCdTe) applications
JPL In-Pixel Digitization ROIC Demo

Fourier Transform UV Spectrometer (FTUVS) at the JPL Table Mountain Facility (TMF)

Solar disk imaged through FTUVS

Interferogram from each pixel

Atmospheric Oxygen (A band) Absorption – 760 nm

Fourier transform
A single OPDM controls the optical path difference on both sides of the interferometer.

The friction-free flexure-based parallelogram design has no inherent wear out risks.

Three flight size OPDMs have been built (lab unit, life test unit, and field test unit).

- Flexure pivots (8)
- Plano mirror on UV-Vis side of interferometer
- Piezo-driven tip/tilt stage provides dynamic alignment
- Linear voice coil (non-contact) actuator
- Optical (non-contact) position encoder
OPDM #2 is in Cryo-Vacuum Life Testing

- One year of accelerated life testing at -100 °C. → > 2 million cycles
- OPDM will be at TRL 6 at conclusion of life test
Demonstration of PanFTS Core Capabilities:
Lab - Field - Environmental Test

OPDM life test in flight-like conditions

Laboratory and field demonstration of simultaneous UV-Vis-IR measurement capability

Demonstration of advanced focal plane arrays with on-chip analog-to-digital converters for each pixel

California Laboratory for Atmospheric Remote Sensing

FIELD DEMONSTRATION AT JPL CLARS FACILITY (Mt. Wilson)
NASA has recently funded the development of a PanFTS EM IIP.

The PanFTS EM will be built with flight like optics, optical bench, metrology and alignment system.

The PanFTS EM will cover the spectral range of the flight design (0.28 µm to 15 µm).

The PanFTS EM performance will be demonstrated in a thermal-vacuum chamber under flight-like conditions.

The PanFTS EM will achieve Technology Readiness Level 6 (functional demonstration in a flight-like environment).
PanFTS IIP-07 has successfully demonstrated:

- Simultaneous acquisition of high resolution NO$_2$ spectra in Visible and IR bands.
- Successful development of advanced 128x128 digital focal plane arrays for imaging spectroscopy with in-pixel readouts.
- Robust cryogenic optical path difference mechanism currently in life test at -100 °C.
- Atmospheric field tests at JPL Mt. Wilson CLARS facility to begin in June.

A PanFTS EM will be developed over the next three years and ultimately demonstrate functional performance in a flight-like environment (TRL 6)

A PanFTS flight instrument could be ready by 2016 (depending on funding)