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# Resolved ultraviolet surface reflectance spectroscopy of Mercury from MESSENGER

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## Abstract

The MESSENGER spacecraft successfully entered orbit around Mercury on March 18, 2011. Although no clear diagnostic absorption features were found from the surface reflectance spectra collected during the earlier Mercury flybys, an inflection in the middle-ultraviolet, not seen in spectra from the Moon, was identified. Ultraviolet spectra have now been acquired from several locations on the planet, and we search for and interpret any variability.

## 1. Introduction

The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft [1] was launched in 2004. During a cruise phase of more than 6 years, the onboard remote sensing instruments obtained observations of the Moon, Venus, and Mercury during gravity-assist encounters. MESSENGER observed that even in areas of Mercury's surface presumed to be comparatively unaltered by space weathering, a process that decreases the contrast of spectral absorptions, no clear indication of a feature attributable to ferrous iron within silicates was found [2, 3]. The absolute reflectance of Mercury was found to be comparable to that of the nearside of the Moon [2, 4], consistent with a previous finding [5]. Data from the Neutron Spectrometer suggested a component in the surface that is strongly neutron absorbing [6], supporting an interpretation that the surface is rich in iron-titanium oxide minerals but low in iron-bearing silicates [2, 7]. A disk-integrated spectrum of Mercury and one resolved spectrum in the middle ultraviolet (220-300 nm) were found to exhibit a positive slope steeper than that seen from a spectrum of the Moon acquired during the Earth flyby [3, 4]. This feature was interpreted as evidence of an electronic charge transfer between oxygen and a transition-metal cation, with its spectral position indicating a relatively low abundance of Fe or Ti. Because the Mercury surface is presumed to be highly space-weathered, the presence of such an absorption was surprising. The ultraviolet spectral region has been shown to be sensitive to both composition [8] and space weathering [9]. Spectral observations obtained by MESSENGER from orbit may thus provide insight into Mercury's origin and history.

## 2. Instrumentation

MESSENGER carries two optical remote sensing instruments: the Mercury Dual Imaging System (MDIS) and the Mercury Atmospheric and Surface Composition Spectrometer (MASCS). MDIS consists of two distinct channels: the Narrow-Angle Camera (NAC), which has a 1.5°×1.5° field of view and is panchromatic, and the Wide-Angle Camera (WAC), which has a 10.5°×10.5° field of view with 11 selectable spectral filters spanning the wavelength range 430–1020 nm [10]. MASCS also consists of two distinct channels that share a common telescope: the Visible and Infrared Spectrograph (VIRS) and the Ultraviolet and Visible Spectrometer (UVVS) [11]. VIRS samples a single spatial area within a 0.023° field of view in one integration period while spanning the wavelength range 320-1450 nm. Offset from the VIRS by 0.038°, the UVVS is a long-slit (1°×0.04°) point spectrometer designed primarily for measuring emissions from Mercury's tenuous atmosphere in the wavelength range 115-600 nm. Although the surface is too bright to observe at visible wavelengths, with a smaller entrance slit (0.05°×0.04°) the UVVS is able to acquire surface reflectance spectra in the wavelength range 115–320 nm.

## 3. Dataset

MESSENGER instruments began nominal science observations of Mercury and its environment about one week after orbit insertion. As of May 25, 2011,

over 450,000 spectra of the surface have been obtained by VIRS, each spanning the wavelength range 320–1450 nm. In addition, there are over 700 targeted observations of the surface by the UVVS. Although many of these ultraviolet measurements overlap because they were acquired for photometric studies, the UVVS has observed several distinct locations across the surface.

## 4. Analysis

The UVVS is a scanning-grating monochromator, so it observes only a single, narrow-wavelength passband during an integration period. A complete spectrum is acquired by stepping the diffraction grating to sample multiple wavelengths, which can take up to 12 s. During this time, the spacecraft must continuously reorient its attitude so that the same area of the surface is sampled at all wavelengths. For observations when the pointing was not held fixed, variations in albedo, composition, maturity, topography, and shadowing may contribute to structure in the spectrum. Due to the sensitive coupling of spectral shape, pointing drift, and surface morphology, high-spatial-resolution images from the NAC are being used to interpret the geometry of these observations. Figure 1 shows the footprint of the UVVS field of view for one observation of the surface. Multispectral images from the WAC and surface reflectance spectra from VIRS are being used to extend the interpretation of ultraviolet reflectance into the visible and near-infrared.

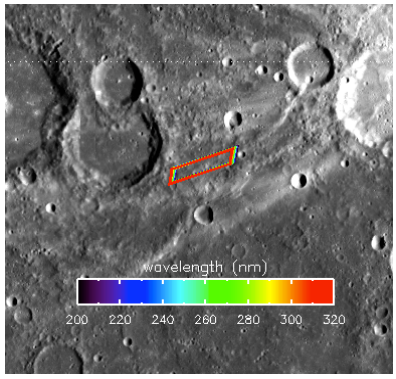


Figure 1: An example of the slight drift in pointing during the acquisition of a single ultraviolet spectrum by the UVVS. The polygons represent the intersection of the instrument field of view on the planet, and colors depict the sampled wavelength.

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