THE THERMAL IMPACT OF THE SELF-HEATING EFFECT ON THE PERMANENTLY SHADOWED REGIONS OF MERCURY'S NORTH POLE CRATERS .

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Introduction: Earth-based radar observations revealed areas within Mercury's north polar regions with peculiar high radar backscatter [1,2]. The presence of this radar-bright material was interpreted as water ice within permanently shadowed regions (PSRs) because the radar characteristics resemble those observed for the Martian polar ice caps. [3] indicated that Mercury's polar environment is capable of hosting stable water-ice-deposits over geologic time-scales. Later, the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission has confirmed that these radar-bright materials are predominantly composed of water ice.

The detection, global mapping, and analysis of the composition of PSRs with an unprecedented high-resolution are among the primary scientific goals of the Spectrometer and IMagers for MPO Bepicolombo Integrated Observatory SYstem (SIMBIO-SYS) suite [4]. Understanding these features can provide key insight into the evolution and composition of Mercury's volatile polar deposits. However, interpretation of the highest-resolution images of Mercury's polar deposits is limited by the availability of illumination and thermal models. In fact, estimation of illumination conditions and calculation of the surface radiative intensity on the surface of Mercury are fundamental to study the effect of the insolation weathering affecting the PSRs. These areas can receive only scattered light, emitted thermal energy from the surrounding topography, and thermal energy from Mercury's interior. To obtain the surface and subsurface temperature distributions of an airless body, any thermophysical model which aims to consider realistic physical conditions such as topography, orbital elements, surface roughness, and thermophysical parameters (e.g., thermal inertia or thermal conductivity) needs to consider two illumination cases occurring on a surface: 1) the direct and 2) the scattered sunlight cases. In the first case, the surface is in daylight if the Sun is above the local horizon, while others are not illuminated if the Sun is below the local horizon. Afterwards, the inclusion of the multi-scattering in a thermal model allows to consider the formation of shadows and penumbra. In particular, in the case of Mercury, the solar disk cannot be approximated as a point source, and the back scattered light needs to be calculated. This allows also to quantify the self-heating effect, which results from the absorption of thermal radiation by elements of the topography from surrounding visible portions. As a result, the coldest facets can be heated by the hotter ones, increasing the total amount of insolation received by the surface.

In this work, we explore how temperature and volatile stability depend on the inclusion of the self-heating effect in the illumination and thermal model we develop.

Method and preliminary results: To investigate the role of the self-heating effect on the PSRs we developed a ray-tracing illumination and 3D thermal model. Calculations were performed by using local Digital Terrain Models (DTMs), generated by [5], of Mercury's north polar craters with a resolution of 125 m/px (see Fig.1). The crater DTM was used as input of the solar illumination model. The model is based on the ray-tracing technique and treated the Sun as a disk and not as a point source due to the proximity of Mercury to the Sun. This illumination model allows

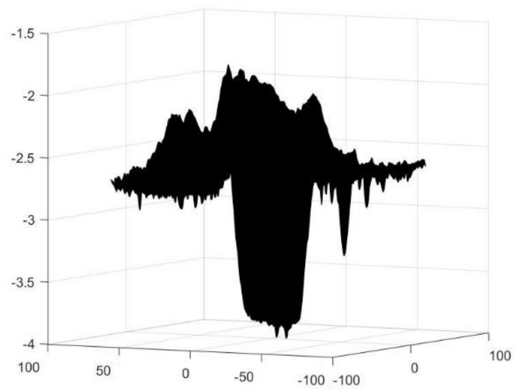
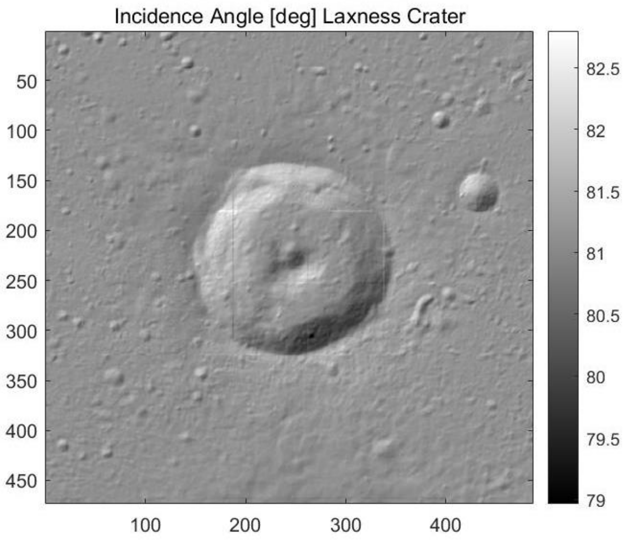


Fig.1 Digital Terrain Model of the Laxness crater. Units are km.

to trace solar rays to each point on the DTM evaluating the direct illumination throughout a Mercury solar day. To calculate the amount of direct insolation received from the Sun, the values for the incidence angles and the portion of the sun eclipsed by horizon are supplied by the NAIF SPICE toolkit. Meshes are then input into the 3D thermal model and the model is given an initial temperature based on latitude. The initial temperature is calculated by applying a 1D thermal model to the selected feature. We run the 3D thermal model until it has equilibrated. Then, the thermal model computes the surface temperature of each facet of the geometry as it evolves over time. The calculation of the temperature is calculated by balancing direct insolation, multiple scattering of visible and infrared radiation from other facets, infrared emission, and 1D subsurface heat conduction. The effect of terrain shadowing is included. The 3D thermal model output is finally input into the volatile transport model, which outputs volatile loss rates from the given geometry.



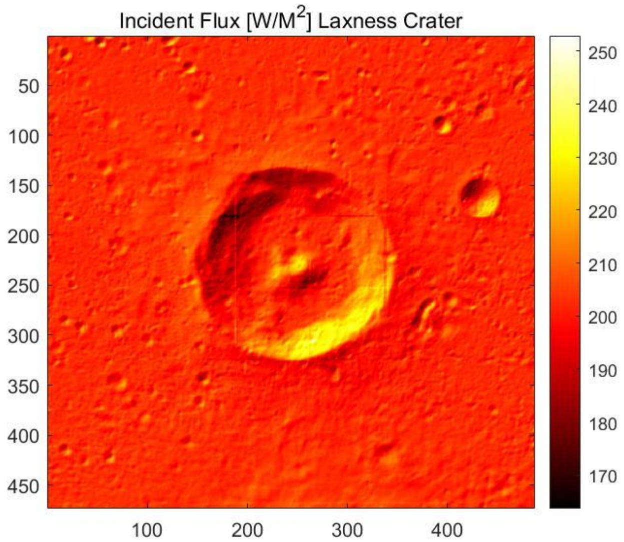


Fig.2. Incidence angle (top) and flux (bottom) maps of the Laxness crater.

This work focuses on two polar craters of Mercury, Laxness (83.27°N 50.04°W, diameter 27 km) and Fuller (82.63°N, 42.65°W, diameter 25.9 km), located in the northern part of the Goethe Basin. In Fig. 3 an example of the results is shown. For both craters we calculated the surface and sub-surface temperature including or excluding the contribution of the scattered light

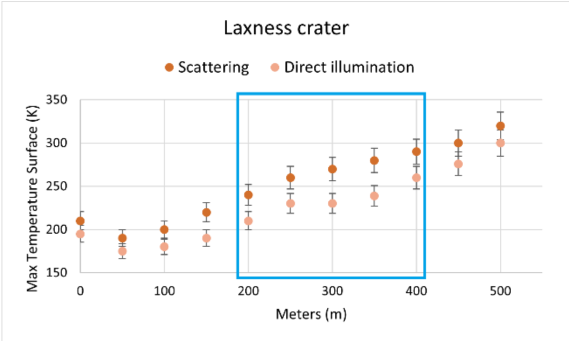


Fig.3. Maximum temperature surface (K) of the Laxness crater. Temperatures are calculated only considering the direct illumination (orange dots), or including the scattered light (pink dots). The blue square indicates the polar deposit boundaries. Zero on the x-axis refers to the center of the crater.

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