Lasers and the Dynamic Mesosphere/Thermosphere of Venus

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A review of ground based mid-infrared uniquely high spectral resolution measurements of Venus dynamics, temperature, and chemistry will be presented. The described studies will focus on the use of CO_2 absorption features and the discovery and use of CO_2 thermospheric non-thermal emission lines as probes of Venus' atmosphere, from the cloud tops to ~120 km in the thermosphere. The first investigations using infrared heterodyne spectroscopy with resolving power $\lambda/\Delta\lambda \sim 10^6$ to measure true emission line profiles and to determine their non-thermal nature and lasing component will be described. The use of the thermospheric non-thermal CO_2 emission to directly measure sub-solar to anti-solar winds and zonal circulation near 110 km altitudes on Venus to ~2 m/s accuracy will also be described. The measured emission lines are also used to obtain global maps of mesospheric/thermospheric kinetic and rotational temperatures as well as to obtain evidence of the natural lasing phenomena. Carbon dioxide absorption features globally probe lower altitudes in the atmosphere and can be used to determine nightside temperatures. Isotopic $^{13}CO_2$ absorption lines are used to probe deeper in the atmosphere to measure the sub-solar to anti-solar return flow at altitudes just above the cloud tops. These results provided a model for global circulation in the 65 – 120 km altitude region first proposed by Goldstein (1989, PhD.Thesis, U. Pennsylvania, Philadelphia, USA). Results of similar wind and temperature measurements made in recent years will be compared to earlier results to investigate changes in the circulation and temperatures since ~1990. The high resolution infrared heterodyne technique was also used to investigate chemical processes above the cloud tops, specifically evidence and constraints on oxygen-based chemistry.

Described measurements were made by infrared heterodyne spectroscopy using the Goddard Space Flight Center Infrared Heterodyne Spectrometer (IRHS) the GSFC Heterodyne Instrument for Planetary Wind And Composition (HIPWAC) and the University of Cologne Tuneable Heterodyne Infrared Spectrometer (THIS).

Results of these ground-based high spectral resolution studies provide complementary data for interpreting spacecraft measurements (e.g., ESA/VEX, JAXA/Akatsuki) and high altitude constraints on current GCM/photochemical models of the atmosphere of Venus.