Final Technical Report
January - October 1974

"A Comparison of Lyman α and He I λ10830 Line Structures and Variations in Early-Type Star Atmospheres" NGR 33-219-002

Dr. David D. Meisel
Asst. Prof. Astronomy
Department of Physics and Astronomy
State University of New York
College at Geneseo
Geneseo, New York 14454

on behalf
of

The Research Foundation of
State University of New York
Albany, New York 12224

NASA Technical Officer

Nancy G. Roman
Chief of Astronomy
NASA, Headquarters
Code SG
Washington, D. C. 20546

(NASA-CR-140572) A COMPARISON OF LYMAN ALPHA AND He LAMBDA 10830 LINE STRUCTURES AND VARIATIONS IN EARLY-TYPE STAR ATMOSPHERES (State Univ. of New York, Genesco.) 27 p HC $3.75 CSCL 03A
N75-10876
Unclas
G3/89 51074

Operations and Equipment

The purpose of the present research has been to use the modified Vaughan Fabry-Perot interferometer on the 24-Inch reflector of the C.E.K. Mees Observatory of the University of Rochester at South Bristol, New York. During the first half of 1974 Dr. R. A. Berg joined in the use of the instrument. We originally had expected the instrument to become operational by March 1974, but we discovered that one of the original quartz windows was fractured and had to be replaced. It took about five months to obtain a satisfactory replacement. After considerable delays we have just received this replacement and we will resume observation in November. While waiting for the interferometer to be available again we have worked in several areas.

(a) Modifications to the pressurization system to permit the use of ultrapure CO_2 as our scanning gas.

(b) Experimentation with Kodak I-N and I-Z hypersensitized emulsions for the purpose of obtaining unwidened slit spectra at moderate dispersion on the Mees telescope. The purpose of these is to produce survey spectra of our program stars.

(c) Experimentation with digital and analog methods of spatial filtering in order to deconvolve unwidened stellar spectra (see b above). This work is still in progress. Most of the support for the Fourier transform work has been internal to S.U.N.Y.-Geneseo. One graduate student thesis is in progress on this (by Mrs. M. Mongiori). Initial results are encouraging for digital methods, but some problems have been encountered with the analog method involving laser illuminated coherent processing. Possible patentable designs have resulted and these are presently being investigated.

(d) Development of Fourier transform deconvolution programs which will permit display of Fabry-Perot profiles in real-time.

Before the quartz window fracture in late March we obtained observations of several objects with the interferometer.

(a) Comet Kohoutek
(b) Spica (α Vir)
(c) Regulus (α Leo)
(d) Castor (α Gem)
(e) Vega (α Lyr)

In preparation for making more observations, we have now on hand blocking filters which will permit scans in the following spectral regions

(a) λ10830 He I
(b) λ10940 HI
(c) λ11024 CH_4 band
(d) λ7060 He I
(e) λ7774 OI
(f) λ8446 OI

selectively excited because of pumping by the solar chromospheric He I (λ10830) line. This interpretation is reinforced by 18 cm OH radio observations (Biraud, 1974) which indicated that solar UV pumping of OH was near zero at the time of the infrared OH detection (1974 Jan. 7.95).

The observations will be published in detail in Icarus. Equipment and data reduction procedures will be published elsewhere. This work was sponsored under NASA Grant NGR 33219002.

References

1. Biraud, F., Bourgois, G., Crovisier, J., Fillit, R., Gerard, E., and Kazes, I., "OH Observations of Comet Kohoutek at 18 cm", Comet Kohoutek Workshop, MSFC, June 13,14, 1974.
2. Potter, A.E. and Del Duca, D., 1964, Icarus 3, 103.

Infrared Observations of Stars

Prior to instrument failure, we obtained preliminary scans of λ10830 He I in four bright stars--Regulus, Spica, Vega and Castor.

The observations of Spica were obtained at a maximum velocity phase of the spectroscopic binary system which completely eliminated effects of blending that usually plague line profile studies of this star. A paper on this phase of our work entitled "Helium λ10830 in Alpha Virginis A and B" by D. D. Meisel and R. A. Berg was submitted recently to Astrophysical Journal Letters. In this paper equivalent widths, rotational, and orbital velocities are presented along with comments on several recent theoretical analyses of this star.

The analysis of He I λ10830 in Regulus must await further observation. The line is wider than our N_2 scanning range and it was necessary to make two separate scans on different nights. The two sets of data do not agree well because of the difference in relative humidity between the two nights.

The profiles of Vega and Castor show no obvious λ10830 line, but several weak metallic(?) lines appear in each scan. Again, re-observation seems necessary. We doubt that good scans of Castor will ever be obtained because the star is double and the two stars cross-modulate the interferometer pattern. Observations of these and other program stars will commence in November 1974 and continue into 1975. During the same period ultraviolet scans of Lyman α and OI λ1303 will be obtained for several of the same stars using the Copernicus Satellite Telescope of Princeton University Observatory.

Ultraviolet Observations of Stars

Ultraviolet scans of program stars previously obtained by other Copernicus Guest Investigators were examined in order to develop a suitable observing strategy for our own program stars. Proposals for a formal UV/IR data exchange were made to roughly 20 different Guest Investigators with nearly a 99% favorable return.

A copy of the Princeton Telescope Control Program has been run on the CDC-6600 Computer at the University of Buffalo. Command programming is now in progress in preparation for the coming 1974-75 observing season.

Continuation of the Research

Observations will continue at least through 1975 with support from NASA, S.U.N.Y.-Geneseo, and University of Rochester. A grant renewal has been requested to operate under the same number for one additional year.

Bibliography

1. Meisel, D. D. and Berg, R. A. 1974, Icarus October 1974. (In Press) "High Resolution Spectrophotometry of Selected Features in the 1.1 micron Spectrum of Comet Kohoutek (1973f)"

2. Meisel, D. D. and Berg, R. A. 1974, NASA Comet Kohoutek Workshop, MARSHALL SPACE FLIGHT CENTER, Huntsville, Alabama, June 13, 14, 1974. (Summary of Icarus article on Comet Kohoutek)

3. Meisel, D. D. and Berg, R. A. 1975(?), Ap. J. Letters (submitted) "Helium λ10830 in Alpha Virginis A and B."

Helium $\lambda 10830$ in Alpha Virginis A and B

by

David D. Meisel*
Department of Physics and Astronomy
State University of New York
College at Geneseo
Geneseo, New York 14454

and

Richard A. Berg
Department of Physics and Astronomy
and the C.E.K. Mees Observatory
University of Rochester
Rochester, New York

Abstract

Line profiles of He I $\lambda 10830$ obtained at maximum velocity separation of the spectroscopic binary Spica (α Vir) are presented.

Submitted to the
Astrophysical Journal Letters

Received ____________________

*[redacted] Associate of the C.E.K. Mees Observatory

Spica has been the subject of two recent studies of its spectroscopic orbit and β Cephei nature (Shobbrook, Lomb, and Herbison-Evans, 1972; Dukes, 1974). During initial tests of the Vaughan pressure-scanned Fabry-Perot interferometer (modified to restrict the bandpass to a single order), we obtained a scan of Spica at He I λ10830. Although this scan is not of maximum possible quality, it was obtained within hours of the maximum velocity separation of the line components. The interferometer was attached to the 24 inch reflector of the C.E.K. Mees Observatory at South Bristol, New York. The scan consisted of 13 separate 30^s integrations at 1.5 Å intervals. The scan epoch was 1973 April 15 between 0600-0650 U.T. The half-power full width of the interferometer was 1.2 Å and the scanning gas was N_2 between 2 to 120 P.S.I. above ambient atmospheric pressure. The wavelength stability of the instrument is better than ±0.1 Å (±3 km/sec) during a given night. The wavelength scale zero point is established using dome-diffused, He I emission lamp radiation. Contributions to each point due to finite instrumental bandwidth have been removed using an iterative deconvolution procedure. Corrections for blocking filter transmission have also been applied where necessary. The wavelengths, radial velocities, and normalized intensities are given in Table I and Figure 1.

Taking the γ velocity to be zero, the following line velocities (±5 km/sec) and total absorptions were derived.

α Vir A

V sin i = 80 km/sec

He I λ10830 Equivalent Width = 0.45 ± 0.04 Å

Radial Velocity

(a) Line Depth Weighted Average = +115 km/sec

(b) Minimum Line Intensity = + 84 km/sec α Vir B

V sin i = 100 km/sec

He I λ10830 Equivalent Width = 0.61 ± 0.04 Å

Radial Velocity

(a) Line Depth Weighted Average = -164 km/sec

(b) Minimum Line Intensity = -210 km/sec

Using the line-depth weighted velocities, we obtain M_A/M_B = 1.4 for the mass ratio for α Vir. Both line profiles are asymmetrical with the secondary showing the greatest line distortion. The orbital elements of Dukes (1974) for the primary predict a velocity of +114 km/sec in good accord with that obtained using line-depth weighting. Neither of the weighted velocities agree with the predictions of the orbit given by Shobbrook et al. (1972), but the maximum depth velocity of the secondary (-210 km/sec) agrees acceptably with the predicted -208 km/sec. Shobbrook et al. (1972) state that their measurements refer to the line cores. However, the core of the λ10830 line of the primary is displaced -56 km/sec away from the point predicted by the Shobbrook et al. elements. This is somewhat large to be attributable entirely to the β Cephei variation.

The profiles are both asymmetrical and the rotational velocities implied by the half-intensity full widths are only somewhat less than would be expected from synchronous rotation. Our rotational velocities cannot be easily reconciled with the 155 km/sec quoted by Watson (1972) unless his value was obtained at a phase where blending was significant. The rotational frequency estimate made by Dukes (1974) based on Watson's value is therefore too high. Our results imply that the equatorial velocity is 88 km/sec and Ω = 0.22 c/d for α Vir A. Arguments concerning the rotational splitting of the β Cephei pulsation modes should be revised accordingly. For Spica it seems that models such as those considered by Denis (1972) assuming synchronous rotation would be applicable if extended to higher polytropic indices.

No quantitative discussion of the observed equivalent widths of He I λ10830 has been attempted because of the uncertainty of the spectral classification of α Vir B. It seems well established that B1 V is reasonable for α Vir A (Jaschek, Conde, and de Sierra, 1964). A mean spectral type for α Vir A+B of B1.5 V in a spatial configuration similar to the maximum velocity phase was derived by a careful intercomparison of microphotometer tracings of 40 Å/mm plates taken with the 72-inch Perkins telescope of the Ohio State and Ohio Wesleyan Universities at Lowell Observatory in the years 1965-66. The exposure of Spica was made on baked Kodak IIa-O plates by Philip Ianna. A total spectral range of 3400-4900 Å is available. The epoch of the Perkins plate was 1965 June 25.12 U.T. at a time when the velocity separation between A and B lines was 90 km/sec and the phase was such that the "backside" of α Vir A and "front side" of α Vir B were toward the earth in a configuration +0.1 orbital phase away from that of the λ10830 profile. Our classification is based on the relative strengths of the He I lines shortward of the Balmer limit, the relative strengths of the H I and He I lines at the Balmer limit, the O II and N II lines, and the relative strengths of the He I lines longward of Hγ. The MK standard star tracings available included ω^1 Sco (B1 V), ζ Cas (B2 V), o Per (B1 III) and σ Sco (B1 III). Comparison was also made to a tracing of 23 Ori A (B1 IV). We are in the process of studying near infrared spectra of Spica taken with the 24-inch Mees Telescope at maximum velocity phases in an effort to improve the spectral classification especially of the B component. Preliminary inspection indicates $B2^+$ V for B but this is somewhat uncertain at this point and more plates must be taken to improve the result. The above classification of the composite spectrum (with the A component assumed predominant) is slightly cooler than the usual estimates (Jaschek et al., 1964) for this star, but the microphotometric tracings indicate quite clearly that Spica A+B is intermediate to the standards with regard to temperature and not intermediate with regard to luminosity.

This work is supported by NASA grant NGR 33-219-002 and a Research Grant from the State University College at Geneseo. We thank Dr. Arne Slettebak of the Perkins Observatory, Delaware, Ohio for extended loan to one of us (D.D.M.) of Perkins plates used to derive the spectral type of α Vir A.

References

1. Denis, J. 1972, Astr. and Ap. 20, 151.

2. Dukes, R. J. 1974, Ap. J. 192, 81.

3. Jaschek, C., Conde, H., and de Sierra, A. C. 1964, Ob. Astron. Univ. Nac. de La Plata, Serie Astronomica 28, No. 2.

4. Shobbrook, R. R., Lomb, N. R., and Herbison-Evans, D. 1972, M.N.R.A.S. 156, 165.

5. Watson, R. D. 1972, Ap. J. Suppl. 24, 167.

Table I

Spica April 15, 1973 0600-0650 U.T.
Epoch JD 2441787.75

Rest Wavelength	Radial Velocity (km/sec)	Normalized Intensity
10819.5	-294	1.00
10821.0	-252	0.88
10822.5	-210	0.72
10824.0	-168	0.79
10825.5	-126	0.85
10827.0	- 84	0.86
10828.5	- 42	0.93
10830.0	0	1.00
10831.5	+ 42	0.94
10833.0	+ 84	0.73
10834.5	+126	0.79
10836.0	+168	0.80
10837.5	+210	1.00
RMS Deviation ±0.1 Å	RMS Deviation ±3 km/sec	RMS Deviation ±0.02

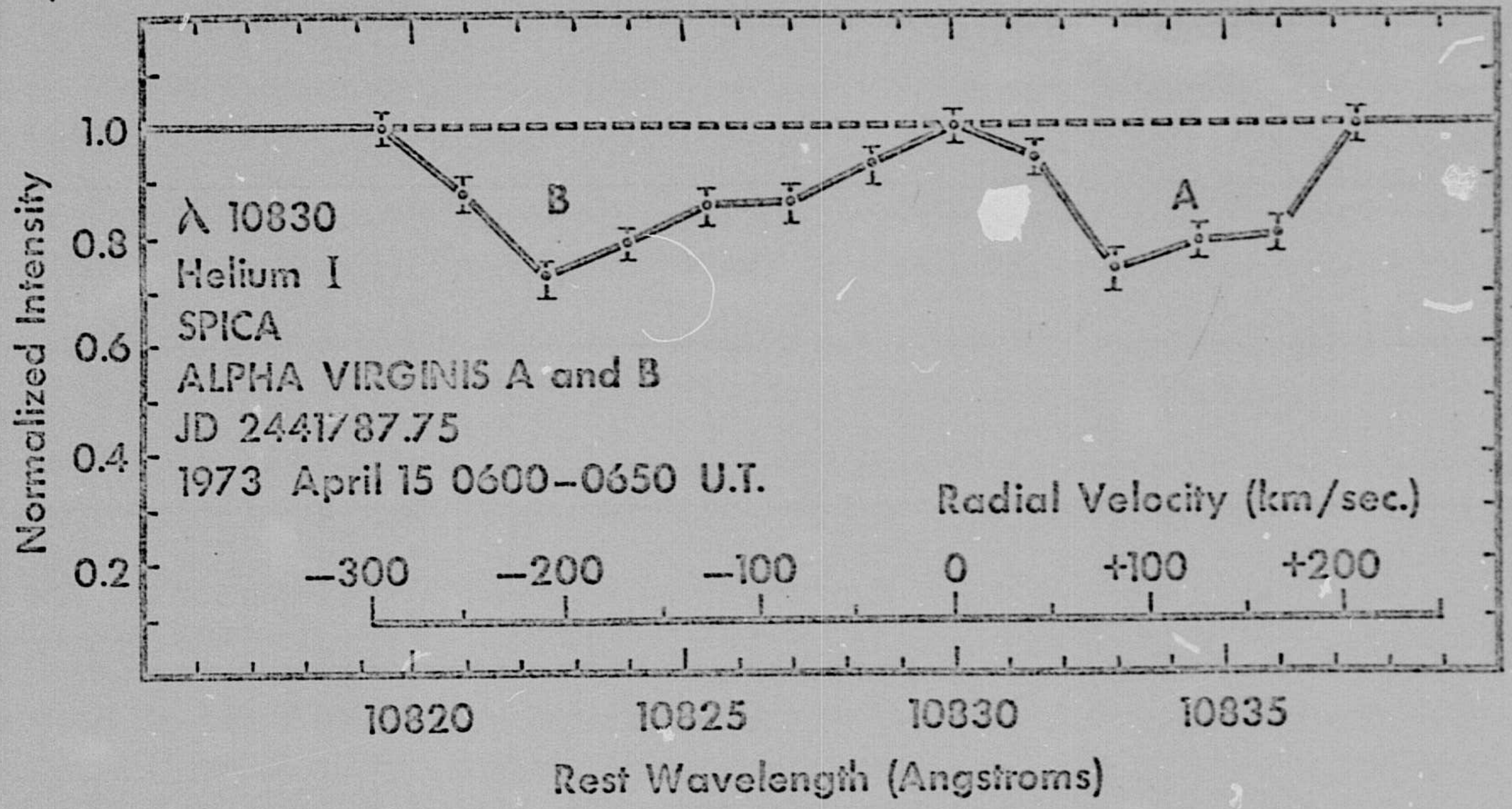

Fig 1 - Helium line λ10830 profile in Spica. The error bars indicate uncertainty due to counting statistics.

High Resolution Spectrophotometry of Selected Features in the 1.1 micron Spectrum of Comet Kohoutek (1973f)

by

David D. Meisel*
Department of Physics and Astronomy
State University College
Geneseo, New York
14454

and

Richard A. Berg
Department of Physics and Astronomy
and the C.E.K. Mees Observatory
University of Rochester
Rochester, New York
14627

Received ______________________

Revised ______________________

* Associate of the C.E.K. Mees Observatory.

Original and 3 copies, consisting of 11 pages, 3 tables, and no figures.

Page Head: 1.1μ Spectrum of Comet Kohoutek

Proof Address: Dr. Richard A. Berg
Space Science Center
Dept. of Physics and Astronomy
University of Rochester
Rochester, NY 14627

Abstract

Fabry-Perot interferometry of Comet Kohoutek (1973f) at 1.1 microns with a resolution of 1.2 Å showed emission features identified as OH and CN lines in addition to a strong Fraunhofer continuum. Central intensities have been derived for three cases (uniform, gaussian, and gaussian plus ρ^{-1} law) of brightness profiles in the comet coma. Limits for CH_4, H_2O, HeI, SiI and CrI are also derived.

The Fabry-Perot interferometer designed and described by Vaughan (1967) has recently been modified to permit pressure scanning with N_2 gas over a free-range of 30 Å at a wavelength of 1.1 microns with 1.2 Å halfpower full-width. Overlapping orders are blocked by prefiltration. We describe here observations of Comet Kohoutek (1973f) obtained with the interferometer attached to the 24-inch reflector of the C.E.K. Mees Observatory, University of Rochester, at Bristol, New York on 1974 January 4.95 and 1974 January 7.95 U.T. when the comet heliocentric distances were 0.34 and 0.43 astronomical units respectively and the geocentric Doppler velocities were -37.5 km/sec and -26 km/sec respectively (Yeomans, 1973).

Observations were made with a 54" of arc diaphragm centered on the visible central condensation. A dry-ice cooled ITT FW-118 photomultiplier with very low dark currents was employed. Pulses from the photomultiplier were accumulated in 30^s and 60^s time-intervals at each wavelength. Scans were obtained in 0.5 Å steps. Wavelength and instrumental profile calibrations were performed by observing dome-diffused He I λ10830 from a voltage regulated discharge lamp and then extrapolating through successive free-ranges to those regions where no direct calibration lines were available. Wavelength stability and repeatability are usually better than ± 0.1 Å per hour. Intensity calibrations were performed using both Jupiter and the B9III star α Andromedae. On 1974 January 04.95, we alternated between sky plus comet and sky alone at each wavelength. The sky corrected results were then compared to a smoothed version of the reference continuum of Maillard et al (1973) appropriately Doppler-shifted for each date. Emission-free and absorption-free regions of the continuum were then selected and used as discrete references for the 1974 Jan. 07.95 observations at particular search positions. This was done in an effort to cut down on the required scan times.

After correction for atmospheric extinction and source size differences, the Jupiter and α And calibrations agreed within 7% so we conclude that in spite of the fact that the observations were obtained through very large air masses, the photometric stability was better than 10%. However, because of the faintness of the comet, our count rates were low and the quoted errors are scaled from the counts assuming Poisson statistics. Counts at each wavelength were totaled and then corrected for extinction and incomplete pre-filtration by the blocking filter when necessary.

We have computed the central intensity of the comet inner-coma for three separate cases. Case A assumes a uniform intensity over the entire 54" of arc diaphragm. For Case B we assume a pure Gaussian profile. For Case C, we joined a Gaussian in the inner-coma with a ρ^{-1} law (where ρ is the projected radial distance from the nucleus) at a point where the Gaussian and $1/\rho$ slopes match. Using the 1.1 micron image-tube spectrogram of the central coma of Comet Bennett (1969i) (Meisel and Deutsch, 1972) and scaling to the geocentric distance of Comet Kohoutek indicates that the mean $\sigma_{1.1\mu}$ value which should be used in Cases B and C is 4" of arc. This is in good agreement with the visual coma half-intensity full-width of 10" of arc estimated in the guiding eyepiece of the interferometer on both Jan. 04.95 and Jan. 07.95 U.T. (It should be noted, however, that a definite stellar nucleus was seen with the 24-inch only on Jan. 07.95.) We have, therefore, adopted $\sigma_{1.1\mu}$=4" of arc in our calculations. Values for other $\sigma_{1.1\mu}$ can be scaled from our quoted results. We consider both Case A and Case B as extremes. Case C seems to be the most likely coma configuration.

The value of the mangitude at 1.09μ for Jupiter was $+0^{m}.1$, using data in Harris (1961) and Savage and Danielson (1968). Compared to Jupiter, we derived for comet Kohoutek an average 1.2 Å (monochromatic) magnitude (over a 54" of arc diaphragm) for the 1.1 micron continuum of $+4^{m}.2$ for Jan. 04.95 U.T. and $+4^{m}.5$ for Jan. 07.95 U.T. This compares favorably with the magnitude interpolated from the broad-band photometry of Ney, Stoddart and Wardrop (1974). In Table I we list our positive identifications giving the date, species, transition, line identification and air wavelength along with the computed intensity (maximum values for Cases B and C) in rayleighs (10^6 photons/sec for all angles integrated over a column of 1 cm^2 cross-section to the comet nucleus). In Table II we list lines for which explicit searching gave marginal or negative results. With an expansion velocity of comet gas of ≈ 1 km/sec and an average lifetime against dissociation by solar UV radiation of 10^4-10^5 seconds for both H_2O and CH_4 (Potter and Del Duca, 1964), it is likely that our 54" diaphragm included most of the coma that would contain these neutral molecules. We present deconvolved results for Case C in Table III, where intrinsic Fabry-Perot inter-peak leakage and off-axis vignetting have been removed.

Most of the radiation we detect occurs within a few (<10) thousand kilometers of the nucleus in an environment where collisional processes may not be negligible (Code and Savage 1972; Bertaux, et. al. 1973). In view of the extremely low OH excitation temperatures implied by radio observations of Comet Kohoutek over a larger area of the comet (Turner 1974), and the uncertainty in the radial temperature distribution near the nucleus, we do not attempt to derive molecular densities.

This work was sponsored under NASA Grant NGR 33219002 to one of us (D.D.M.).

References

Benedict, W. S. (1964). New bands in the vibration-rotation spectrum of water vapor. Phys. Rev. 74, 1246.

Bertaux, J. L., Blamont, J. E. and Festou, M. (1973). Interpretation of hydrogen Lyman-alpha observations of Comets Bennett and Encke. Astron. Astrophys. 25, 415.

Code, A. D. and Savage, B. D. (1972). Orbiting Astronomical Observatory: Review of Scientific Results. Science 177, 213.

Herzberg, G. (1964). "Molecular Spectra and Molecular Structure. II. Infrared and Raman Spectra of Polyatomic Molecules." Van Nostrand, Princeton.

Harris, D. L. (1961). "Photometry and Color of Planets and Satellites." Planets and Satellites, Vol. III, Kuiper and Middlehurst, ed. (U. of Chicago, Chicago).

Krassovsky, V. I., Shefov, N. N., and Yarin, V. I. (1962). Atlas of the airglow spectrum 3000-12400Å. Planet. Space Sci. 9, 883.

Maillard, T. P., Combes, M., Encrenaz, Th., and Lecacheux, J. (1973). New infrared spectra of the jovian planets from 12000 to 4000 cm^{-1} by fourier transform spectroscopy. Astron. Astrophys. 25, 219.

Meisel, D. D. and Deutsch, J. L. (1972). A 1.1 micron spectrogram of the central coma of Comet Bennett (1969i). Publ. Astron. Soc. Pac. 84, 732.

Ney, E. P., Stoddart, J. and Wardrop, A. (1974). IAU Circular No. 2619.

Potter, A. E. and DelDuca, B. (1964). Lifetime in space of possible parent molecules of cometary radicals. Icarus 3, 103.

Savage, B. D., Danielson, R. E., (1968). "Models of the Atmosphere of Jupiter," Infrared Astronomy, P. J. Brancazio and A. G. W. Cameron, ed. (Gordon and Breach, New York).

Turner, B. E. (1974). Detection of OH at 18-Centimeter Wavelength in Comet Kohoutek (1973f). Astrophys. J. Letters, 189, L137.

Vaughan, A. (1967). Astronomical Fabry-Perot interference spectroscopy. Ann. Rev. Astron. Astrophys. 5, 139.

Yeomans, D. K. (1973). Ephemeris distributed by NASA Operation Kohoutek Office (Computer Sciences Corp.).

Table I. Features Observed in 1.1 micron Spectrum of Comet Kohoutek (1973f)

Date 1974 U.T.	Species	State or Transition	Line Identification	λ_{air}	Observed Maximum Intensity Case A (R)	Case B (kR)	Case C (kR)
Jan 04.95	Continuum	--	--	~11010 Å	2300±150/Å	390±25/Å	35±2/Å
07.95	Continuum	--	--	~10838 Å	2100±150/Å	350±25/Å	33±2/Å
Jan 07.95	CN	(0-0)					
		$A^2\pi - X^2\Sigma$	$Q_1(12)$	11018.1	450±210	75±35	7.0±3.3
			$P_1(6)$	11024.9	530±150	90±25	8.2±2.3
Jan 07.95	OH	(5-2) $X^2\pi$	Q_1	10831.0	310±150 (*)	53±25	4.8±2.3

(*) For comparison, the terrestrial nightglow value (Krassovsky et al, 1962) is approximately 700R, a value which is in agreement with our own night-sky observations with our instrumentation.

Table II. Features Not Present or Marginal in the 1.1μ Spectrum of Comet Kohoutek

Date 1974 U.T.	Species	Transition and Identification	λ_{air}	Maximum Intensity Case A (R)	Case B (kR)	Case C (kR)	Notes
04.95	CH_4	$3\nu_3$ R(J=1)	11025.3	-210 ± 150	-35 ± 25	-3.3 ± 2.3	(1)
07.95	H_2O	000 - 012 $P(3_{-2}-2_{-2})$ $P(3_{+2}-2_{-3})$ $Q(3_{0,+3}-3_{+2})$ $P(3_{+2}-2_{0,+2})$	11017-11020	< 150	< 25	< 2.3	(2)
07.95	HeI	$2\,^3P_{1,2}-2\,^3S$	10830	14 ± 150	2 ± 25	0.2 ± 2.3	(3)
07.95	SiI	Mult. 39	11018	< 150	< 25	< 2.3	
07.95	CrI	Mult. 221	11016	< 150	< 25	< 2.3	
07.95	CN	$R_1(25)$ $Q_2(16)$	11014.6	< 150	< 25	< 2.3	

NOTES:

(1) Corrected for CN blending.
(2) Identifications based on calculations using H_2O molecular constants (Benedict, 1948; Herzberg, 1964).
(3) Corrected for OH blending.

Table III - Deconvolved Emission Line Features and Computed Molecular Emission Rates for Central Coma of Comet 1973f

Jan. 1974 Date	Feature	Wavelength Å	I_c (kilorayleighs)	Total Luminosity (photon sec^{-1})
04.95	continuum	11015	33 ± 1/Å	9.9×10^{36}/Å
07.95	continuum	10828	31 ± 1/Å	9.3×10^{36}/Å
07.95	CN $Q_1(12)$	11018.1	9 ± 2	2.7×10^{36}
	$P_1(6)$	11024.9	10 ± 1	3.0×10^{36}
	OH $Q_1(5-2)$	10831.0	6 ± 1	1.8×10^{36}
04.95	CH_4 $3\nu_3$	11025.3	< 1	$< 3 \times 10^{35}$
07.95	H_2O	11017-11020	< 1	$< 3 \times 10^{35}$
	HeI	10830	< 1	$< 3 \times 10^{35}$
	SiI	11018	< 1	$< 3 \times 10^{35}$
	CrI	11016	< 1	$< 3 \times 10^{35}$
	CN $R_1(25)$	11014.6	< 1	$< 3 \times 10^{35}$
	CN $Q_2(16)$	11013.3	< 1	$< 3 \times 10^{35}$

Errors shown are those after spatial filtering.

List of Symbols (in order of use)

Page 2

μ	-	Greek letter "mu"

Page 3

Å	-	abbreviation for angstrom
ρ	-	Greek letter "rho"

Page 4

"	-	seconds of arc
λ	-	Greek letter "lambda"
$\pm$	-	"plus or minus"
α	-	Greek letter "alpha"

Page 5

%	-	"percent"

Page 6

σ	-	Greek letter "sigma"
superscript ^{m}	-	abbreviation for magnitude
$\approx$ or ~	-	"approximately equal to"

Page 9

π	-	Greek letter "pi"
Σ	-	Greek letter "uppercase sigma"

High Resolution Spectrophotometry of Selected Features in the 1.1 micron Spectrum of Comet Kohoutek (1973f) [Summary]

by

David D. Meisel*
Department of Physics and Astronomy
State University College
Geneseo, New York
14454

and

Richard A. Berg
Department of Physics and Astronomy
and the C.E.K. Mees Observatory
University of Rochester
Rochester, New York
14627

NASA Comet Kohoutek Workshop
MARSHALL SPACE FLIGHT CENTER
Huntsville, Alabama

June 13,14, 1974

*Associate of the C.E.K. Mees Observatory.

A pressure-scanned Fabry-Perot interferometer with complete blocking of overlapping orders was used on the C.E.K. Mees Observatory (University of Rochester) 24-Inch reflector (at Bristol, N.Y.) to observe Comet Kohoutek (1973f). Selected regions in the 1.1 μ near-infrared spectrum were scanned with a resolution of 1.2 Å half-power-full-width. Profile deconvolution as carried out using a newly-developed Fourier transform, non-linear sampling and transform inversion procedure, enabled weak spectral line emissions to be detected against the comet Fraunhofer continuum on 1974 January 4.95 U.T. and 1974 January 7.95 U.T.

Two radicals, CN(0-0)[A $^2\pi$-X $^2\Sigma$] and OH(5-2)[X $^2\pi$] were observed but searches for He I (λ10830), H_2O (000-012), and CH_4 $3\nu_3$ R (J=1) were negative although it is likely that our 54" of arc diaphragm probably included most of the coma that is likely to contain neutral molecules (Potter and Del Duca, 1964).

Central intensities (or upper limits) were derived for three possible cases for the change of intensity within the Fabry-Perot diaphragm. Limits to molecular production rates for CH_4 and H_2O were not derived because of the difficulties in assessing the contribution of collisional effects in the regions near the comet nucleus.

Although a quantitative analysis of the OH infrared emission has not yet been carried out, it is plausible that the OH (5-2) Q_1 line was

For (a) and (b) we have both wide and narrow versions so that eventually we will develop He I line indices in a manner analogous to the Balmer line filters used extensively in spectral classification studies of early-type stars. The oxygen line filters were obtained with a grant to R. A. Berg by the University of Rochester. The CH_4 filter was obtained through a special Comet Kohoutek NASA grant.

Equipment modifications and additional computer support during Summer 1974 were funded through a S.U.N.Y.-Geneseo summer research grant.

Grant-Related Professional Activities

1) In October 1973, Meisel participated in the NASA sponsored "Comet Kohoutek Workshop" in preparation for making interferometer observations at 1 micron of Comet Kohoutek.

2) In spring 1974, Meisel went to Princeton Observatory to make arrangements and preparations for obtaining Copernicus Telescope data on Stellar Lyman α and the OI lines at 1303 Å.

3) In June 1974, Meisel (with additional NASA support) presented the Comet Kohoutek results at the 2nd "Comet Kohoutek Workshop" held at NASA Marshall Space Center.

4) In October 1974, Meisel (with additional S.U.N.Y.-Geneseo and NASA support) participated in the I.A.U. symposium "The Nature of Comets". Although the paper presented was not directly related to the infrared and ultraviolet project, we probably will be able to operate the instrument should another bright comet appear in the northern hemisphere.

5) In August 1974, Meisel and Berg participated in the American Astronomical Society meeting at University of Rochester.

Infrared Observations of Comets

Although comet observations are not covered within the usual program of observation proposed for this grant, the unique capabilities of the Vaughan interferometer for performing high resolution scans of selected comet spectral features in the near-infrared have not been neglected. With additional NASA support, we were able to make observations of Comet Kohoutek in January 1974. These results have been published in Icarus (October 1974) as well as appearing in summary form in the Comet Kohoutek Workshop proceedings as a paper entitled "High Resolution Spectrophotometry of Selected Features in the 1.1 micron Spectrum of Comet Kohoutek (1973f)" by D. D. Meisel and R. A. Berg.