**GROUND-BASED INFRARED SPECTROSCOPY OF MERCURY'S NEAR-GLOBAL SURFACE WITH IRTF/SPEX: COMPLEMENTING MESSENGER COMPOSITIONAL OBSERVATIONS.** J. Warell[1], R.W. Kozlowski[2], A.L. Sprague[3], J. Helbert[4], A. Önehag[1], G. Trout[2], D. Rothery[5], [1]Dept. of Physics and Astronomy, Uppsala University (Box 515, SE-751 20 Uppsala, Sweden, johan.warell@fysast.uu.se), [2]Susquehanna University, Selinsgrove, PA, USA, [3]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA, [4]DLR Institute for Planetary Research, Berlin, Germany, [5]Open University, Milton Keynes, UK.

**Introduction:** The compositionally discriminative wavelength region 1-6 μm is observationally a largely neglected range for Mercury. While the NASA MESSENGER mission's [1] MASCS instrument [2] obtains spectra from 0.3 to 1.45 μm, only a few up to 2.5 μm [3, 4] and further to about 6 μm [4, 5] have been published. To remedy this situation, and to complement and extend close-range MESSENGER spectroscopic studies, we have largely completed the observational part of an extensive spectroscopic study of Mercury. Using the SpeX medium-resolution spectrograph [6] at the NASA Infrared Telescope Facility (IRTF) on Mauna Kea, Hawaii, we have obtained disk-resolved spectra of a near-global part of Mercury's surface as well as lunar sites in the wavelength range 0.8-5.5 μm. This data set will be analyzed with the same Hapke radiative transfer-based photometric model as applied to MASCS spectra from the first flyby [7] for comparison of results, extended search for infrared spectral features, and determination of material properties from the thermal emission spectrum.

**Background:** To understand planetary formation in our own and other solar systems it is critical to know the surface composition of Mercury, the inner planetary end-member of our system. The specific minerals and rock types present, as well as their abundances and geologic distributions, can be used to infer the type of crust, thermal and geologic history, composition of mantle magma source regions, bulk composition, and ultimately the mode of formation of the planet.

**Previous results:** As Mariner 10 lacked spectroscopic capacity, information on its surface composition has largely been derived from ground-based observations. Reflectance spectroscopy from 0.4 - 1.0 μm [cf. 8] indicates low or no FeO (likely <2 wt%) on average. Using the expanded spectral range of SpeX (0.8 - 5.2 μm) the results are the same only with a much higher S/N [4]. Thermal infrared spectroscopy indicates that Mercury's surface composition is definitely heterogeneous in composition, composed of low- to no-iron pyroxene and intermediate to feldspathic rock types with spotty regions of ultramafic make-up [9-12]. These results on Mercury's surface composition are corroborated by MESSENGER MDIS imagery and MASCS spectroscopy obtained at the first flyby [13, 14]. Of particular interest is the fact that MASCS did not detect any sign of FeO in its extended equatorial scan across a range of geologic units, stressing the need for complementary wavelength observations extending into the IR to search of absorption features.

**Motivation:** Spectra of airless silicate bodies in the SpeX wavelength range contain features diagnostic of surface composition. For Mercury, particularly interesting features include 1) reflectance absorptions due to the $Fe^{2+}$ electronic transfer in mafic silicates near 0.9 and 2.0 μm, 2) the anomalous 5 μm flux excess found by [9], and 3) volume scattering emission features between 2.8 and 5.5 μm, particularly important for an iron-poor lithology. The data from our five SpeX runs consitutes a global disk-resolved IR spectroscopic survey of Mercury's surface such that comparison with and extension of MESSENGER spectroscopy will be possible for basically the global planet. The results will be contrasted and put into relation to the findings obtained from the MASCS instrument which will perform a detailed global spectroscopic survey from orbit. Since its wavelength range only extends up to 1.45 µm, MASCS does indeed cover the range around 1.0 µm where electronic crystal field transitions in FeO rich ferrous silicates occur as evidenced by a prominent absorption band, but misses the discriminative 2.0 µm band which is present in some pyroxenes but not in others, and not in olivine. Discrimination of these minerals is critical to understand Mercury's thermal and geologic history. Also, MASCS misses any volume scattering bands which may occur at wavelengths up to 5.5 µm which are discriminative of the composition, as well as the infrared excess near 5 µm which is an important indicator of the development of regolith surface gradients and grain size [9, 15].

**Thermal properties vs. composition:** As Fig. 1 illustrates, the September and October 2008 elongations of Mercury in combination presented an important and interesting opportunity to study the magnitude of the infrared excess, the shape of the emittance spectrum, the depth of the volume scattering bands in emittance, and the depth of absorption bands in reflectance, as a function of surface temperature. Such a study is possible as the same surface features, and thus constant compositions, are visible at the two runs at similar phase angles, but illuminated in inverted illumination geometries. Thus, features at the bright limb, close to the hot (470 K) daytime surface with the Sun near zenith at aphelion in September were close to the terminator (local evening, 470 K) in October (white dots). Similarly, features at the bright limb, close to the hot (710 K) daytime surface with the Sun near zenith at perihelion in October were close to the terminator (local morning, 350 K) in September (black). Locations illustrated in gray have less extreme temperature variations.

**Observations:** At the time of writing, four observing runs have been successfully completed on site, while a final fifth run in February 2009 will be carried out remotely. These are all four days long, and centered at phase angles slightly greater than 90 degrees: 8-11 May, 5-8 Jul, 3-6 Sep, 24-27 Oct 2008 and 21-24 Feb 2009. All targets (Mercury's resolved disk, Petavius central peak and Mersenius C validation sites on the Moon, solar analogs and thermal infrared standard stars) are observed through a 0.3" slit in the low-resolution LR15 mode at R=250 (0.8-2.5 µm), the SXD2.3 mode at R=2000 (0.8-2.5 µm), and LXD mode at R=2500 (2.4-5.5 µm). Using both LR15 and SXD modes takes specific advantage of each for redundancy, calibration, validation, and full coverage of illuminated surface: the full-wavelength, single-order, coverage in LR15, versus higher-resolved, multi-order and non-saturated central-disk spectra in SXD.

The spectrograph plate scale of 0.15"/pixel and a disk diameter of around 7" at the major elongations selected corresponds to ~40 pixels across the illuminated disk. The best seeing encountered is about 0.7" at full-width half-maximum, which allows disk-resolved data to be obtained by placing the slit at several adjacent positions across the disk.

**Conclusion and future work:** The data are now being reduced with SpexTools [16] and will then be analyzed according to the model of [7]. Of primary interest is a specific search, in a spatially resolved manner, for the 1.0 µm and 2.0 µm reflectance absorption bands caused by the $Fe^{2+}$ electronic transfer in crystalline mafic minerals, and volume scattering absorptions indicative of the presence of surface silicates in the 3 – 6 µm region. This will be done for both the primary target Mercury, and the secondary target, the Moon. We will specifically target locations found to be of specific interest at the MESSENGER flybys, particularly potentially immature and crystal-rich ray crater ejecta and spatially more homogeneous smooth plains, two types of geologic units which may show the largest differences in composition and type of crust.

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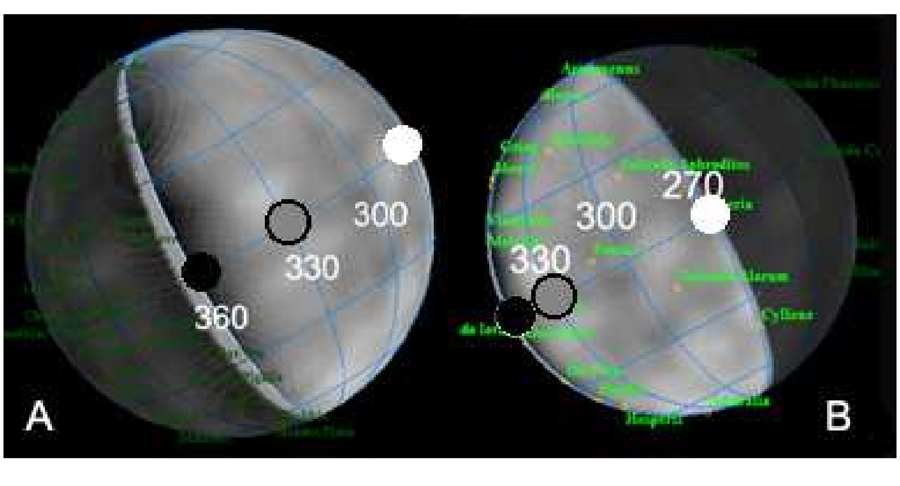


Fig. 1. The elongations centered on Sep. 4 (A) and Oct. 25 (B), 2008, offered an interesting opportunity to study the thermal properties of Mercury's surface, as the solar illumination geometry at the two elongations was inverted. Dots of same shades illustrate disk locations of the same equatorial surface sites, which are observed at a wide range of local time and surface temperature. See text for details.