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THERMOSPHERIC OXYGEN MAPPER (TOM)

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ABSTRACT

A new 2.1 THz heterodyne receiver capable of mapping the global excitation and dynamics of atomic oxygen from a satellite is being developed. We propose to validate the science concept and verify the instrument performance by using a prototype aboard SOFIA. In addition, coordinated SOFIA observations could provide valuable “ground-truth” data necessary to calibrate a future orbiting instrument.

INTRODUCTION

Neutral atomic oxygen is the dominant constituent of the Earth’s thermosphere and upper mesosphere, and yet it is difficult to measure the atom’s excitation and dynamics because of its sparse spectral properties. The lowest energy lines that are thermalized lie at obscured far-infrared wavelengths, and the more observable optical and UV forbidden lines are excited only by non-thermal processes. Interest in thermospheric “weather” has increased in recent years with the discovery of gravity waves in the lower atmosphere that may transport material above the mesopause. Solar heating can also produce upwelling motions at the sub-solar point that flow tangentially across the terminator to the nightside where they subside. The oxygen UV-lines that are commonly observed are completely saturated. Consequently, they yield inconclusive information on excitation because of the complicated radiative transfer calculations that are needed. The same is true for the oxygen “red” and “green” lines, which are seen in airglow and associated with various recombinations. Furthermore, the small optical- and UV-spectrometers flown on spacecraft don’t have adequate spectral resolution to measure Doppler shifts of the required 10 m/sec accuracy. Fortunately these problems do not generally affect the far-infrared fine-structure line at λ=146 μm (2.1 THz) and (to a lesser extent) the ground-state line at λ=63 μm (4.7 THz). The energy levels defining these transitions are completely thermalized at the densities extant to the thermosphere. The λ=63 μm line can appear a little saturated, however, and so we are stressing observations of the weaker λ=146 μm line at high resolution. The expected linewidth is only 6 MHz, so we need 1 MHz resolution to measure thermally broadened linewidths.

A THERMOSPHERIC OXYGEN MAPPER

We are currently developing hardware components for a 2.1 THz heterodyne receiver capable of mapping the global excitation and dynamics of atomic oxygen from a satellite. The instrument is all solid-state and fits in a volume <0.5 m^3. We propose to validate the science concept and verify the instrument performance by using a prototype aboard SOFIA to observe atomic oxygen at slant angles between roughly 30-60 degrees from horizontal. Later, should a flight-qualified TOM reach space, coordinated SOFIA observations could provide valuable “ground-truth” data necessary to calibrate the orbiting instrument. All observations must necessarily be done above the tropopause because of absorption by water vapor in the lower atmosphere.

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REFERENCES

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