The OSAS-B instrument: a balloon-borne heterodyne spectrometer for atomic oxygen in the mesosphere and lower thermosphere

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***Abstract* — We present the design and evaluation of the OSAS-B instrument which is dedicated to probing the 4.7 THz emission of atomic oxygen in the atmosphere of Earth.**

The Oxygen Spectrometer for Atmospheric Science on a Balloon (OSAS-B) has been developed for probing the emission of atomic oxygen in the mesosphere and lower thermosphere (MLT), a region of Earth's atmosphere, where atomic oxygen is the dominant species and plays an important role for the chemistry and energy balance [1, 2]. OSAS-B is a heterodyne receiver for the ground state fine-structure transition of atomic oxygen at 4.745 THz. Due to water absorption, this line cannot be observed from ground. The only instrument, which is currently capable of observing and resolving this transition, is the upGREAT heterodyne receiver (German REceiver for Astronomy at THz Frequencies) on board of SOFIA [3]. However, observations are limited to night time.

Figure 1 shows a CAD visualization of the instrument. The central unit is a dewar with a liquid helium stage for the hot-electron-bolometer (HEB) mixer as the heterodyne detector and a solid nitrogen stage for cooling the quantum-cascade laser used as local oscillator. The Si lens of the quasi-optical HEB mixer allows for an angular resolution of 30'. A pointing mirror is used to measure the atomic oxygen emission for different elevation angles. The backend of the receiver is a digital Fourier transform spectrometer. The instrument weights approximately 60 kg and consumes 100 W in operation.

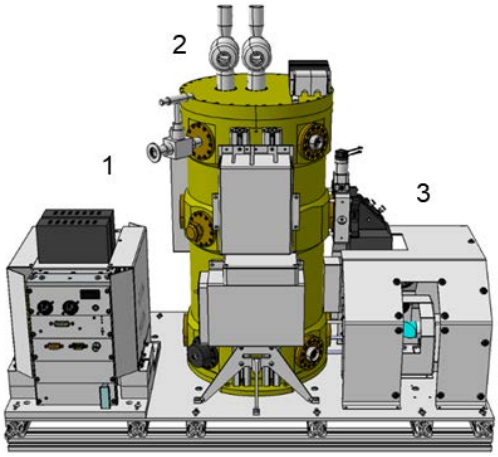

Fig. 1. CAD visualization of the OSAS-B instrument. 1: central control unit with digital Fourier transform spectrometer. 2: cryostat with pressure and periphery control. 3: optics compartment.

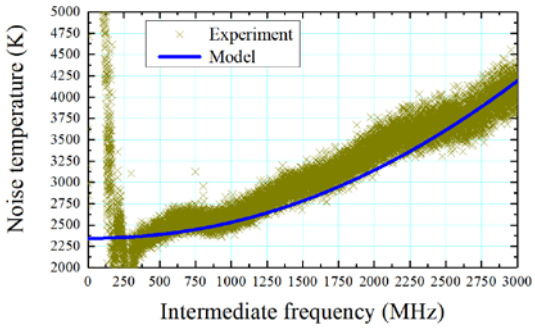

Fig. 2. Measured system noise temperature as a function of the frequency. The solid line represents a simulation of the HEB.

In order to evaluate the performance of the instrument, we studied the stability and system noise temperature T_n in a thermal vacuum chamber using two blackbodies at 90 K and room temperature. T_n is shown in Fig. 2 as a function of the intermediate frequency together with a noise model of the HEB mixer. A noise temperature of 2500 K is achieved up to an intermediate frequency of 1 GHz, similar to the typical performance of the upGREAT receiver in SOFIA. The OSAS-B flight will take place at Esrange, Sweden, in autumn 2022 in the frame of the European HEMERA program. A total flight duration of 12 h is anticipated.

References

[1] M. G. Mlynczak and S. Solomon, "A detailed evaluation of the heating efficiency in the middle atmosphere," *J. Geophys. Res.*, vol. 98, 10517, 1993.

[2] H. Richter, C. Buchbender, R. Güsten, R. Higgins, B. Klein, J. Stutzki, H. Wiesemeyer, H.-W. Hübers, "Direct measurements of atomic oxygen in the mesosphere and lower thermosphere using terahertz heterodyne spectroscopy," *Commun. Earth Environ.*, vol. 2, 19, 2021.

[3] C. Risacher, *et al.*, "The upGREAT Dual Frequency Heterodyne Arrays for SOFIA," *J. Astron. Instrum.*, vol. 7, 1840014, 2018.

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