MID-INFRARED SPECTROSCOPY OF MERCURY FROM THE KUIPER AIRBORNE OBSERVATORY. A.L. Sprague[1], F.C. Witteborn[2], R.W.H. Kozlowski[3] and D.H. Wooden[2]: [1] LPL, U. of Arizona; [2]NASA ARC, [3]Susquehanna U.

We present mid-infrared (5 - 10 μm) spectroscopic measurements of the planet Mercury obtained from the Kuiper Airborne Observatory (KAO) using the High Efficiency Infrared Faint Object Grating Spectrograph (HIFOGS). Spectra show features characteristic of plagioclase feldspar that was previously observed near 120° mercurian longitude [1]. The spectra also show spectral features that could be interpreted indicative of the presence of pyrrhotite ($Fe_{1-x}S$). An analysis that fully accounts for the effects of large field of view (FOV), thermal gradients, rough surface and absolute calibration is still underway.

These are the first spectra ever obtained from Mercury's surface in the 5 - 7.5 μm region inaccessible to ground-based instrumentation. Bands in the 4 - 7 μm region are mostly overtones and combination tones of the stretching and bending of Si-O and Al-O fundamentals with some lattice modes present. Spectral features are characteristic of photon interactions with the material in the 'transition region' where absorption bands show up as troughs in reflectance and peaks in emission. Subtle features can help differentiate between types of silicates, ilmenite, sulfides, and elemental sulfur. The 7 - 9.5 μm region is largely dominated by surface scattering except at the Christiansen frequency (CF) which also falls in this region. The wavelength of this emission maximum is highly diagnostic of bulk rock time and chemical composition of minerals. The strong reststrahlen bands (RB) of most silicates fall in the 8 - 12 μm region. These bands, appearing as minima and maxima in the emitted radiance from Mercury will not be discussed here.

The analysis of these data has focused our attention on the effects of thermal gradients, rough surface, field-of-view and stellar calibration. We note that these effects have not previously been thoroughly accounted for in the interpretation of most lunar mid-infrared spectroscopic measurements.

Our KAO data show a smoother spectral character than our ground-based measurements because we were above the Earth's tropopause and thus most of telluric water vapor and because of the larger the larger field-of-view (FOV). On board the KAO we observed the entire Earth-facing disk of the planet which results in the blending of many thermal gradients and mixes several compositions, if they are present. The effects of this blending is to lower the relative fluctuations in spectral emissivity. Generally, the spectral features described above are strongest when emanating from hot solid, rocky surfaces and from fine powdered and glassy surfaces with steep positive (hotter, deeper) thermal gradients [2] in the top hundred microns or so of the surface. Lack of, or mixing of many thermal gradients subdues spectral features and makes the spectrum appear smoother, as does a significant layer of fine particles covering crystalline or glassy fragments (Sprague, Kozlowski, Witteborn and Wooden, work in progress: our rocks and powders at Mt. Lemmon).

Another effect of thermal gradients in the upper layer of regolith materials can have the apparent effect of a shift in the emissivity maximum with a steep positive gradient shifting maxima to shorter wavelengths [2]. This is an obvious effect and is well known in atmospheric remote sensing where established techniques rely on the ability to probe to greater depths and higher temperatures under the conditions of a steep positive thermal gradient and decreasing extinction coefficient. For solid surfaces the extinction coefficient decreases on the short wavelength side of the the reflectance minimum (or emission maximum).

Mercury was viewed near 21° angular separation from the sun during both flights. The physical parameters for the observations at both elongations (May 8, E 21 and July 6, W 21) are given below in Table I. The primary mirror was covered with a black plate to prevent sunlight from scattering off the primary into the telescope and spectrograph. Mercury was viewed with the portion of the primary that is shaded by the fuselage.

Table I. Physical Parameters for Mercury Observations: 1995

	May 8	July 6
Elongation (deg.)	E 21	W 21
RA	4 22	5 29
Dec	+24 06	21 13
Distance (heliocentric)	0.3611955	0.3595302
Diameter (arcsec)	7.24	8.1
fraction ill.	0.482	0.531
phase angle (deg.)	92.1	86.5
sub-Earth lat. (deg.)	-0.2	6.0
sub-Earth long. (deg.)	99.2	86.9
sub-solar lat. (deg.)	0.0	-0.0
sub-solar long. (deg.)	7.2	173.25
longitude of measurement (deg.)	20 - 40	120 - 150

Results from a variety of ground-based measurements of Mercury have been taken together as support for the presence of a significant inventory of sulfur in the surface materials and in the atmosphere [3]. These are highly radar-reflective regions at the north and south poles of Mercury [4,5], low microwave opacity of the Mercurian regolith [6], the Na and K atmosphere [7,8,9], the index of refraction derived from disk-integrated photometry [10], low FeO absorption in near-infrared spectra [11], and the indication in mid-infrared spectra of a plagioclase-rich regolith at Mercury [1,12]. Sprague *et al.* [3] suggest that elemental sulfur is cold-trapped at the poles and is the primary substance causing the bright radar backscatter signature previously attributed to water ice. Sprague *et al.* [3] also suggest that the cause of the high index of refraction of regolith materials is Fe-bearing sulfides such as pyrrhotite ($Fe_{1-x}S$), daubreelite ($FeCr_2S_4$), alabandite ((Mn,Fe)S), sphalerite (Zn,Fe)S and oldhamite (CaS) mixed with impact generated silicate (feldspathic) glasses.

Any Mercury formation model must be able to explain the several recent observations of Mercury's surface and atmosphere mentioned above, and also the exceptionally high density of Mercury. All the evidence points toward a planet with a thick feldspar crust and absence of FeO-rich basaltic magma events that would have vented heat out from the interior [13]. It is suggested [9] that the high abundance of atmospheric potassium (K) they observed at Mercury may be related to Caloris Basin and the antipode through increased outgassing of K from subsurface materials. All of these considerations strongly motivate mid-infrared surface studies of Mercury.

[1] Sprague, A., R.Kozlowski, F. Witteborn, D. Cruikshank, and D. Wooden (1994) *Icarus,* **109**, 156-167. [2] Henderson and Jakosky. DPS Abstracts, (1995) p 62, 21.04. [3] Sprague, A., D. Hunten, and K. Lodders (1995) *Icarus,* **118**, 211-215. [4] Butler, B., Muhleman, D., and Slade, M. (1993) *J. Geophys. Res., Planets*, **98**, 15,003 - 15,023. [5]Slade, M., Butler, B. and Muhleman D. (1993) *Science,* **258**, 635 - 640. [6] Mitchell, D. and dePater, I. (1994) *Icarus,* 110, 2 - 32. [7]Potter and Morgan. (1995) *Science,* **229**, 651-653. [8]Potter and Morgan. (1996) *Icarus,* **67**, 336-340. [9] Sprague, A., R. Kozlowski, and D. Hunten. (1990) *Science,* **249**, 1140-1143. [10] Hapke, B. (1994) *Lunar and Planetary Science Conference Abs.*, XXV, 507. [11] Vilas, F., M.A. Leake and Mendell, W.W. (1984) *Icarus,* **59**, 60-68. [12] Tyler (Sprague), A., Kozlowski, R. and L. Lebofsky. (1988) *Geophys. Res. Letters,* **15**, 8, 808 - 811. [13] Jeanloz, R., Mitchell, D., Sprague, A. and I. de Pater. (1995) *Science,* **268**, 1455-1457.