The Compact Imager and Radiometer (CIIR)

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Recent Infrared Space Instruments in Oxford

- **Composite InfraRed Spectrometer (CIRS) on Cassini**
  - Designed and built focal plane assembly (FPA) and radiative cooler

- **Mars Climate Orbiter** (lost in orbit insertion)
  - Transmissive optics and detector, supply, calibration, and test for Pressure Modulated Infrared Radiometer (PMIRR)

- **Mars Climate Sounder (MCS) on the Mars Reconnaissance Orbiter**, and the **Lunar Diviner Radiometer Experiment** on the **Lunar Reconnaissance Orbiter**, both built by JPL.
  - Supplied filter arrays with Reading

- **Compact Modular Sounder (CMS) on TechDemoSat**
  - Designed, integrated, calibrated, and qualified by Oxford and RAL
Example Science from Thermal Infrared Measurements

The Diviner Lunar Radiometer Experiment, built by JPL

- Christiansen feature measurement (ch 3,4,5)  
  -> mapping of silicate mineralogy

- Surface temperature measurement (ch 6,7,8,9)  
  -> Temperature maps
Example Science from Thermal Infrared Measurements

Compositional maps produced from Diviner data:

- Significant data on the origin and evolution of the Moon

Physical properties retrieved from Diviner temperature maps:

- Thermal Inertia
- Rock Abundance
- Albedo
- etc.
Thermal Infrared Measurements of Asteroids

Compositional:

- Selection of spectral bands in the infrared from known spectral features
- Band differences of 1-3% distinguish different meteoritic compositions
- Compositional analysis assists asteroid formation and evolution theories, meteorite classifications, and space weathering models.

Lab Spectra of Pure Minerals and Example Radiometer Bands – *K. Donaldson Hanna*
Thermal Infrared Measurements of Asteroids

Physical Properties:
- Broadband imaging gives temperature maps
- Mapping over many orbits gives temporally resolved temperature distributions

Derived from maps:
- Thermal Inertia & rock abundance
- Porosity
- Surface roughness
- Temperature gradient
- Albedo
- Yarkovsky & Yorp effects

Didymos model equatorial temperature

Didymoon model temperature map – M. Delbo OCA (Nice, Observatory d’Azur).
Precursor to CIIR, the Compact Modular Sounder (CMS)

- Flew on TechDemoSat (2014)
- Multichannel mapping radiometer
- Onboard blackbody calibration
- Electronics from RAL Space
- Low power (<10 W)
- Low Mass (<4 kg)

Room for improvement:

- Detector resolution (32 x 32 array)
- Volume (380 x 335 x 185 mm)
- Mirror drive mechanism (backlash)
The Compact Infrared Imager and Radiometer (CIIR)

Layout:

- Total 6U (Instrument ~ 4U)
- Layout due to scan mirror and blackbody
- All reflective optics to maximise signal
CIIR Optics and Filters

Optics
- Reflective to maximise signal
- On-axis Cassegrain input
  - As large as practical, 60mm aperture
  - Intermediate filter focal plane
- Off axis relay
  - TMA design from CMS
  - Detector focal plane f#1.7

Filters
- Reading supplied filters
- HIRDLS, MCS, Diviner heritage
- Reduced impact on detector due to optics
CIIR Detector Array

Detector:
- ULIS 17 μm pitch microbolometer array
  - 1024 x 768 pixels.
  - Pixel averaging to increase SNR
- 7-15μm response
- iFOV 180μrad (1.8m @ 10km)
- Passively cooled to -40°C
- Power consumption < 170 mW
In Flight Calibration

- Blackbody based on CMS design
- Shortened for CubeSat volume requirements
- V grooved design
- Allowed to drift with precise temperature measurement
- <0.5K accuracy promising from CMS data

Error in effective temperature versus baffle length for a 2K baffle temperature error
Developing CIIR

Mission design report (2015) for Centre for Earth Observation Instrumentation, Space Technology (CEOI-ST)

- Earth observation based thermal mapping and atmospheric sounder review

- Assessed CIIR CubeSat with HIRDLS heritage filters

- Two areas highlighted for further study under CEOI grant
  - Pointing performance and stability
  - Radiometric calibration stability

Calibration stability test bed using CMS optics
Thanks for listening

With thanks to the CIIR Consortium

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