The Asteroid Thermal Mapping Spectrometer: An Imaging Mid-IR Spectrometer for the Marco Polo–R NEO Sample Return Cosmic Vision Candidate Mission. N. E. Bowles[1], S. Calcutt[1], F. Reininger[2] , [1]bowles@atm.ox.ac.uk, Atmospheric Oceanic and Planetary Physics, Department of Physics, University of Oxford, Parks Road, Oxford, UK, [2]Spectral Imaging Laboratory 1785 Locust St #10, Pasadena CA 91106, USA

Introduction: The Marco Polo-R Near Earth Object (NEO) sample return mission [1] has been selected for further study as part of ESA's on-going Cosmic Vision mission planning exercise [2]. The mission's primary aim is "*To return a sample from a Near-Earth Object belonging to a primitive class to the Earth"* [3].

A multi-spectral, mid-infrared imaging instrument is essential to the Marco Polo-R remote sensing payload [3]. It will provide key information on the nature of the surface by measuring its diurnal thermal response (thermal inertia) and mineralogy, essential to selecting sampling sites compatible with the Marco Polo-R sample acquisition system.

We describe the Asteroid Thermal Mapping Spectrometer (ATMS) Development Model designed at the Spectral Imaging Laboratory (SPILAB) and currently under test at the University of Oxford. The ATMS is a compact Fourier transform spectrometer that fully meets the requirements of the Marco Polo-R mid-IR instrument [3]. The ATMS uses a fixed set of beam splitters and Fourier optics rather than a traditional moving mirror design to generate an interferogram on a two dimensional detector array. The resulting instrument is compact (<5kg), robust (no moving parts except a scan/calibration mirror assembly) and has adequate spectral resolution (3-20 cm^{-1}) and spectral range (5-25 µm, 400-2000 cm^{-1}) depending on detector array used.

Instrument Description: The Development Model instrument (Figure 1) is the latest in a series of interferometers designed by F. Reininger of SPILAB, breadboarded at SPILAB and JPL (e.g. [4]). The instrument uses a mid-infrared beam splitter and all reflective optics to image the interferogram on to a 640x480 micro-bolometer array, rather than using a traditional moving mirror arrangement. The mirrors are fabricated from aluminium alloy and are incorporated into their mounts. The mirrors incorporate high quality replicated surfaces which have been shown to be undamaged by radiation doses of 3Mrad. The development model instrument uses a coated KBr beam splitter. The ATMS approach gives flexible operating modes, with a programmable resolution and extremely efficient light utilization.

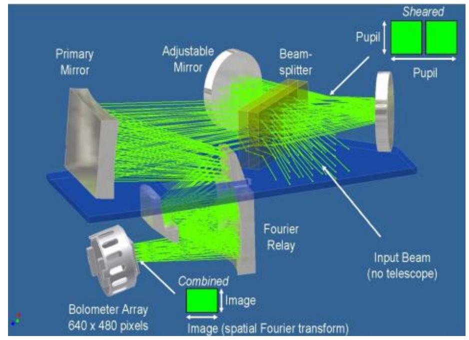

Figure 1. *The ATMS Warm Detector Array Devlopment model optical layout. The base instrument dimensions are approximately 160 x 220 x 370 mm^3.*

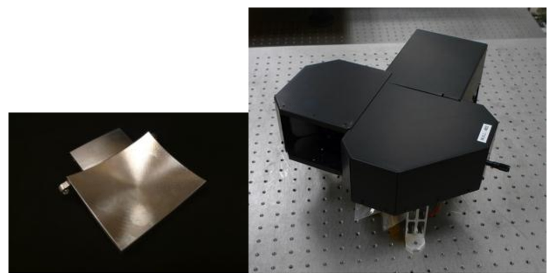

Figure 2. *An example mirror blank prior to replication (left). The ATMS Development model under test at the University of Oxford (right).*

Why a spectrometer? A spectrometer is necessary to meet the science goals described in [3]. Although individual mineral absorption features are relatively broad, higher resolution allows better interpretation of overlapping bands and the opportunity to use the instrument to survey for unknown constituents (since the bulk of our current knowledge is *almost* entirely based on disc averaged spectra). The spectral information may allow improved constraints on particle size distributions to be determined and provide additional science opportunities during any interplanetary cruise phase (e.g. Venus gravity assists).

Current Testing Program. The development model is currently under test at the University of Oxford using a variety of uncooled bolometer arrays based on both vandium oxide and amorphous silicon technologies.

References: [1] Barucci M. A. et al. Exp Astron 2011 DOI: DOI: 10.1007/s10686-011-9231-8. [2] Cosmic Vision Brochure BR-247, 2005. [3] Marco Polo-R Science Requirements (MP-RSSD-RS-001), 2011. [4] Reininger F. M. Infrared Physics and Technology 42 (2001) 345-362.

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