Findings for the OSAS-B 4.7-THz heterodyne spectrometer for atomic oxygen in the mesosphere and lower thermosphere

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***Abstract*— We present results and findings from the first flight of the OSAS-B instrument on a stratospheric balloon. OSAS-B is a heterodyne receiver for the 4.7-THz emission of atomic oxygen which is based on a hot-electron bolometer mixer and a quantum-cascade laser as local oscillator.**

I. Introduction

The Oxygen Spectrometer for Atmospheric Science on a Balloon (OSAS-B) has been developed for probing neutral atomic oxygen (OI) in Earth's mesosphere and lower thermosphere (MLT) from a stratospheric balloon. Atomic oxygen is the dominant species in the MLT region and thus plays an important role for the chemistry and energy balance [1,2]. OSAS-B is a heterodyne receiver for the ground state fine-structure line of OI at 4.745 THz, which cannot be observed from ground due to the absorption by water vapor in the troposphere.

II. Instrument design and first flight in 2022

Figure 1(a) shows a photography of the instrument. The cryostat comprises the receiver front end. It contains a liquid helium stage for the hot-electron bolometer (HEB) as the heterodyne mixer and a solid nitrogen stage for the quantum-cascade laser (QCL), which acts as the 4.7-THz local oscillator. A rotatable 35-mm mirror in the optics compartment collects the atomic-oxygen emission for different elevation angles or alternatively the blackbody radiation from one of the two calibration loads at ambient temperature and 400 K. The backend of the receiver comprises a digital Fourier transform spectrometer for data acquisition.

The first flight of the instrument took place in September 2022 from Esrange, Sweden. Atmospheric data were recorded for several hours during one day. Figure 1(b) depicts measured spectra for 0° (horizontal) and 60° elevation along with synthetic spectra as expected from atmospheric models [3, 4]. The spectrum for 0° elevation exhibits a pronounced wing structure, which is due to an interplay of emission and absorption from different altitudes, and reflects the radiation transport in the MLT region. Results show that OSAS-B allows for observing the subtle line-shape details as predicted for different atomic-oxygen distribution models. In certain spectra, we found signatures of shear winds in the MLT region, which manifest in a relative Doppler shift of components from different altitudes. For the radiometric calibration, we found that incorporating the direct-detection effect plays a crucial role for obtaining a reasonable agreement between the experimental and the expected brightness temperatures of the OI line. We will present further results of the balloon flight and discuss the in-flight performance of OSAS-B.

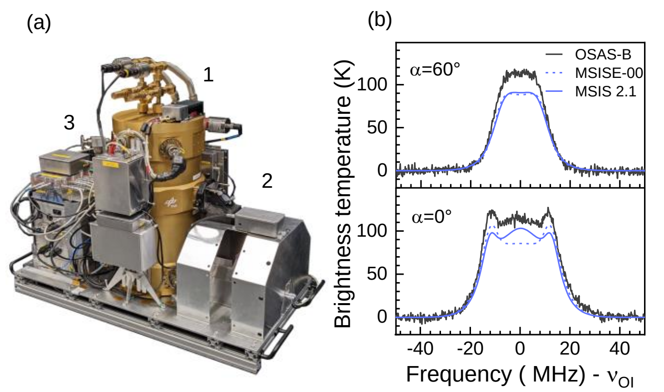

Fig. 1: (a) Photography of the instrument. 1: cryostat, 2: optics compartment, 3: backend electronics. (b) Measured and simulated spectra for 60° and 0° elevation Observation: 2022/09/07 9:14 UTC, 68°19´N,19°40´E, height: 32.6 km , azimuth direction: 23° NNE. Simulated spectra based on the NRL MSISE-00 [3] and MSIS 2.1 model [4].

References

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