VENUS FACILITIES AT THE DLR PLANETARY SPECTROSCOPY LABORATORY (PSL) IN SUPPORT OF THE NASA VERITAS, ESA ENVISION AND NASA DAVINCI MISSIONS. J. Helbert[1], G. Alemanno[1], A. Maturilli[1], A. van Den Neucker, S. Adeli, and M.D. Dyar[2,3], [1]Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany (joern.helbert@dlr.de), [2]Dept. of Astronomy, Mount Holyoke College, South Hadley, MA 01075, [3]Planetary Science Institute, Tucson, AZ, 85719.

Introduction: All three recently selected Venus missions include instruments focused on the 1 µm region in their payloads [1]. The NASA VERITAS and ESA EnVision missions use the Venus Emissivity Mapper (VEM) as a multi-spectral imaging system [2, 3]. Building upon the successes of the Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) on Venus Express, VEM is specifically designed for global mapping of the surface in all available spectral windows. On EnVision, VEM is part of the VenSpec suite as VenSpec-M, joined by a high-resolution IR spectrometer (VenSpec-H) and an UV spectrometer (VenSpec-U). Data from the VenSpec suite will provide unique insights into the coupled surface-atmosphere system [3]. The DAVINCI mission has a descent imager that will also obtain images of the surface around 1 µm.

The Planetary Spectroscopy Laboratory (PSL): The PSL at DLR has been operating in support of planetary missions for almost two decades. Currently PSL operates three Bruker VERTEX 80V FTIR spectrometer with light sources, detectors, and beamsplitters available to cover the spectral range from 180nm to 300µm. A Bruker Hyperion 2000 microscope enables micro-spectroscopy in the visible and near-infrared. A Terra In-Xitu XRD system on loan from the ExoMars project is also temporarily available for sample characterization.

A number of sample preparation and analysis tools and experimental sub-systems are available to users of the facility, including sample holders for reflectance (plastic, aluminum or stainless steel) and emissivity (ceramic cups), various sets of sieves, grinders, mortars, saw, balances, microscope, a 20° to 300°C oven, ultra-pure water, wet chemistry materials, two ovens (30° to 3000°C) for sample treatments (one under high vacuum), a press to produce pellets (10 mm or 20 mm diameter), three large dry cabinets (moisture < 1%) for sample storage, three small desiccators (moisture < 20%) for sample storage, a rotating device for producing intimate mixtures, purge gas generator for water and CO_2 free air, liquid-nitrogen tank, an ultrasonic cleaning unit, two microscopes, and an air compressor pistol for cleaning.

Spectral measurement capabilities for Venus at PSL: To support the orbital remote sensing observations that will be obtained by VERITAS and EnVision, it is key to obtain emissivity spectra for Venus analog materials in the region from 800vnm to at least 1.2 µm at Venus surface temperatures. Bi-directional reflectance data that are typically available in other spectral libraries are not useful for calibration of emissivity measurements, even at high temperatures, because they do not sample all possible angles of incidence and reflectance [4].

However, hemispherical reflectance measurements (ideally) at high temperatures have been shown to be similar to emissivity [4] for most materials. Moreover, measurements performed by the VenDI (Venus Decent Imager) on the DAVINCI mission are best represented by hemispherical reflectance measurements due to the intense scattering of sunlight in the atmosphere of Venus.

Figure 1. The VEM prototype during measurements at PSL to verify the instrument performance using Venus analogs at Venus surface temperatures.

Venus Emissivity measurements at PSL: PSL can now regularly measure emissivity spectra of planetary analogues at temperatures up to 1000K in a vacuum (0.7 mbar) environment. Initially focusing on the MIR and TIR for Mars and Mercury mission support, the system has been fine-tuned over ten years to obtain VNIR emissivity spectra at relevant Venus surface temperatures (400°C, 440°C, and 480°C).

The Venus emissivity setup [5-7] is now in routine operation and available to the international community via the Europlanet Research Infrastructure as part of the Distributed Planetary Lab Facilities (https://www.europlanet-society.org/europlanet-2024-ri/ta2-dplf/) (see [2] for PSL details).

Hemispherical reflectance at PSL: PSL has two hemispherical reflectance units available that can be

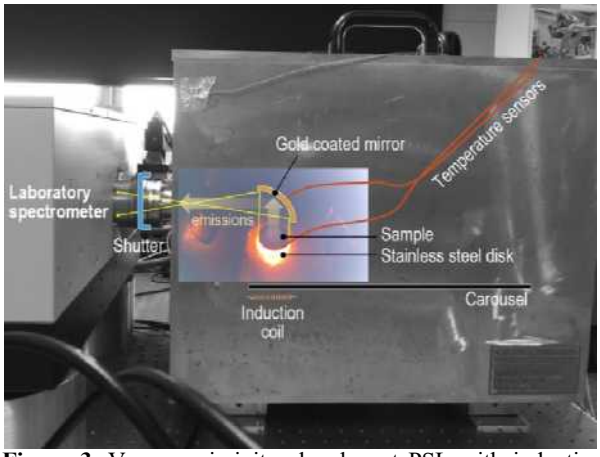

Figure 3. Venus emissivity chamber at PSL with induction heating system.

mounted in the internal chamber of the Bruker VERTEX 80V spectrometer. One unit is optimized for the visible spectral range, while the second unit is optimized for the infrared range. Both units have been modified at DLR to allow hemispherical reflectance measurements under vacuum. The comparison of measurements in hemispherical reflectance and emission spectroscopy for Venus analog materials is shown in [8].

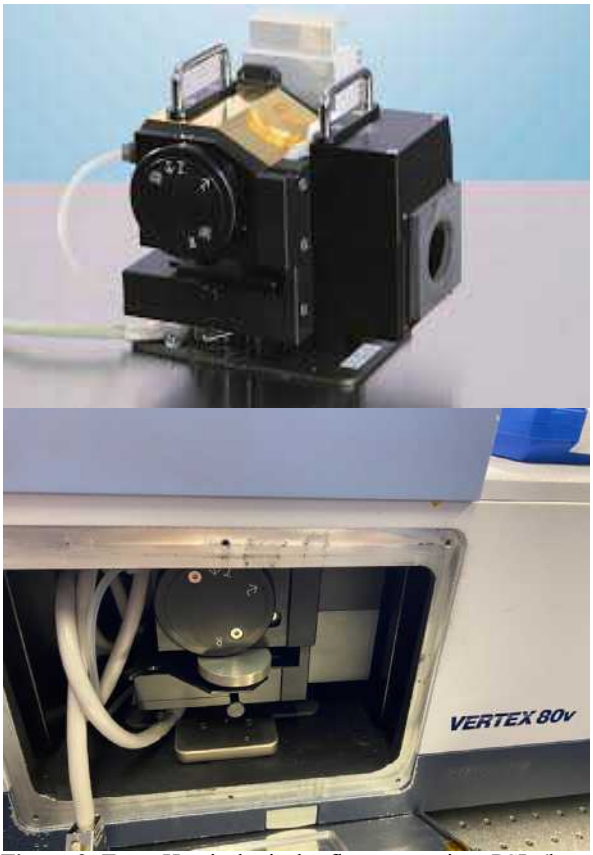

Figure 2. Top - Hemispherical reflectance unit at PSL (here version with gold coating for infrared measurements); Bottom – unit mounted inside the internal chamber of the VERTEX 80v (front panel removed for display purpose)

Rock type mapping for Venus: As part of the calibration and verification efforts for the Venus Emissivity Mapper (VEM) on VERITAS and the VenSpec-M channel on the EnVision mission, we have to date measured the emissivity of more than 100 rock samples at Venus surface temperatures [9]. For each sample, we also recorded the hemispherical reflectance at ambient temperature, in most cases before and after heating. These data will be used as the foundation for the basic and enhanced calibration datasets for the VERITAS and EnVision missions, and we expect to continue to build upon them in the coming decade.

Need for cross-calibration: Because the three Venus spectrometers were all proposed separately as part of distinct missions, no one could have anticipated the need to coordinate their calibrations. Moreover, the extent of an appropriate calibration suite and the necessity of using machine learning approaches to best interpret spectroscopy data were all unconstrained at the time of selection. However, it is essential to establish a good cross-calibration between the missions. Over the last year, team members from VERITAS, EnVision and DAVINCI have already used the Venus spectral facilities at DLR [10]. We plan to establish and foster collaboration among the three missions in the years to come, while making the Venus spectral database available to the whole Venus community. Such coordination will enable creation of consistent, cross-mission data products that support mapping of the surface composition and surface redox states.

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