EPSC Abstracts
Vol. 5, EPSC2010-752, 2010
European Planetary Science Congress 2010

Mercury resolved spectroscopy from NTT

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Abstract

Mercury has been observed in June 2006 with the SOFI instrument at NTT. Resolved spectroscopy was performed in the 0.95-2.5 μm range. The observations were acquired close to a favorable quadrature with maximum elongation.
In contrast to recent observations from IRTF, the present study does not indicate any pyroxene absorption in the NIR, neither in the 2 μm region nor at 1 μm. Detailed spectral analysis allows to derive an upper limit of 1.5% type-A pyroxenes in the regions observed, at the 700 km scale.

Observations

Mercury was observed at NTT in June 2006. Resolved spectroscopy was performed using the SOFI instrument by scanning the disk with the slit. The observations were acquired close to a favorable quadrature with maximum elongation, so as to get an optimal trade-off between observing time, disk size, and illuminated fraction.

The choice of the telescope is related to the minimum altitude allowed, which is particularly low at NTT (13°), therefore permitting the longest observation time on Mercury (with the exception of the IRTF which can perform daytime observations). SOFI is the infrared spectrograph and imaging camera installed on the NTT. It is used here in its long slit spectroscopy mode with 0.6" slit width. This mode is used with the two grisms (respectively "blue" and "red"), which together encompass the near-IR range from 0.9 to 2.5 μm with resolving power ~900.

The data consist in spectral cubes of 30 samples × 7 lines straddling the day and night sides. This provides a spatial resolution of ~700 km at the disk center, limited by the seeing. The observable area of Mercury, both visible and illuminated, ranges from Homer to Beethoven (from limb to terminator), with the sub-Earth point located at 233°E, 5°N, in the night side close to the terminator (Fig.1).

The usual calibration procedure was followed, with particular care for sky background removal. In addition, telluric absorptions were corrected using atmospheric modeling under very large airmass (4 - 4.8), to allow refined spectral studies. The signal to noise ratio is always larger than 30, and can be greatly improved by binning spectral channels with no loss of information.

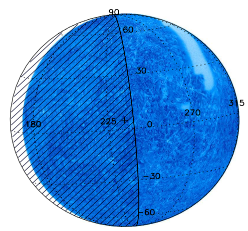

Figure 1: Configuration of SOFI observations, with Mariner 10 shaded surface map overplotted. Longitudes are given in eastern convention. The terminator is showed near the disk center, the night side is hatched. The disk size is 7.5".

Results at short wavelengths

In contrast to recent observations from IRTF [1] [2], the present study does not indicate any pyroxene absorption in the NIR, neither in the 2 μm region nor at 1 μm.

The main variations observed on spectral ratios are related to the spectral slope, especially in the blue range. In each scanning row, spectra acquired along the slit exhibit spectral slope variations at short wavelengths, as expected from differential refraction. The overall variation in shape encompasses the same range as spectra reported by [1]. Hoverever, multivariate analysis does not point out any relationship between slope variations and increasing absorption at 1.1 μm, as suggested by [2] (Fig. 2). A detailed spectral analysis allows to derive an upper limit of 1.5% type-A pyroxenes in the regions observed, at the 700 km scale.

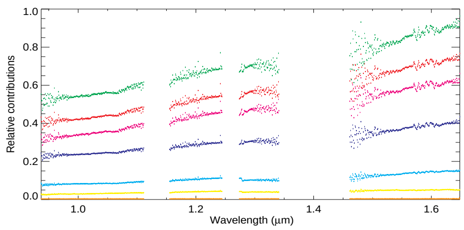

Figure 2: Indepedent components retrieved from integrated spectra. The main variations are related to spectral slope and dispersion in noisy channels and telluric bands. The components are scaled according to their relative contributions to the signal.

Spectral modeling & inversion

The observation are also compared to a simple radiance model of Mercury intended to provide a reference under various viewing geometries and configurations. This model has been originally setup to prepare observations of VIHI, the imaging spectroscopy channel of the SIMBIO-SYS instrument on-board BepiColombo, and encompasses the 0.4-2.5 μm range at 3.1 nm resolution.

The model is used here to simulate the radiance of Mercury in the conditions where the signal is maximum, namely under e=70°, i=33°, and phase=94° (or 11:00 local time at -30° latitude), for a Sun distance of 0.426 au. This leads to an estimated temperature of 593 K, and a radiance level of 10 W m-2 sr-1 μm-1 both at 1 and 5 μm. The SOFI data are scaled to the absolute flux provided by the model. Since the particularly large extinction in the Earth atmosphere makes it difficult to derive an absolute calibration of the data, normalizing to the modeled flux is expected to be more accurate.

The scaled radiance is then inverted with the same photometric model, allowing to retrieve both the spectral reflectance and the temperature. The retrieved surface temperature mostly depends on the measured spectral shape above 1.8 μm and to a lesser extent on the assumed phase function (Lambertian vs Lommel-Seeliger model). The fitted temperatures are similar to those provided by the radiance model, ranging from 590 to 605 K for the first scans spanning the equatorial regions. The inverted reflectance spectra compare very well with previously published spectra up to 2.2 μm. After this removal of thermal emission, they do not exhibit any measurable absorption in the 2 μm region.

Conclusion

The SOFI observations do not confirm previously reported pyroxene absorptions at 1.1 μm observed from IRTF in other regions of Mercury. However, our spectra exhibit significant variegation in the short wavelength range, which could in some conditions be mistaken for surface features. The 2 μm range also appears to be free from absorptions, as previously reported.

Acknowledgements

Study based on observations collected at the European Southern Observatory, Chile, ESO No. 077.C-00569.

References

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[2] P. Vernazza, F. DeMeo, A. Nedelcu, M. Birlan, A. Doressoundiram, S. Erard, and E. Volquardsen. Resolved spectroscopy of Mercury in the near-IR with SpeX/IRTF. *Icarus*, in press, 2010.