A balloon-borne heterodyne receiver for atmospheric studies of atomic oxygen

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Atomic oxygen is the dominant species in the mesosphere and lower thermosphere (MLT) region of Earth's atmosphere. It plays an important role for the chemistry and energy balance of the MLT [1]. Its main coolant line is the $^3P_1$-$^3P_2$ ground state transition at 4.75 THz. The line shape of this transition cannot be resolved with typical Fourier-transform spectrometers. Due to water absorption, this line can also not be observed from ground. Currently, the only instrument which is capable of observing and resolving this transition is the upGREAT heterodyne receiver (German Receiver for astronomy at THz frequencies [2]) on board of SOFIA, the Stratospheric Observatory for Infrared Astronomy. However, observations are limited to night time and the radiometric accuracy is limited by the residual water vapor column still present at flight altitude.

We propose a balloon-borne heterodyne receiver, which is dedicated to the observation of atomic oxygen in the atmosphere. The instrument will allow for a higher radiometric accuracy than upGREAT/SOFIA, due to the much higher flight altitude of stratospheric balloons. It will also enable observations of diurnal variations. Figure 1(a) depicts simulated line profiles as expected for different elevation angles, and Fig. 1(b) shows the absorption profile as expected for column density measurements against the sun.

The instrument will be based on a dewar with a liquid helium stage for the receiver front end (hot-electron-bolometer (HEB) mixer and low-noise amplifier) and a solid nitrogen stage to cool the quantum-cascade laser used as local oscillator [3]. The Si lens of the quasi-optical HEB mixer will allow for an angular resolution of 30'. A pointing mirror will be used to measure at different elevation angles. The instrument will comprise a calibration unit. A filter unit will block most of the radiation from the sun, in order to allow for column density measurements against the sun. The backend of the receiver is a digital Fourier transform spectrometer.

The total weight of the instrument will be approximately 60 kg, which allows for combinations with other instruments on a typical 150-kg payload gondola as provided by the European HEMERA program.

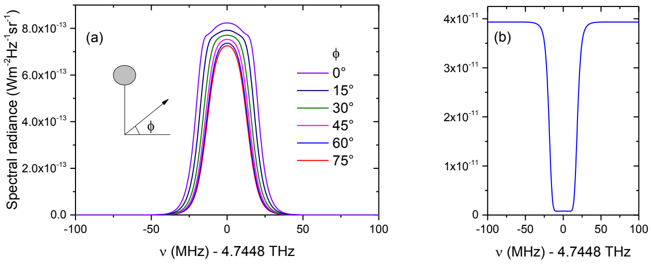

Fig. 1. (a) Simulated OI emission line shape at night for different elevation angles as measured with a ballon-borne heterodyne spectrometer (b) OI line profile with a hot background (sun at sunrise). NRLMSISE-00 data for Nov. 20th 2018, Kiruna N67.8°E20.2°.

References

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