THz Limb Sounder (TLS) for Lower-Thermospheric Wind, Oxygen Density, and Temperature

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Abstract

Neutral winds are one of the most critical measurements in the lower thermosphere and E region ionosphere (LTEI) for understanding complex electrodynamic processes and ion-neutral interactions. In the terrestrial thermosphere where little microwave emission exists, the OI emissions at 2.06 THz (145.525 mm) and 4.75 THz (63.184 mm) are the two brightest emissions that can be used for wind and temperature observations.

In this funded project under NASA Heliophysics Science Division, we are developing a high-sensitivity, low-power, non-cryogenic 2.06 THz Schottky receiver to measure wind profiles at 100–140 km. The new technique, THz limb sounder (TLS), aims to measure LTEI winds by resolving the wind-induced Doppler shift of 2.06 THz atomic oxygen (OI) emissions. As a transition between fine structure levels in the ground electronic state, the OI emission is in local thermodynamic equilibrium (LTE) at altitudes up to 350 km. This LTE property, together with day-and-night capability and small line-of-sight gradient, makes the OI limb sounding a very attractive technique for neutral wind observations. In addition to the wind measurement, TLS can also retrieve [OI] density and neutral temperature in the LTEI region. TLS leverages rapid advances in THz receiver technologies including subharmonically pumped (SHP) mixers and Schottky-diode-based power multipliers. Current SHP Schottky receivers have produced good sensitivity for THz frequencies at ambient environment temperatures (120–150 K), which are achievable through passively cooling in spaceflight. As an emerging technique, TLS can fill the critical data gaps in the LTEI neutral wind observations to enable detailed studies on the coupling and dynamo processes between charged and neutral molecules.