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SIMBIO-Sim: a performance simulator for the SIMBIO-SYS suite on board the BepiColombo mission

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Abstract

BepiColombo is the 5th cornerstone mission of the European Space Agency (ESA) dedicated to the study of the Mercury planet. The BepiColombo spacecraft houses two science modules: the Mercury Planetary Orbiter (MPO) realized by ESA and the Mercury Magnetospheric Orbiter (MMO) provided by the Japan Aerospace Agency (JAXA). The payload of the MPO is composed of 11 instruments; among these, there is the Spectrometer and Imagers for MPO BepiColombo Integrated Observatory System (SIMBIO-SYS). The SIMBIO-SYS suite includes three channels: a Stereoscopic Imaging Channel (STC), a High Resolution Imaging Channel (HRIC), and a Visible and near Infrared Hyper-spectral Imager (VIHI). The aim of this work is to describe the implementation and the features of a simulator developed to predict the performance of the three SIMBIO-SYS channels. This simulator (called SIMBIO-Sim) is also a powerful tool to aid planning the acquisition sequences during the entire BepiColombo mission lifetime.

1. Introduction

The BepiColombo spacecraft has been launched in October 2018 and will reach Mercury in 2025; its 1-year nominal mission will start in March 2026. The two BepiColombo orbiters, i.e. MPO and MMO, have the primary goals to image and map Mercury and to study its magnetic environment.

High resolution images of the Mercury surface are required to cope with the main mission scientific topics of MPO (e.g. surface morphology, crustal differentiation, resurfacing, volcanism,..). Thus a crucial role will be played by the Imagers for MPO BepiColombo Integrated Observatory SYStem (SIMBIO-SYS).

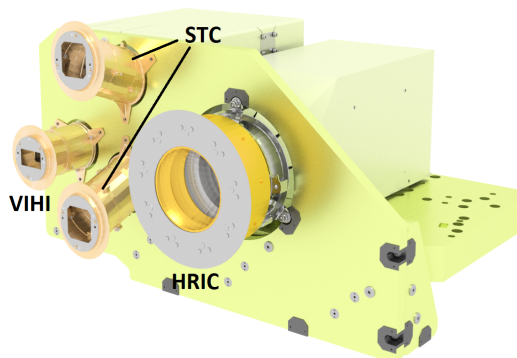

Figure 1: The SIMBIO-SYS instrument.

1.1. SIMBIO-SYS

The SIMBIO-SYS instrument [1] (see Figure 1) includes three channels: an imaging system with stereo capabilities, which is the Stereoscopic imaging Channel (STC) [2], a High Resolution Imaging Channel (HRIC) [3], and a hyperspectral imager in the visible and near IR range, named Visible and near Infrared Hyperspectral Imager (VIHI) [4].

STC performs 60-120 m spatial resolution global mapping in stereo mode and colour imaging in selected areas, HRIC is a camera for high resolution imaging (6-12 m/px) in panchromatic and broad-band filters, and VIHI performs imaging spectroscopy in the 400-2000 nm spectral range. A highly integrated concept is adopted to maximize the scientific return and minimize the resource requirements, primarily mass and power.

The main scientific goals of SIMBIO-SYS are: to map the whole Mercury surface in the visible and near IR, to reconstruct the global DTM, and to image selected regions at high spatial resolution to investigate the morphology and chemical composition of the planet surface.

To fulfill these goals, it is necessary to predict the channels performance and to plan the observation strategy during the different phases of the mission; to this end, an instrument simulator has been developed. Given the observed surface properties, the instrument characteristics, the MPO orbital characteristics and the geometrical relations between the instrument and the surface, the SIMBIO-SYS simulator (SIMBIO-Sim) is capable of estimating the expected signal and integration times for the entire mission lifetime.

2. The SIMBIO-SYS simulator

To calculate the expected signal detected by each SIMBIO-SYS channel, the simulator takes into account: the SPICE toolkit software, to predict the orbital configuration during the entire mission; the Hapke reflectance model [5], [6], with parameters derived by [7] to derive the Mercury expected radiance; the instrument optical characteristics, in which the available measured optical and detector performance are considered. Note that the SPICE toolkit software allows to know at a given time the exact position of the Mercury Planetary Orbiter (MPO) with respect to the planet surface and the Sun.

The outputs of the simulator can be divided in three groups: *i)* the geometrical quantities related to the spacecraft and the channels, which include both the general information about the spacecraft (altitude with respect to the ground, velocity, etc.) and the information for each filter (FoV, footprints, on-ground pixel dimension, boresight velocity); *ii)* the radiometric outputs, which include the planet reflectance, the radiance and the expected signal measured by the detector; *iii)* the quantities related to the channel performance, which are for example the integration time (IT), which has to be defined to avoid the detector saturation, the expected dark current and the smearing time.

The SIMBIO-SYS simulator is a useful tool not only for the determination of the instrument performance [8], but also for defining the in-flight calibration and, more important, the observation planning during the science mission phase at Mercury.

In this respect, the simulator has been applied for the first time during the Near Earth Commissioning Phase (NECP) [9]. The simulator outputs have been the base to prepare a specific operation test with all the three SIMBIO-SYS channels working together (inter-channels test) during a nominal one orbit period at Mercury.

Acknowledgements

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References

[1] E. Flamini, *et al.*, *SIMBIO-SYS: The spectrometer and imagers integrated observatory system for the Bepi-Colombo planetary orbiter*, Planet. Space Sci. **58**, 125 (2010).

[2] V. Da Deppo, G. Naletto, G. Cremonese, and L. Calamai, *Optical design of the single-detector planetary stereo camera for the BepiColombo European Space Agency mission to Mercury*, Appl Opt **49**, 2910 (2010).

[3] M. Zusi, *et al.*, *Optical design of the high resolution imaging channel of simbio-sys*, Applied Optics accepted (2019).

[4] F. Capaccioni, *et al.*, *Vis-nir imaging spectroscopy of mercury's surface: Simbio-sys/vihi experiment onboard the bepicolombo mission*, Geoscience and Remote Sensing, IEEE Transactions on **48**, 3932 (2010).

[5] B. Hapke, *Bidirectional Reflectance Spectroscopy. 5. The Coherent Backscatter Opposition Effect and Anisotropic Scattering*, Icarus **157**, 523 (2002).

[6] B. Hapke, *Bidirectional reflectance spectroscopy 7. The single particle phase function hockey stick relation*, Icarus **221**, 1079 (2012).

[7] D. L. Domingue, B. W. Denevi, S. L. Murchie, and C. D. Hash, *Application of multiple photometric models to disk-resolved measurements of Mercury's surface: Insights into Mercury's regolith characteristics*, Icarus **268**, 172 (2016).

[8] A. Slemer, *et al.*, *Performances of the simbio-sys stereo imaging channel (stc) on board bepicolombo/esa spacecraft*, in *2018 5th IEEE International Workshop on Metrology for AeroSpace (MetroAeroSpace)*, 257–262 (2018).

[9] M. Zusi, *et al.*, *Simbio-sys near earth commissioning phase: A step forward toward mercury*, in *Proc. SPIE*, to be publ. (2019).