N92-14531

NASA Upper Atmosphere Research Program

RESEARCH SUMMARY 1988-1989

A. TITLE OF RESEARCH TASK

"A Facility for High Resolution Spectroscopy: Laboratory and Ground Based Observations in Support of Upper Atmospheric Research"

B. INVESTIGATORS AND INSTITUTIONS

Principal Investigator: J.W. Brault (National Solar Observatory)
Visiting Investigators:

Jet Propulsion Laboratory	Langley Research Center	Goddard Space Flight Center
L. R. Brown	C. Rinsland	J. J. Hillman
E. Cohen	M. A. H. Smith	D. E. Jennings
J. S. Margolis		T. Kostiuk
H. Pickett		
R. Poynter		
R. Toth		

C. ABSTRACT OF RESEARCH OBJECTIVES

This research task consists of operating a *facility* for making spectroscopic observations in support of upper atmospheric research. The facility responds to the needs and interests of the visiting investigators. Therefore, the research objectives are not predetermined except in broad outline. The emphasis is on studies that take advantage of the particular strengths of the Fourier transform spectrometer on Kitt Peak: high spectral resolution combined with wide spectral range and low noise.

D. SUMMARY OF PROGRESS, RESULTS AND PROPOSED WORK

During 1988 and 1989, eight sessions with the Kitt Peak FTS were scheduled by the laboratory spectroscopy group at NASA Langley Research Center. The Langley group has used the McMath FTS to record numerous high-quality spectra of methane and several of its isotopes in the 2.5 to 5 μm region and in the 6 to 8 μm region. These spectra are being analyzed along with similar methane spectra recorded in previous years to determine N_2-, O_2-, Ar-, and air-broadening coefficients and pressure-induced line shifts for a large number of absorption lines belonging to several different vibration-rotation bands of $^{12}CH_4$, $^{13}CH_4$, and $^{12}CH_3D$. Results for $^{12}CH_4$ and $^{13}CH_4$ in the 6 to 8 μm region have been published and have already been applied in analysis of atmospheric data.

Continuing analysis of ozone absorption spectra recorded by the Langley group in 1984, 1985 and 1987 has resulted in improved line positions, intensities, and assignments in the 3 to 15 μm region. Analysis is also in progress to determine N_2- and air-broadening coefficients and pressure-induced line shifts for lines in the 3.6 μm region, and self-broadening coefficients for lines in the 5 to 15 μm region.

A series of atmospheric solar absorption spectra were recorded using the McMath telescope and FTS in May 1988 and in November-December 1988, and a single spectrum was

recorded in May 1989. These spectra are being analyzed along with similar spectra previously recorded at the McMath since 1980 to obtain total column amounts of atmospheric trace species such as HF and CFCs to determine trends of these species amounts with time.

In FY89 Goddard Space Flight Center used the NSO FTS on two occasions. In January Fox, Jennings, Plymate, and Wagner recorded spectra of the 9 μm band of methane broadened by N_2, O_2, He, H_2, Ar, CO, Ne, Kr, and Xe. The spectra were used to study the line widths and shifts induced in methane by these gases. Results were presented at the Spring APS meeting in Baltimore.

In May Jennings, Hillman, and Reuter recorded spectra of several gases at low temperature (160-180K). These included acetylene, propane, and N_2O. These were broadened by N_2, H_2, and He. Data is being analyzed at present.

F. JOURNAL PUBLICATIONS

Flaud, J. -M., C. Camy Peyret, J. W. Brault, C. P. Rinsland, and D. Cariolle, Nightime and Daytime Variation of Atmospheric NO_2 From Ground-Based Infrared Measurements, *Geo. Phys. Res. Lett.*, 15, 261-264 (1988).

Flaud, J. -M., C. Camy Peyret, A. N'Gom, V. Malathy Devi, C. P. Rinsland, and M. A. H. Smith, The ν_2 Bands of $^{16}O^{18}O^{16}O$ and $^{16}O^{16}O^{18}O$: Line Positions and Intensities, *J. Mol. Spectrosc.*, 133, 217-223 (1989).

Fox, K., D. E. Jennings, E. A. Stern and R. Hubbard, Measurements of Argon, Helium and Hydrogen N_2-Broadened Widths of Methane Lines Near 9000 cm^{-1}., *J. QSRT.*, 39, 473 (1988).

Fox, K., D. E. Jennings, Spectral Shifts of Methane Lines in Collisions With Hydrogen, Helium, Nitrogen, and Argon, *J. QSRT.*, 42, 201-206 (1989).

Malathy Devi, V., D. C. Benner, M. A. H. Smith, and C. P. Rinsland, Measurements of Air-, N_2-, and O_2- Broadened Halfwidths and Pressure-Induced Line Shifts in the ν_3 Band of $^{13}CH_4$, Manuscript submitted to *Appl. Opt.* (1989).

Margolis, J. S., Measured Line Positions and Strengths of Methane Between 5500 and 6180 cm^{-1}, *Appl. Opt.*, 27, 4038 (1988).

Margolis, J. S., Imperical Values of Ground State Energies for Methane Transitions Between 5500 and 6150 cm^{-1}, Manuscript submitted to *Appl. Opt.* (1989).

Rinsland, C. P., M. A. H. Smith, J.-M. Flaud, C. Camy-Peyret, and V. Malathy Devi, Line Positions and Intensities of the $2\nu_3$, $\nu_1+\nu_3$, and $2\nu_1$ Bands of $^{16}O_3$, *J. Mol. Spectrosc.*, 130, 204-212 (1988).

Rinsland, C. P., D. W. Johnson, A. Goldman, and J. S. Levine, Evidence for a Decline in the Atmospheric Accumulation Rate of $CHClF_2$ (CFC-22), *Nature*, 337, 535-537 (1989).

Rinsland, C. P., V. Malathy Devi, M. A. H. Smith, and D. C. Benner, Measurements of Argon-Broadened Lorentz Width and Pressure-Induced Line Shift Coefficients in the ν_4 Band of $^{12}CH_4$, *Appl. Opt.*, 28, 2111-2118 (1989).

Smith, M. A. H., C. P. Rinsland, V. Malathy Devi, J. -M. Flaud, C. Camy-Peyret, and A. Barbe, The 3.6 μm Region of Ozone: Line Positions and Intensities, Manuscript submitted to *Appl. Opt.* (1989).

Task Summary, August 1989

A. Title: Calibration Facilities for NASA Payloads at SURF

B. Principle Investigator: Robert P. Madden

Institution: U. S. Department of Commerce
National Institute of Standards and Technology
Radiation Physics Division
Gaithersburg, MD 20899

C. Abstract of Research Objectives:

It is critically important to have a common VUV radiometric base for the wide range of scientific missions being carried out by rocket, by satellite, and on the space shuttle. It has been demonstrated that this can be achieved utilizing the NASA Spectrometer Calibration Facility beamline at SURFII, the Synchrotron Ultraviolet Radiation Facility at the National Institute of Standards and Technology. This beamline, with its large spectrometer calibration chamber, utilizes the calculable nature of synchrotron radiation to calibrate a wide range of spectrometer and photometer systems, thereby serving as a common radiometric base. The accuracy of this calibration source has been thoroughly documented and is adequate to this task.

D. Summary of Progress and Results:

The NASA/SURF Spectrometer Calibration Facility was solidly booked during 1988 and 1989. In 1988, users included: J. Mentall (three times), GSFC (rocket spectrometers); W. Neupert (twice), GSFC (grating calibrations); G. Rottman/T. Woods (twice), LASP (UARS-SOLSTICE); P. Jelinsky, SSL (EUV Explorer); M. VanHoosier (twice), NRL (UARS-SUSIM); D. Judge, USC-SSC (EUV Spectrometer); T. Woods, LASP (EUV Spectrometer). In 1989, all of the above again performed calibrations using the facility. In all, some 29 NASA-related instrument calibrations were performed in 88-89.

SURF II was improved during this period. Maximum currents were increased from 221mA to 300mA, average currents were similarly improved, and the lifetime of the beam was increased by over 40%. New buffer amplifiers were designed, built, and installed on all beam lines to improve beam current monitoring.

Improvements to the Spectrometer Calibration Facility included adding three new higher capacity cryopumps to the Large Spectrometer Calibration Chamber and its bellows, two being supplied by the Naval Research Laboratory. A radiant heating system for the Large Spectrometer Calibration Chamber was implemented, and a new computer was provided for the on-site calculation of all fluxes in all geometries used by the calibration users. A new cryopump was installed at the 11m calibration station which has significantly decreased the time required for calibration at both the 11m station and in the Large Spectrometer Calibration Chamber. The gimbals drive return spring system was redesigned, the new system operated successfully in 1989, and the data

transmission rate for this drive system was speeded up by a factor of four. The hydraulic drive system for motion of the Large Spectrometer Chamber was completely overhauled, and a new computer to drive this system and the pitch and yaw motions of the internal gimbals will be installed by the end of the contract period.

E. Journal Publications:

Furst, M. L. and Madden, R.P., "Synchrotron Ultraviolet Radiation Facility (SURF II) Radiometric Instrumentation Calibration Facility," submitted for publication, 1988.

Lean, J. L., Kostkowski, H. J., Saunders, R. D., and Hughey, L. R., "Comparison of the NBS SURF and Argon Mini-Arc Irradiance Standards at 214 nm," Applied Optics 28, 3246 (1989).

P. Jelinsky, S.R. Jelinsky, A. Miller, J. Vallerga, R.S. Malina, "Synchrotron Radiation Calibration of EUVE Variable Line Spaced Diffraction Gratings at the NBS SURF II Facility", SPIE Proceedings, Vol. 982 (1988).

T. N. Woods and G. J. Rottman, "Solar EUV Irradiance Derived from Rocket Experiments on 10 Nov. 1988", submitted to J. Geophysics Research (Feb. 1989).

R. P. Madden, "News from SURF", an article published in Synchrotron Radiation News, March/April 89.

Additional talks given during this period include:

L. R. Hughey, "Record Capture and Acceleration Efficiency in the SURF-II 300 Mev Circular Storage Ring", an invited paper presented at the Accelerator Conference, Chicago (1989).

R. P. Madden, "UV-VUV Radiometry at NIST", an invited paper presented at the Committee on Optical Radiation Measurements (CORM) meeting, Gaithersburg (1989).

R. P. Madden, L. R. Hughey, A. Hamilton, and M. L. Furst, "SURF II - Progress and Opportunities" a poster paper presented at the U.S. Conference on Synchrotron Radiation Instrumentation, Berkeley, 1989.

J. Lean, "Solar Emission Variation Measurements and Interpretation", a NIST seminar, Gaithersburg (1989).