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ADVANCED INFRARED ASTRONOMY

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Objective: The goals of this research include high resolution spectroscopic studies of planetary atmospheres and comets. Laser heterodyne and Fourier transform spectrometers are utilized in order to obtain high spectral and spatial resolution. This makes it possible to study localized, non-thermal, phenomena in low temperature and low density regions and to detect trace constituents. Ultrahigh spectral resolution and stability also enables the study of dynamical phenomena such as winds in planetary atmospheres, thermal tides, and the outflow of material in cometary comae.

Accomplishments: The CO_2 laser heterodyne spectrometer was used at the 3-m IRTF on Mauna Kea to make measurements of Mars during the 1984 opposition. Analysis of the observations of the mesospheric non-thermal emission demonstrated the existence of a warming of the Mars polar mesosphere, similar to the seasonal effects which are well known to occur at the Earth's mesopause.

A new laser heterodyne system was established at the McMath telescope on Kitt Peak. This system will be complimentary to the system at the IRTF, and will be used for observations of a more synoptic nature. A search for CO_2 and NH_3 on Comet Halley was done with the new Kitt Peak system (11/85) as well as with the IRTF heterodyne system (12/85, 4/86).

A Lamb-dip absorption cell was designed and constructed. Its use will allow extreme frequency stabilization of the laser local oscillator, which will greatly facilitate measurements of winds and dynamical phenomena. The Lamb-dip cell was used at Kitt Peak to study zonal and meridional winds in the atmosphere of Venus.

Water vapor was detected in Comet Halley using Fourier transform spectrometer on the Kuiper Airborne Observatory. The 2.65 μm ν_3 band was seen in emission, confirming non-thermal-equilibrium excitation models for comets.

A study was made of the variability of Jovian Ethane emission. The average volume mixing ratio of Ethane in the Jovian stratosphere was

found to be 3×10^{-6}, with the greatest variability seen in the auroral regions.

Proposed Research: Analysis of Fourier transform and laser heterodyne spectroscopic data will be completed, to determine the relative abundance of candidate parent molecular species (H_2O, CO_2, NH_3, etc.) and to refine radiative transfer and excitation models for cometary comae. Measurement of winds in the atmosphere of Venus will continue using Lamb-dip stabilized laser heterodyne spectroscopy. These wind measurements will be extended to the atmosphere of Mars during the 1986 opposition; this effort will provide scientific support for the forthcoming Mars Orbiter Mission. The nature of variability in the Jovian Ethane emission will be clarified by making observations at higher spatial resolution using the IRTF.

Figure: Example of laser heterodyne observations of an individual line in the ν_9 band of Ethane, seen in emission from the stratosphere of Jupiter. A model atmosphere fit to the data is also shown.

Publications: "Observations of the 10-μm Natural Laser Emission from the Mesospheres of Mars and Venus", D. Deming, F. Espenak, D. Jennings, T. Kostiuk, M. J. Mumma and D. Zipoy (1983) Icarus 55, 347.

"Modeling of the 10-μm Natural Laser Emission from the Mesospheres of Mars and Venus", D. Deming and M. J. Mumma (1983) Icarus 55, 356.

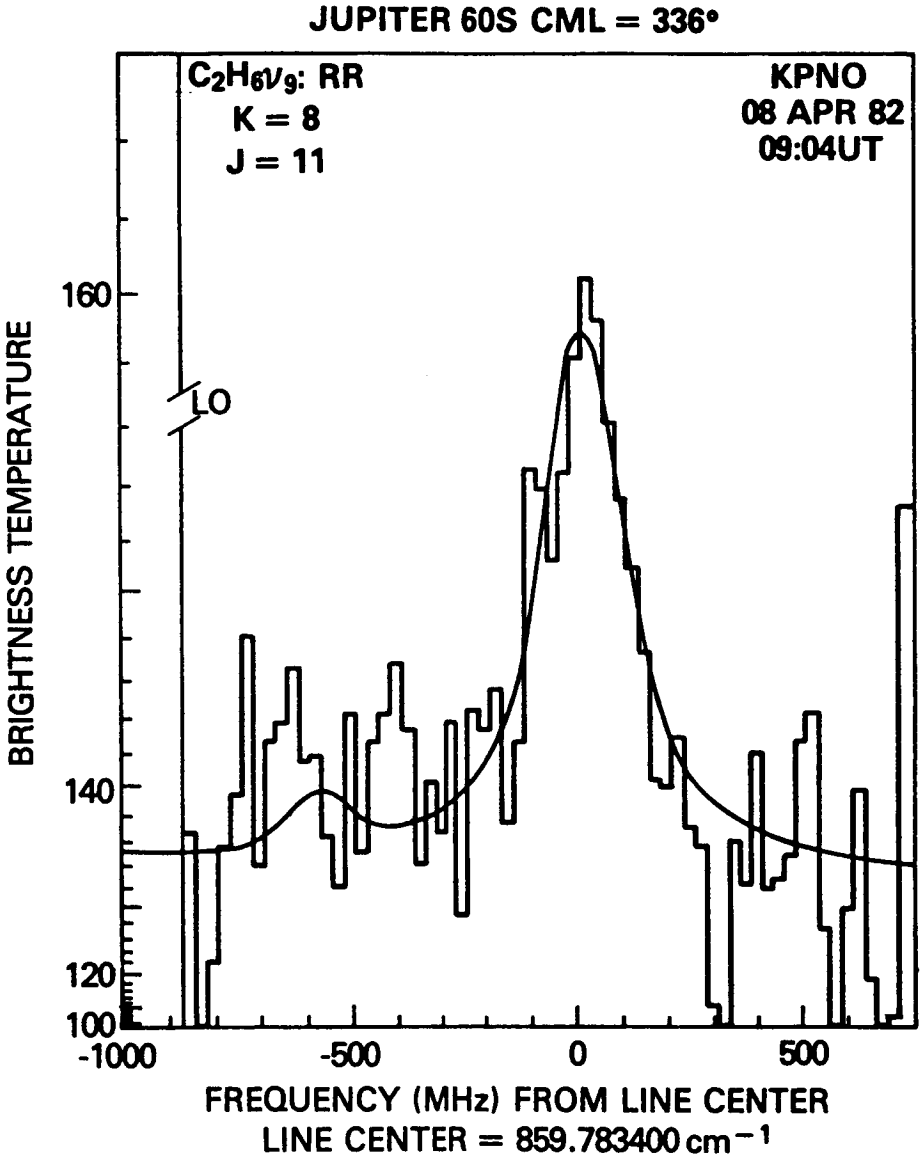
"Measurements of Stratospheric Ethane in the Jovian South Polar Region from Infrared Heterodyne Spectroscopy of the ν_9 Band Near 12 Microns", T. Kostiuk, M. J. Mumma, F. Espenak, D. Deming, D. E. Jennings, W. Maguire and D. Zipoy (1983) Astrophys. J. 265, 564.

"Infrared Molecular Emissions from Comets", H. A. Weaver and M. J. Mumma (1984) Astrophys. J. 276, 782.

"Infrared Heterodyne Observations of Comet IRAS-Araki-Alcock (1983d)", H. A. Weaver, T. Kostiuk and M. J. Mumma (1985), submitted to Icarus.

"Polar Warming in the Middle Atmosphere of Mars", D. Deming, M. J. Mumma, F. Espenak, T. Kostiuk and D. Zipoy (1986) Icarus, to appear in the March 1986 issue.

"Detection of Water Vapor in Halley's Comet", M. J. Mumma, H. A. Weaver, H. P. Larson, D. S. Davis, and M. Williams (1986), submitted to Science.


JUPITER 60S CML = 336°
C2H6ν9: RR
K = 8
J = 11
KPNO
08 APR 82
09:04UT
BRIGHTNESS TEMPERATURE
160
LO
140
120
100
-1000
-500
0
500
FREQUENCY (MHz) FROM LINE CENTER
LINE CENTER = 859.783400 cm−1