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European Stratospheric Balloon Observatory (ESBO) – Identification of Planetary Science Applications

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Abstract

This paper presents the European Stratospheric Balloon Observatory *Design Study* (ESBO *DS*) [1] following up on the ORISON project [2]. The goal of ESBO *DS* is to create a community-accessible, versatile, and regularly flying stratospheric balloon-based observatory. Balloon-based systems such as the ones presented have the potential to complement ground and space-based observations. The stratospheric observation conditions and much shorter turn-around times for fast reactions make such systems particularly suitable for planetary observations. They not only provide access to spectral regimes inaccessible from the ground and photometric stabilities not obtainable from the ground, but also observational opportunities for uninterrupted long-integration measurements throughout the year. Particularly long-duration circumpolar flights offer almost continuous observation possibilities over up to 30 to 40 days, with Ultra Long Duration mission on the horizon promising even longer flights of 100 days and more. In this paper, we present our ESBO *DS* plans and the ongoing work for the prototype platform currently under development. We identify exemplary mid- and long-term applications for planetary science.

1. Introduction

In 2016/2017, the H2020-funded project ORISON studied the general feasibility of a balloon-based observatory [2]. The work showed that the concept of versatile balloon-based telescopes operated as an observatory is feasible, but that some further technological development is required. The plans for ESBO in the long term, and the currently ongoing ESBO *DS* (2018-2021) pick up from these conclusions [1].

In particular, ESBO represents the goal of establishing a larger service provider that flies and operates balloon-based telescopes, providing instrument space and observation time on different flight platforms, with up to several hundred hours observing time per flight. Currently envisioned flight platforms include a prototype platform carrying a 0.5 m aperture telescope for the UV and visible range, an intermediate flight platform for telescopes in the 1.5 m aperture class, and, in the long term, a platform for far infrared observations in the 5 m aperture range.

2. Technical Concept

The goal of ESBO is to provide modular flight platforms that can accommodate exchangeable instruments. This observatory-type approach requires, besides a modular and scalable gondola that provides customized support for astronomical instruments, regular flights and ergo save recovery of the payload.

2.1 UV/visible prototype mission

The STUDIO (Stratospheric Ultraviolet Demonstrator of an Imaging Observatory) mission is being developed as the first prototype flight platform of ESBO, with a first flight currently foreseen for 2021. It will carry a fully-reflective ~0.5 m aperture telescope, along with an imaging and photon counting microchannel plate UV detector for the wavelength range from 180 to 330 nm as the main science instrument, developed and built by the Institut für Astronomie und Astrophysik at the Universität Tübingen [3]. In addition, it will carry a visible light imaging instrument that will mainly serve as the tracking sensor in a closed-loop fine image stabilisation system, but that may also be used as an auxiliary science instrument. With a telescope focal ratio of f/13, the UV instrument is baselined to achieve a circular field of view (FOV) of 21.1 arcmin diameter, at an angular resolution of 1 arcsec. The visible channel is baselined with a 7.0 x 7.0 $arcmin^2$ FOV and a pixel size of 0.2 arcsec. A centroid-tracking algorithm used on the visible channel will allow image motion tracking with a precision below the pixel scale and, in combination with a piezo-actuated tip/tilt mirror, an image stabilisation to below 0.5 arcsec.

Besides providing first scientific capabilities, the STUDIO platform will serve as a testbed and demonstrator for the image stabilisation system, the modular and scalable gondola, as well as for a controlled landing technique.

2.2 NIR/FIR future concept

The approach for ESBO is to extend the spectral coverage and telescope size range step by step. As a first step after the STUDIO mission(s), a platform for near infrared (NIR) telescopes in the 1 to 1.5 m aperture class is currently envisioned, in a timeframe of 2 to 3 years after the first STUDIO flight. This system could extend the wavelength coverage up to 3 or even 5 µm and could be optimized for photometric stability or spectroscopic measurements. Interesting instruments might be a multi-channel imager based on GROND [4] or the NIMBUS [5] proposal, or a low/medium spectral resolution (R ~ several hundred) spectrograph, similar to the one envisioned on the proposed EXCITE balloon mission [6].

For the long-term (timeframe ~15 years), ESBO *DS* studies the feasibility of operating far infrared (FIR) telescopes with an effective diameter of 5 m and potentially elliptical shape under balloons, to offer a next-generation FIR platform, improving on the capabilities of SOFIA and Herschel in particular with regard to spatial resolution and confusion limit.

3. Planetary Science Applications

The stratospheric observation conditions will provide a beneficial environment for a large range of planetary science applications. To illustrate the applicability, in table 1 we present a selection of planetary science cases that could be pursued particularly with the UV prototype or the NIR platforms described above.

Table 1: *Planetary Science Cases for ESBO*

Science Case	Stratospheric Advantage
Multichannel exoplanet transit observations for cloud and haze studies	Photometric stability, no scintillation noise, long continuous observations possible
Exoplanet transit spectroscopy for atmospheric studies	See multichannel transits, + accessibility to UV & NIR
Extended asteroid topology including near UV	Accessibility to UV spectral regions
Study of the 1.4 and 1.9 µm OH/H_2O bands on asteroids	Absence of telluric bands limiting NIR spectroscopy from the ground
Study of Mercury's exosphere	Observations close to the Sun possible
Small body light curves and absolute photometry	Increased photometric stability

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