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A CONGERIES OF ABSORPTION CROSS SECTIONS FOR WAVELENGTHS LESS THAN 3000Å

by J. O. Sullivan and A. C. Holland

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SECTION I
INTRODUCTION

1. Purpose

The absorption of ultraviolet solar radiation is of prime importance for the study of planetary atmospheres. The absorption coefficients of most of the atmospheric gases have been measured by a number of investigators, but the results are scattered throughout the literature. This report contains a detailed collection of absorption cross sections of the gases listed in Table 1 for wavelengths less than 3000Å.

The data in this report were obtained from (1) the literature, (2) studies recently completed in our laboratories, and (3) private communications from other investigators. The available data on each gas are given together with a historical sketch of the study of the gas and a list of the pertinent references. We have also included an entirely new study of the absorption and photoionization coefficients of the major atmospheric gases at intense solar emission lines.

2. Techniques

The equipment necessary to obtain absorption cross sections includes a light source, a light dispersing device such as a monochromator, an absorption cell, and a detector.

Light sources for the vacuum ultraviolet are basically discharge tubes whose output is either a continuous or a line emission spectrum. In order to obtain a high-resolution absorption profile it is essential to use a light source that produces a continuous spectrum in the wavelength region to be studied, together with a high-resolution dispersing device. With a continuum light source, the highest resolution obtained photoelectrically, consistent with a usable signal, is about 0.2Å. Line emission sources, on the other hand, are often more intense than continuous light sources and the individual lines produced have widths of about 0.05Å. For investigations of the absorption at precise wavelengths — for example, in the case of known solar emission lines — line sources admit precise wavelength identification, and the narrow line produced allows high resolution to be achieved with a monochromator of moderate resolution.

Detectors are either photographic plates or photoelectric devices. The early investigators used photographic detection exclusively; however, this method required extreme care in the calibration of the photographic plates. In the last decade, the use of photomultipliers, photon counters, and Geiger counters in vacuum ultraviolet spectrometry has increased. Photoelectric devices which have linear responses eliminate the laborious and difficult

TABLE 1

Summary of Absorption Cross Section Studies

Gas	Absorption Curves (Wavelength Region) (Å)	Tabulated Values (Wavelength Region) (Å)
Oxygen	600-1800 1850-2500	112-1751
Ozone	1050-3000	526-1305 2002-2992
Carbon Dioxide	840-1750	165-1752
Carbon Monoxide	600-1006 1050-1065	304-1306
Water Vapor	600-1850	195-1855
Nitrogen	600-1000	145-1306
Argon	283-788	283-788
Nitric Oxide	590-960 1065-2300	168-1450
Nitrous Oxide	600-960 1080-2160	163-981 1080-2160
Nitrogen Dioxide	1080-3000	2400-3000
Ammonia	560-1000 1080-2200	374-1306
Methane	170-1000 1065-1610	374-1306
Hydrogen Sulfide	1050-2720	--
Sulfur Dioxide	1065-3150	--

task of calibration required in photographic photometry and hence simplify data analysis.

Measurements of the absorption cross sections, σ_λ, are based on the Lambert-Beer Law:

$$I_\lambda = I_{o(\lambda)} \exp(-n \sigma_\lambda L) \quad (1)$$

where $I_{o(\lambda)}$ is the photon flux at wavelength λ, incident upon the absorbing gas; I_λ is the photon flux transmitted through the absorbing gas; L is the length of the absorption path (cm), and n is the molecular number density of the absorbing gas ($molecules/cm^3$). The absorption cross section can be related to the absorption coefficient k_λ by the relation $\sigma_\lambda = k_\lambda/n_o$, where n_o is Loschmidt's number ($2.7 \times 10^{19}/cm^3$ at STP). The Lambert-Beer Law is strictly true only for monochromatic radiation. However, if the absorption cross section does not vary too rapidly with wavelength, the use of the Lambert-Beer Law over a finite wavelength region defines an effective absorption cross section for that waveband. Increasing the resolution of the measurements will not appreciably affect the value of the effective cross section. However, if the absorption cross section varies considerably over the wavelength of the incident radiation, the Lambert-Beer Law as stated above does not hold, and the following form must be used

$$I_\lambda = I_{o(\lambda)} \exp(n L \int_{\Delta\lambda} \sigma_\lambda \, d\lambda), \quad (2)$$

where $\Delta\lambda$ is the wavelength interval of the incident light. Use of Equation (1) will yield an absorption cross section that shows an apparent dependence on the number density of the absorbing particles. Increasing the resolution of the measurements (decreasing $\Delta\lambda$) will result in a marked change in the apparent cross section.

3. Presentation of Data

The principal sources of data in this report are tables and graphs of absorption cross sections for various wavelengths in the ultraviolet region. These tables are, wherever possible, reproduced directly from the cited sources. In some cases the values of absorption cross sections have not been reported in the literature and only plots of the cross sections have been published. In these cases, the data were reproduced directly from the open literature if the investigator employed a continuum light source and a sufficiently high resolution. To give the reader a convenient review of the data available and of the range of values of the absorption cross sections of each gas in the entire wavelength region, we have included graphs of the cross sections versus wavelength provided again that a continuum emission light source with a sufficiently high resolution was used. When additional data were available at solar lines (for O_2, N_2, CO, CO_2) these data are shown with vertical lines calling attention to the fact that they are taken with line emission light sources. With the exception of the data of Watanabe and co-workers, whose plots are used, all other line emission measurements are presented in tabular form only.

SECTION II

ABSTRPTION CROSS SECTION STUDIES

1. Oxygen

a. Historical Survey [1-3]*

Ditchburn and Young [4] measured absorption cross sections for the Herzberg dissociation continuum in the spectral region from 2000Å to 2500Å and calculated values for the region from 1850Å to 2000Å. In the region of the Schumann-Runge continuum, absorption coefficients were first measured by Ladenburg and Van Voorhis [5], and later measured by Schneider [6]. Absorption coefficients for this region were calculated by Stueckelberg [7]. Recently, the measurements were repeated by Watanabe et al. [8], and by Ditchburn and Heddle [9]. Below 1300Å, the absorption spectrum was first observed by Price and Collins [10] and by Tanaka [11]. The absorption of O_2 at the Lyman-alpha line has been measured by Preston [12], and more recently by Watanabe et al. [8], Ditchburn et al. [13], and Lee [2]. Weissler and Lee [14] reported absorption coefficients below 1300Å. Watanabe et al. [8] obtained the contour of O_2 in the region 1050Å to 1350Å, but the results were considered by the authors as semiquantitative. Watanabe et al. [15] and Watanabe [16,17] reinvestigated this area. Clark [18] presented absorption values below 1000Å. Lee [2] measured the region from 200Å to 1320Å to establish the range and magnitude of the continua therein. Aboud et al. [19] presented preliminary absorption results in the region down to 100Å. Other investigators who have measured absorption coefficients below 1000Å include Matsunaga and Watanabe [20], Wainfan et al. [21], Watanabe and Marmo [22], Huffman et al. [23], Cook and Metzger [24], Samson [25], and Samson and Cairns [26].

Photographic detection was used in three cases; i.e., Clark [18], Weissler et al. [14], and Lee [2] and photoelectric detection was used in seven cases; namely, Aboud et al. [19], Watanabe and Marmo [22], Matsunaga and Watanabe [20], Samson [25], Samson and Cairns [26], Huffman et al. [23], and Cook and Metzger [24].

b. Spectral Region 1850Å to 2500Å. The Herzberg Continuum [4]

Herzberg [27] discovered a weak system of bands and an associated continuum in molecular oxygen in the spectral region 1850Å to 2600Å. He attributed the bands to the forbidden transition $^3\Sigma_g \rightarrow {}^3\Sigma_u^+$ and the continuum to the dissociation $O_2(^3\Sigma_g^-) \rightarrow O(^3P) + O(^3P)$. The bands have been investigated experimentally by Chalonge and Vassy [28], Herzberg [29], and Broida and Gaydon [30]. Theoretical calculations have been made by Pillow [31]. Heilpern [32] measured the absorption of oxygen at a single wavelength (2144Å) in the

*Numbers in [ ] throughout text indicate reference numbers.

continuum and Vassy [33] measured absorption of air at wavelengths from 4000Å to 1900Å. Some measurements of oxygen have been reported in a thesis by Stopes-Roe [34]. The band spectrum has been observed in the spectrum of the night sky by Meinel [35].

Ditchburn and Young's [4] measured values include the effects of Rayleigh scattering, which may amount to a maximum of 0.4×10^{-24} cm^2 at 1900Å. This is less than the experimental error of $\pm 1.0 \times 10^{-24}$ cm^2 quoted by the investigators. The data taken below 2000Å was obscured by the overlying Schumann-Runge bands which are approximately 10^6 times stronger than the Herzberg continuum. Extending the continuum to smaller wavelengths required qualitative calculations of the absorption cross sections for different values of the internuclear distance; those for $r_e = 1.50$Å agreed best with the measured values. The calculated values show a maximum value of absorption of 15×10^{-24} cm^2 at 1870Å and yield a total oscillator strength for the continuum of 3.5×10^{-5}.

The work of Watanabe, Zelikoff, and Inn [36] has been extended to 2030Å by Thompson, Harteck and Reeves [37] to include the (3,0),(2,0),(1,0) and (0,0) bands of oxygen. Continuity between the data from Watanabe et al. [36] and Ditchburn [4] with that of Thompson et al. [37] is shown in Figure 7 which gives the absorption data underlying the structure and continua of all three investigators.

c. Spectral Region 1250Å to 2000Å. The Schumann-Runge Continuum and Bands [16]

The bands (1750Å to 2000Å), which overlap the Herzberg continuum, are attributed to the transition ${}^3\Sigma_g^- \rightarrow {}^3\Sigma_u^-$ and the continuum to the dissociative transition ${}^3\Sigma_g \rightarrow {}^3\Pi_u$. The bands have been studied by Curry and Herzberg [38], Knauss and Ballard [39], and more recently by Brix and Herzberg [40] and Wilkinson and Mulliken [41]. These latter investigators concluded that the photochemical dissociation of O_2 in the region 1750Å to 1850Å consists of predissociation and direct dissociation involving the ${}^3\Pi_u$ state.

Watanabe et al. [36] obtained absorption cross section values for the bands with a resolution of 1Å. They indicate that their maxima are probably too low and their minima too high, but that their results are consistent with those of other investigators. The region from 1250Å to 1750Å shows essentially continuous absorption, but Watanabe et al. [42] and Tanaka [11] reported three diffuse bands or narrow continua between 1293Å and 1352Å. Tanaka suggests that the band at 1293Å leads to the dissociation product ${}^3P + {}^1S$ and the other two bands to ${}^1D + {}^1D$ or ${}^3P + {}^1S$. Watanabe et al. [8] reported an f-value for the Schumann-Runge continuum of 0.161.

d. Spectral Region 1100Å to 1250Å [16]

Price and Collins [10] and Tanaka [11] attribute the diffuseness of the bands which occupy this region to predissociation. Contained in this area are seven deep windows including one at Lyman-alpha (1215.7Å) at which the absorption cross section reduces to 1.0×10^{-20} cm^2. It is suggested that since solar Lyman-alpha reaches the D-layer through this window, its enhancement during chromospheric eruption may be responsible for radio fadeout. It is apparent that most of the bands are pressure dependent at comparatively low pressures. Underlying the bands, there probably exists a weak continuum with a maximum absorption cross section of about 10^{-20} cm^2.

e. Spectral Region 850Å to 1100Å [16,20,43]

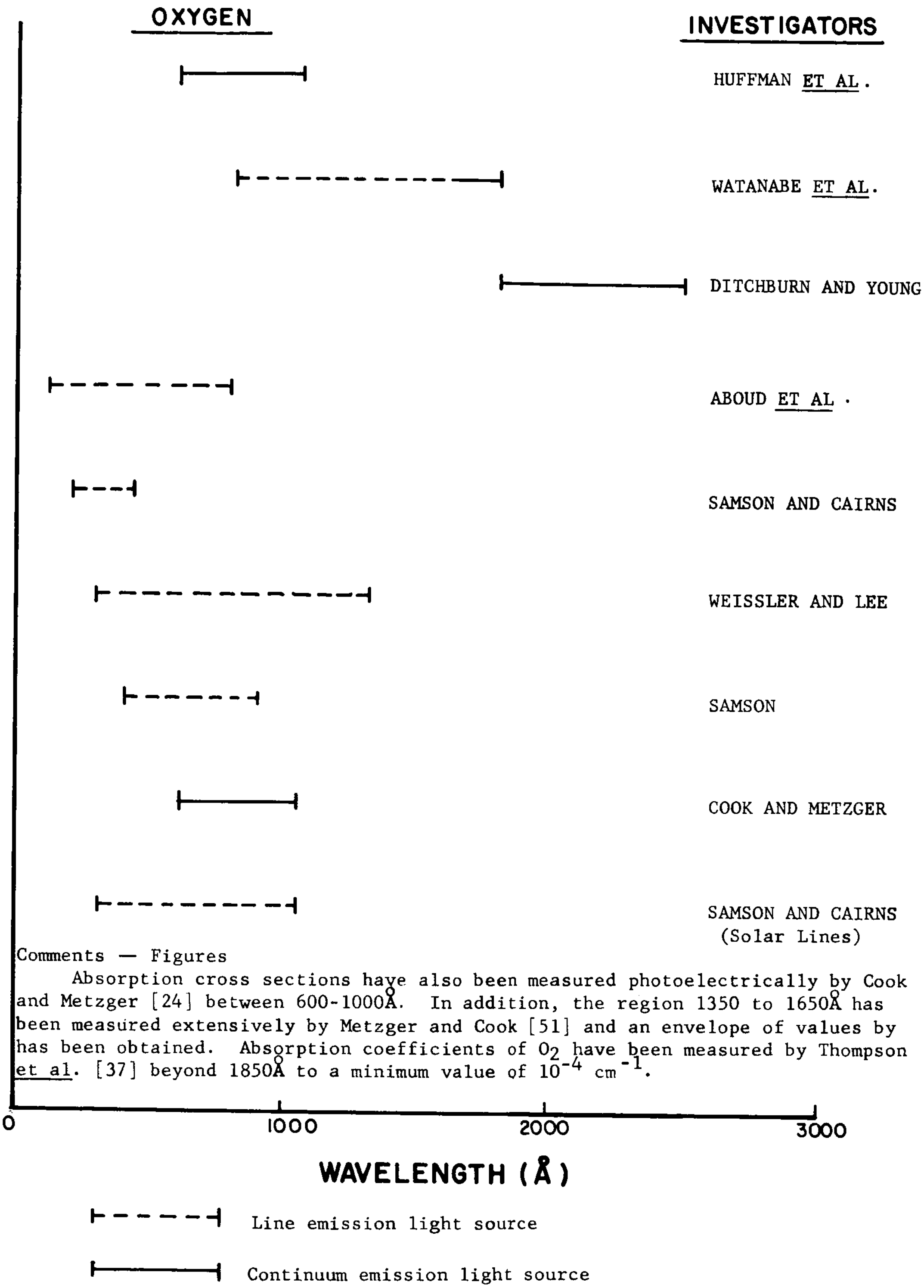
Hopfield [44] first studied the bands, which bear his name, within this region. Many of the bands are expected to be members of the Rydberg series converging to the first ionization potential at 1026.5Å although no series has yet been identified. The value of the first IP is taken from the work of Watanabe and Marmo. However, recent work in this laboratory indicates that this value may actually represent the (1,0) transition, whereas the (0,0) transition occurs at 1046Å [45]. Price and Collins [10] and Tanaka [11] have investigated this. Matsunaga and Watanabe [20], who measured this region with an improved resolution of 0.2Å, observed a pressure effect for the pre-ionized H, H′, M, and M′ bands. A weak dissociation continuum is apparent in the region from 1030Å to 1100Å, which Lee [2] attributed to the dissociation transition $O_2(^3E_g^-) \rightarrow O_2^+ \; X \; ^2\Pi_3$. Huffman et al. [23] have shown a continuum rising linearly from $\lesssim$ 20 cm^{-1} at the first ionization threshold (1026.7Å) to about 3000 cm^{-1} at 840Å where the continuum begins to rise more sharply. Toward shorter wavelengths there are three maxima in the continuum at about 800, 720 and 610Å. An approximate k-value for 800 and 720Å is 850 cm^{-1} and for 610Å the k-value is approximately 1000 cm^{-1}.

f. Spectral Region 100Å to 850Å [2,19] The Extreme Ultraviolet

This spectral region is characterized by strong continuous absorption upon which are superimposed band absorptions corresponding to several series believed to be associated with the ionization of O_2. On the basis of measured minima for the continuum, an f-value of 6.9 was computed by Aboud et al. [19]. However, they report that, owing to scattered light, the data below 300Å from their investigation has little meaning. To the region from 683Å to 740Å, Lee [2] attributed the molecular transition $O_2(^3\Sigma_g^-) \rightarrow O_2^+ \; (A \; ^2\Pi_u)$ and to the region from 200Å to 683Å, he attributed $O_2 \; (^3\Sigma_g^-) \rightarrow O_2^+ \; (b \; ^4\Sigma_g^-)$. The Hopfield bands, which extend to 680Å, form three Rydberg series that converge to the second, third, and fourth ionization limits of O_2 at 770Å and 680Å. An additional Rydberg series converging to 610Å was found by Tanaka and Takamine [46].

g. Atomic Oxygen

The photoionization cross section of atomic oxygen has been computed by Bates and Seaton [47], Dalgarno and Parkinson [48], and most recently by Dalgarno et al. [49] who listed cross sections appropriate to some important solar lines with wavelengths less than 900Å. Recently unpublished work in this laboratory by Cairns and Samson [50] has produced the first measurements of the total absorption cross section of atomic oxygen within the wavelength range 910 - 504Å.



Comments — Figures

Absorption cross sections have also been measured photoelectrically by Cook and Metzger [24] between 600-1000Å. In addition, the region 1350 to 1650Å has been measured extensively by Metzger and Cook [51] and an envelope of values by has been obtained. Absorption coefficients of O_2 have been measured by Thompson et al. [37] beyond 1850Å to a minimum value of 10^{-4} cm^{-1}.

Figure 1. Spectral ranges of data obtained with line and continuum light sources: Oxygen (Figures 2 through 7 and Tables 2 through 10).

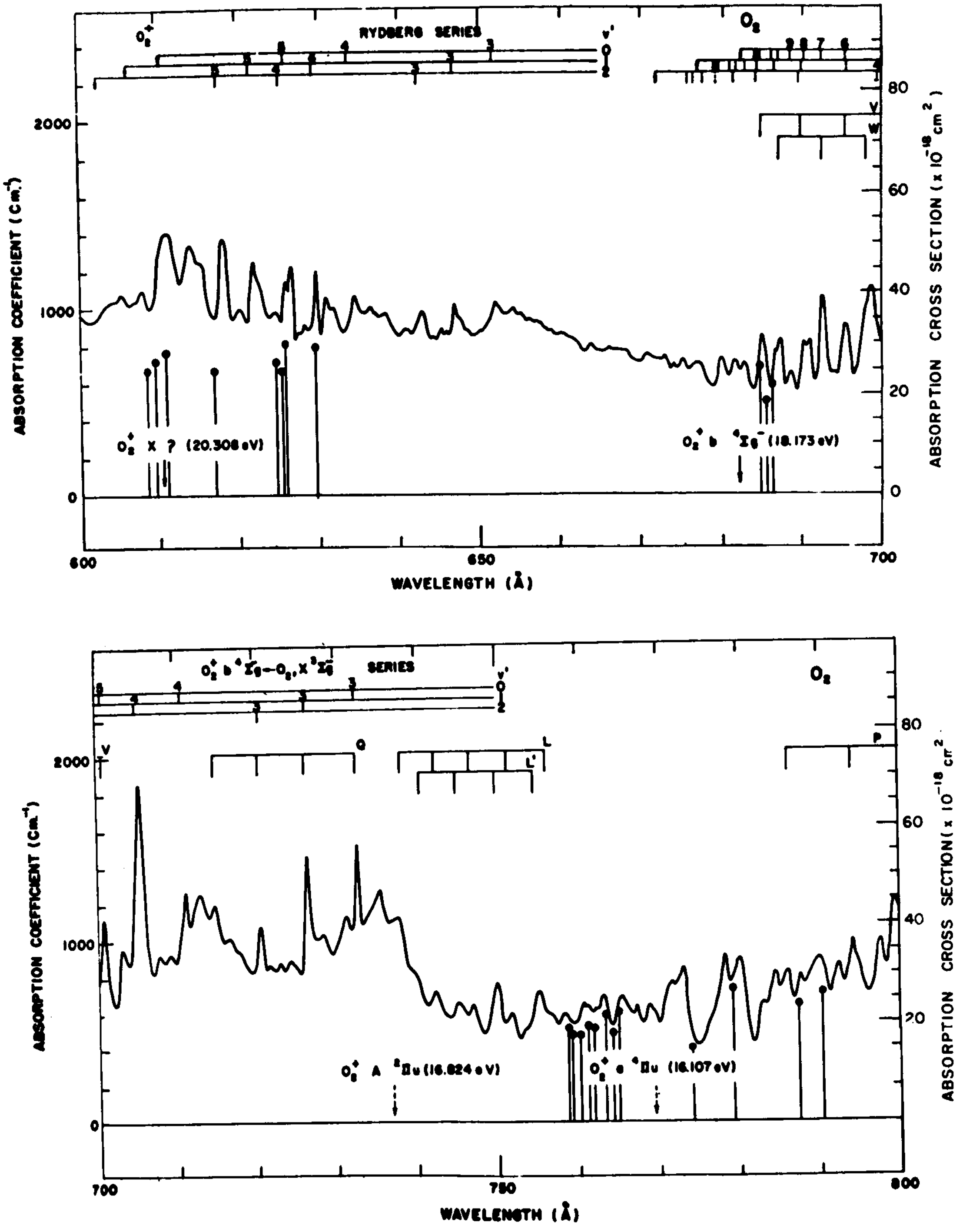


Figure 2. Absorption coefficients and cross sections of O_2.
λ = 600Å to λ = 800Å
Method: Photoelectric detection
Ref: R. Huffman et al., J. Chem. Phys. 40, 356 (1964)
Experimental error: ±10% for values greater than 50 cm^{-1}, λ < 722Å, ±15%

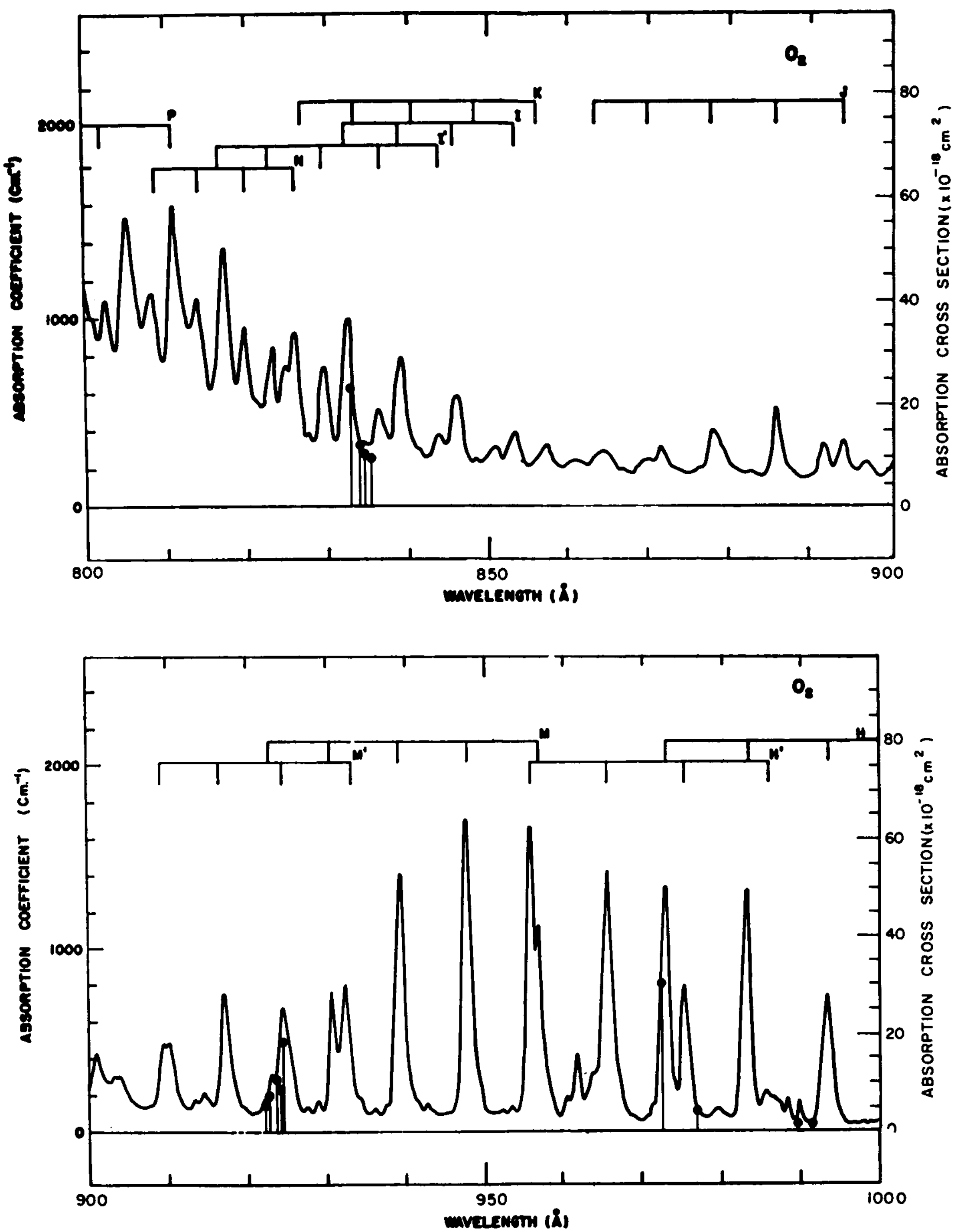


Figure 3. Absorption coefficients and cross sections of O_2.
λ = 800Å to λ = 1000Å
Method: Photoelectric detection
Ref: R. Huffman et al., J. Chem. Phys. 40, 356 (1964)
Experimental error: ±10% for values greater than 50 cm^{-1}

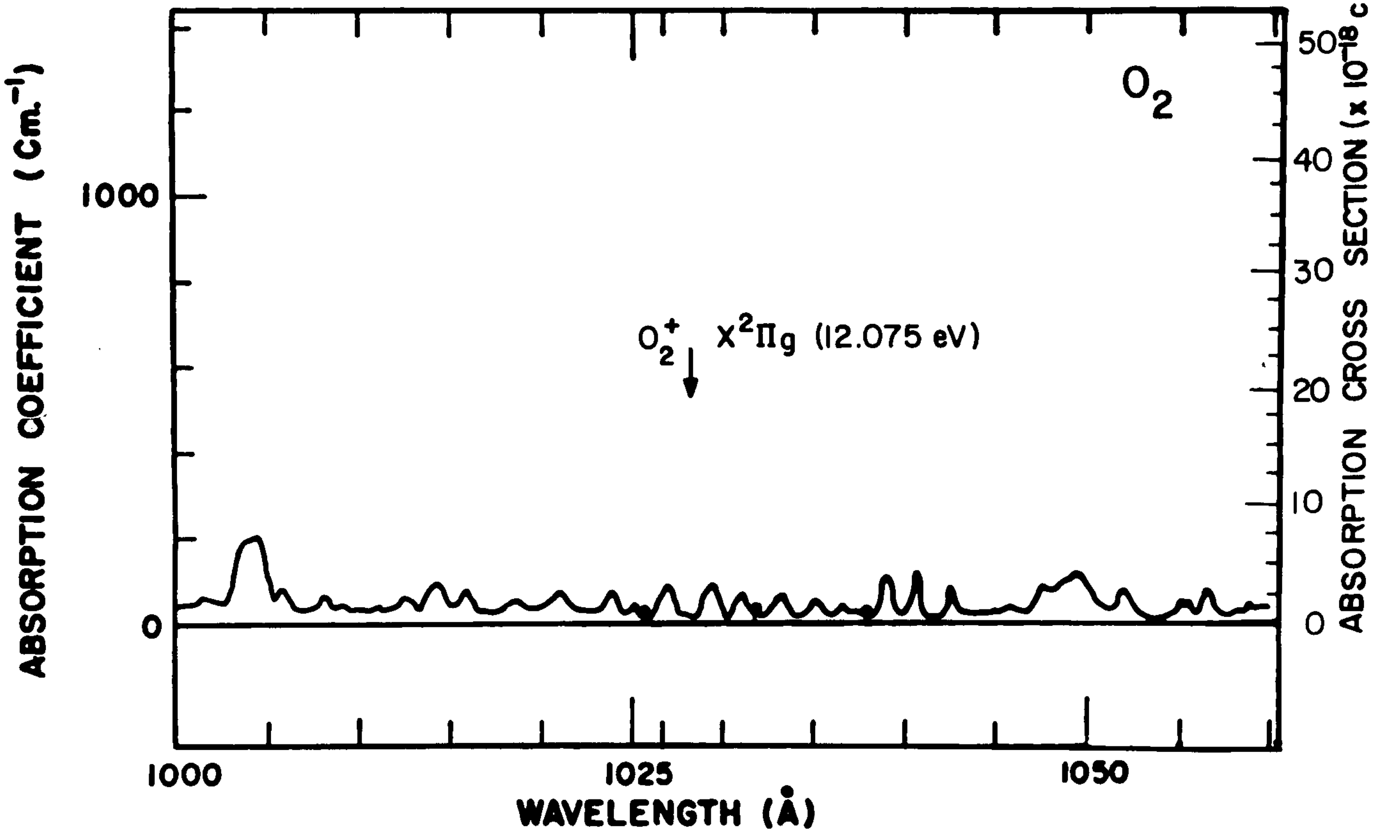


Figure 4. Absorption coefficients and cross sections of O_2.
λ = 1000Å to λ = 1060Å
Method: Photoelectric detection
Ref: R. Huffman et al., J. Chem. Phys. 40, 356 (1964)
Experimental error: ±10% for values greater than 50 cm^{-1}

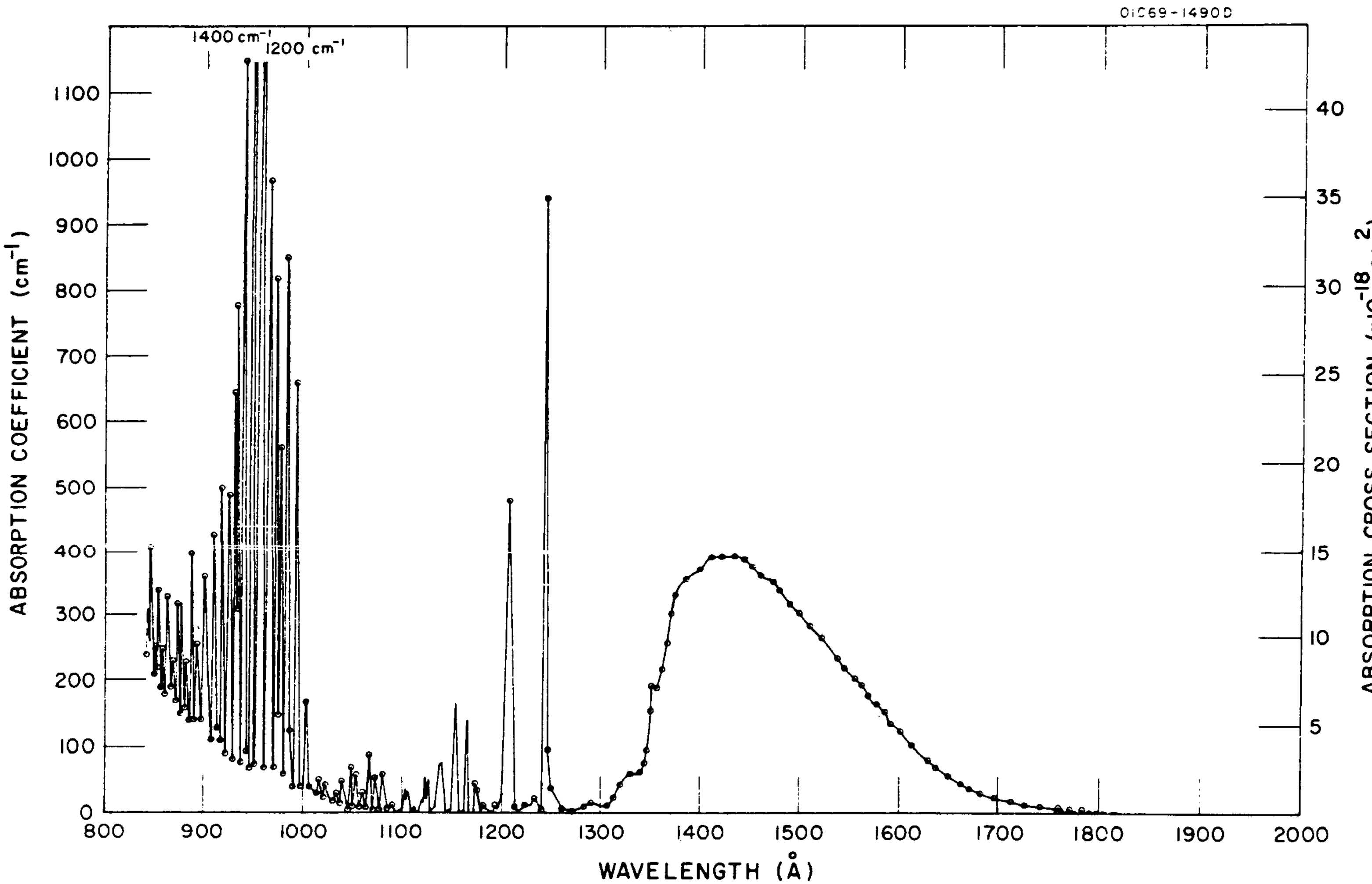


Figure 5. Absorption coefficients and cross sections of O_2.
λ = 840Å to λ = 1060Å
Method: Photoelectric detection
Ref: K. Watanabe <u>et al</u>.
Experimental error: 1060Å to 1170Å, 1750Å to 1900Å semiquantitative only

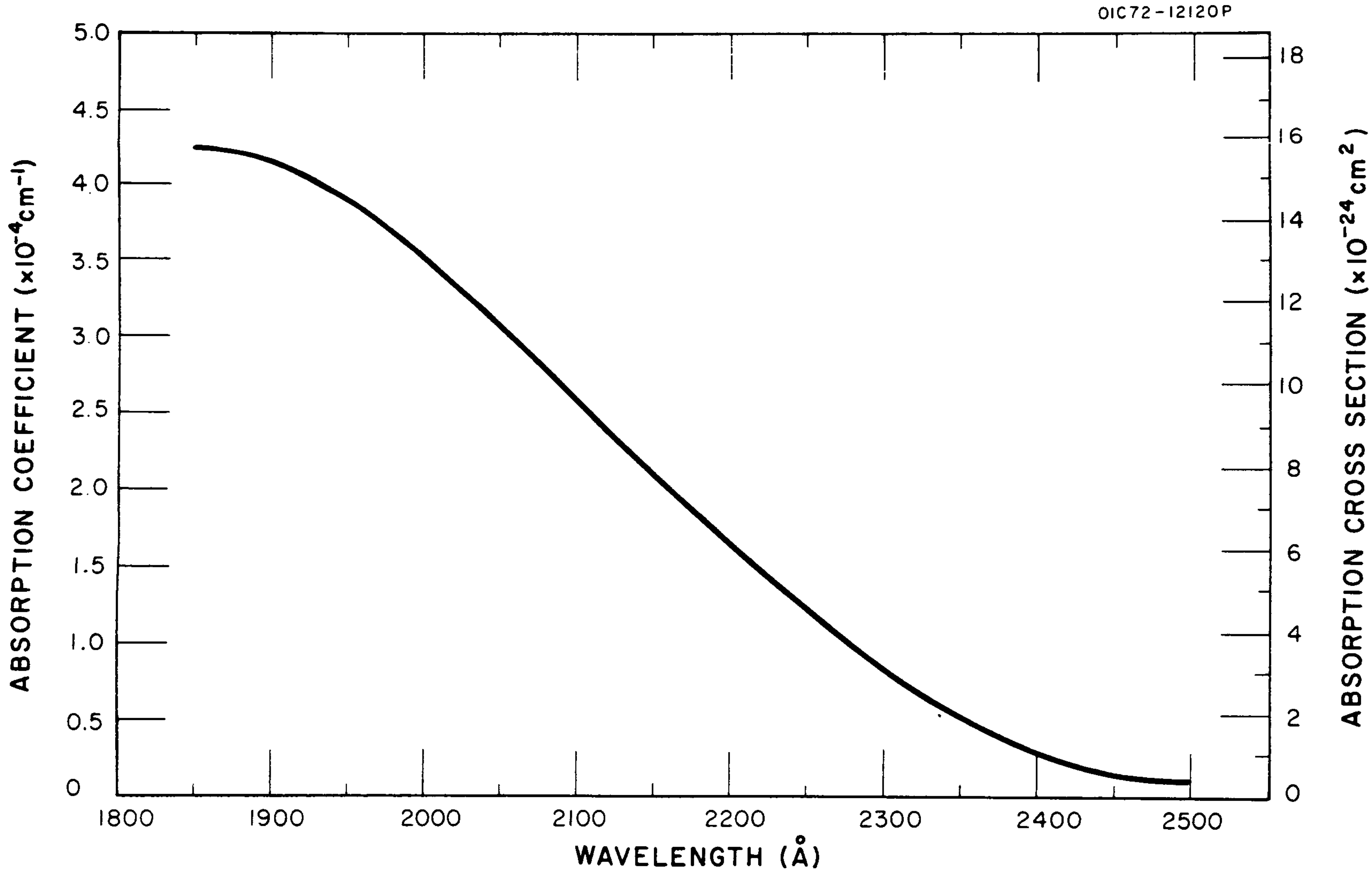


Figure 6. Absorption coefficients and cross sections of O_2.
λ = 1850Å to λ = 2500Å
Method: Photoelectric detection
Ref: R. W. Ditchburn, P.A. Young, J. Atm. Terr. Phys. 24, 127 (1962)
Experimental error: $\pm 1.0 \times 10^{-24}$ cm^2
Values include the effect of Rayleigh scattering.

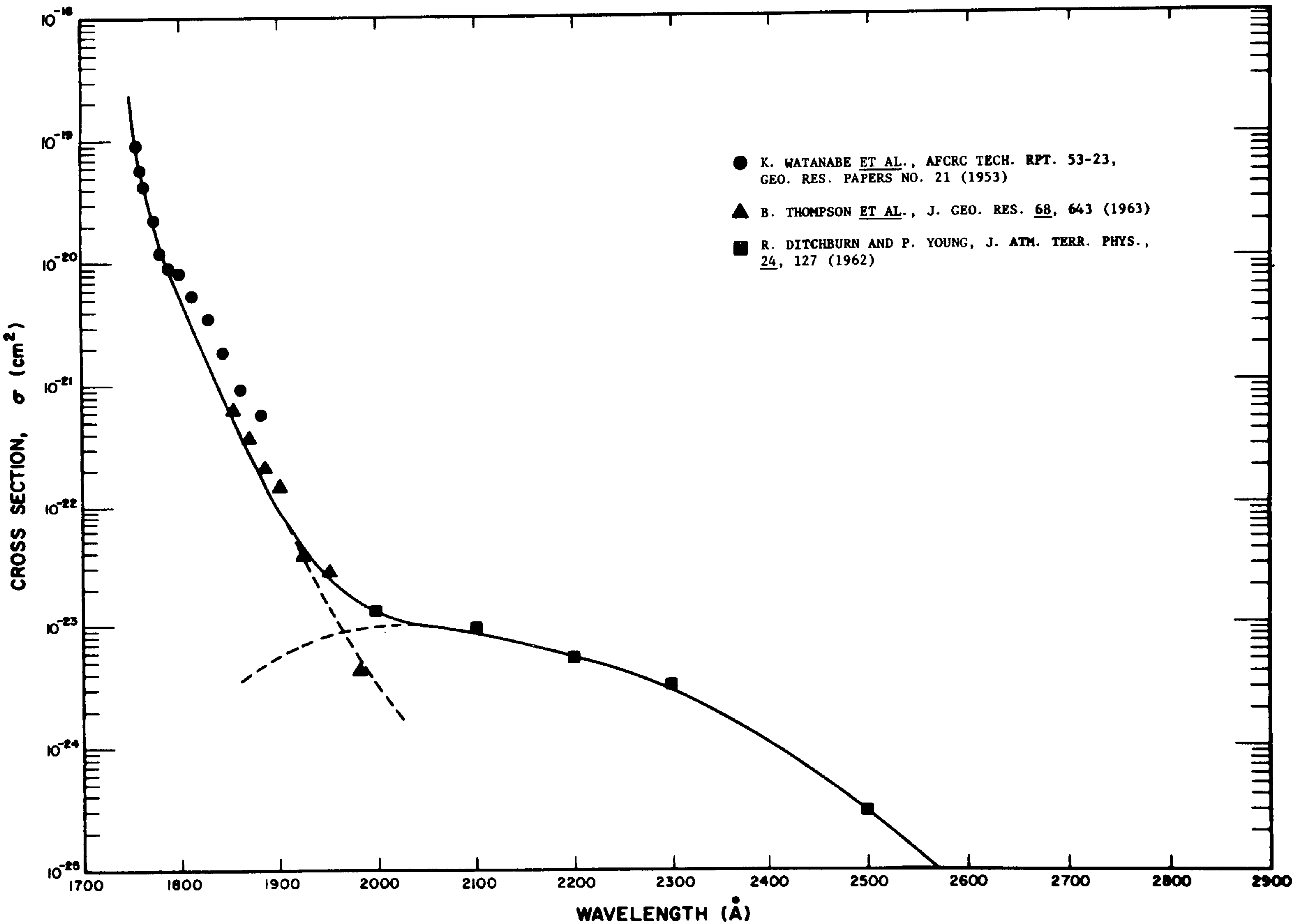


Figure 7. Absorption cross sections of oxygen in the continuum region.

TABLE 2

ABSORPTION COEFFICIENTS OF O_2

λ = 112Å to λ = 866Å

Method: Photographic Detection

Ref: A.A. Aboud, J.P. Curtis, R. Mercure, and W.A. Rense, J. Opt. Soc. Am. 45, 767 (1955)

k in Reciprocal Centimeters

λ	k	λ	k
112.0	5	553.0	960
125.0	20	617.0	970
155.0	200	630.8	940
276.3	210	634.0	970
304.1	610	694.1	1080
377.1	470	700.9	980
407.2	520	704.2	1080
476.5	680	735.1	860
503.8	850	755.0	480
520.7	1030	866.3	360
552.0	990		

TABLE 3

ABSORPTION COEFFICIENTS OF O_2

$\lambda = 303Å$ to $\lambda = 1306Å$

Method: Photographic Detection

Ref: G.L. Weissler and P. Lee, J. Opt. Soc. Am. 42, 200 (1952)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
303.8	530	685.5	720	977.0	470
429.6	890	685.8	720	988.8	110
430.0	930	702.3	710	989.8	170
525.8	800	702.9	820	990.2	150
529.5	842	703.8	800	990.8	170
529.8	830	718.5	600	991.6	180
537.8	860	745.8	710	999.5	110
538.2	700	747.0	760	1025.7	43
539.2	770	771.9	510	1036.3	500
539.5	760	772.4	640	1037.0	540
539.8	740	776.0	490	1084.0	100
574.6	840	796.6	680	1110.0	770
580.4	750	832.9	670	1134.2	59
581.0	720	833.3	380	1134.4	59
584.3	550	833.7	340	1135.0	82
599.6	780	835.1	360	1152.1	120
600.6	790	835.3	300	1175.7	410
616.3	740	877.8	490	1199.5	66
617.0	810	886.6	440	1200.7	83
644.1	690	904.0	540	1206.4	872
644.8	750	904.1	590	1217.6	54
645.2	720	904.5	420	1243.2	909
660.4	780	915.96	280	1302.2	24
671.4	720	916.01	240	1304.9	24
672.3	670	916.7	240	1306.0	7

TABLE 4

ABSORPTION COEFFICIENTS OF O_2

λ = 209Å to λ = 434Å

Method: Photoelectric Detection

Ref: J.A.R. Samson and R.B. Cairns, GCA Corporation, Bedford, Mass., private communication (Dec. 1964)

k in Reciprocal Centimeters

λ	k	λ	k
209.3	245	314.9	446
225.2	288	323.6	446
234.2	287	335.1	454
239.6	323	345.1	461
247.2	333	358.5	---
260.5	---	362.9	473
266.3	379	374.4	484
283.5	412	387.4	501
297.6	---	428.2	526
303.1	441	434.3	530

TABLE 5

ABSORPTION COEFFICIENTS OF O_2

λ = 404Å to λ = 883Å

Method: Photoelectric Detection

Ref: J.A.R. Samson, GCA Corporation, Bedford, Mass., Private communication Preliminary Data (1963)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
404	591	518	662	612	784
405	582	519	700	615	775
410	582	522	645	617	691
411	592	524	724	625	739
416	591	527	682	630	810
424	600	529	704	634	754
426	630	532	682	637	719
429	591	533	698	642	631
434	545	537	692	644	650
435	596	538	732	649	698
437	590	541	746	651	766
445	595	544	715	660	680
448	600	548	724	663	668
451	598	551	732	668	605
459	617	555	738	675	580
462	611	558	738	677	562
464	623	562	745	680	544
468	623	564	734	683	519
471	622	568	739	685	644
474	638	570	720	689	485
475	632	573	712	692	814
479	631	577	700	695	562
484	645	583	655	700	868
486	646	585	620	703	703
492	658	589	579	705	1090
497	662	594	628	709	691
501	673	596	768	714	876
506	660	600	782	715	801
505	686	603	772	717	770
513	680	604	770	720	734
516	678	609	749	725	695

TABLE 5 (continued)

ABSORPTION COEFFICIENTS OF O_2

λ = 404Å to λ = 883Å

Method: Photoelectric Detection

Ref: J.A.R. Samson, GCA Corporation, Bedford, Mass., Private communication, Preliminary Data (1963)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
727	839	783	589	840	423
730	842	787	660	843	372
737	820	789	755	845	539
740	682	794	735	850	290
742	591	796	646	852	415
744	545	799	772	857	338
746	572	800	774	860	330
750	539	804	875	869	352
755	610	807	822	871	329
760	539	810	669	872	424
765	594	818	609	877	285
772	664	821	479	878	365
776	570	827	370	883	339
779	719				

TABLE 6

ABSORPTION COEFFICIENTS OF O_2

λ = 600Å to λ = 1025Å

Method: Photoelectric Detection

Ref: G. Cook and P. Metzger, J. Chem. Phys. 41, 321 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
600.0	682	694.0	690	739.8	720
610.0	690	694.5	1003	742.2	640
620.0	698	695.0	1003	743.7	590
630.0	700	695.9	790	744.8	570
640.0	699	697.7	930	746.0	540
650.0	695	699.5	650	746.7	545
660.0	685	700.5	820	748.0	540
670.0	670	701.5	660	749.6	742
674.6	660	704.6	1480	750.7	540
675.2	655	706.4	750	751.3	545
676.0	650	706.8	800	752.2	530
678.2	635	707.8	740	754.5	725
679.3	630	708.3	800	755.6	658
680.2	600	708.8	745	757.3	600
680.5	590	709.4	790	758.5	615
681.0	570	709.8	760	760.0	575
681.5	555	710.5	1000	760.8	660
682.0	548	711.0	890	761.4	625
682.5	660	712.5	920	762.2	610
683.6	580	718.7	820	762.5	625
684.2	900	720.0	900	763.2	660
685.0	900	724.8	740	764.2	610
686.0	555	725.9	1007	765.5	690
687.0	760	728.5	810	766.2	507
687.6	695	730.3	1190	766.6	610
688.3	710	731.0	920	767.0	505
688.8	690	732.2	1130	767.2	620
690.0	900	733.2	950	768.0	502
691.0	620	734.5	1020	769.0	620
691.9	815	735.9	680	770.0	500
693.0	695	737.0	960	771.5	770
693.5	700	738.0	770	772.0	765

TABLE 6 (continued)

ABSORPTION COEFFICIENTS OF O_2

λ = 600Å to λ = 1025Å

Method: Photoelectric Detection

Ref: G. Cook and P. Metzger, J. Chem. Phys. 41, 321 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
773.0	850	818.7	750	877.6	403
775.0	490	819.5	982	882.5	250
778.0	880	821.0	600	885.4	520
778.8	830	822.9	820	890.0	205
779.9	875	823.6	560	891.5	365
782.0	485	824.0	780	892.5	300
784.6	840	824.6	760	893.8	405
785.0	740	826.0	940	895.5	315
786.0	890	828.0	420	897.0	335
787.0	760	829.5	760	898.0	255
787.5	862	830.8	410	900.5	430
788.9	810	832.3	950	902.5	300
789.9	860	834.5	400	903.1	360
791.2	820	835.7	830	908.0	156
792.3	990	837.9	500	909.2	490
792.7	760	839.1	770	910.6	490
794.0	945	842.2	350	912.0	230
795.6	910	843.8	460	914.5	290
797.5	1090	845.5	420	915.7	155
798.0	900	846.0	640	916.5	570
799.0	1220	848.6	270	920.5	250
801.0	940	850.0	390	922.9	380
802.2	1080	851.5	350	924.5	650
803.2	890	853.0	442	926.5	250
804.7	1520	854.5	305	930.6	460
807.0	1005	856.8	407	931.5	430
808.0	1140	858.5	285	932.5	770
809.5	800	860.5	305	936.0	128
810.3	1570	862.0	300	938.9	1170
812.8	1000	864.0	360	944.0	115
813.9	1130	868.5	270	947.9	1310
815.0	695	871.0	395	950.0	190
817.2	1300	875.5	250	956.1	1370

TABLE 6 (continued)

ABSORPTION COEFFICIENTS OF O_2

λ = 600Å to λ = 1025Å

Method: Photoelectric Detection

Ref: G. Cook and P. Metzger, J. Chem. Phys. 41, 321 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
957.2	1370	974.3	272	989.0	60
959.5	92	977.5	465	993.0	800
962.0	480	981.0	340	995.0	60
964.5	270	983.0	920	1004.0	380
965.4	920	984.7	72	1010.0	140
971.5	83	985.7	250	1025.7	58
972.6	1660				

TABLE 7

ABSORPTION COEFFICIENTS OF O_2

λ = 605Å to λ = 1059Å

Method: Photoelectric Detection

Ref: R. Huffman, et al., J. Chem. Phys. 40, 356 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
605.2	1080	687.2	830	750.0	750
608.1	1100	688.7	640	751.6	590
611.2	1400	690.1	820	755.0	700
614.1	1330	690.4	820	756.2	590
615.4	1230	692.4	1050	758.4	590
618.2	1370	695.2	910	760.7	640
620.1	900	697.3	960	762.1	620
621.9	1250	698.3	1090	763.2	680
625.9	1140	700.8	1100	765.4	670
626.6	1220	703.1	940	767.3	620
627.5	870	705.3	1820	768.8	630
628.3	900	707.9	890	771.6	750
629.6	1200	709.3	900	773.1	830
630.8	540	711.0	1240	778.1	900
631.7	1000	712.9	1240	780.0	880
634.4	1060	714.7	1180	782.9	650
636.3	990	716.5	1000	784.4	810
638.1	970	720.4	1080	786.0	800
640.7	880	721.8	840	787.6	800
642.5	970	722.9	860	790.0	870
645.0	880	724.4	860	792.4	850
646.7	1020	726.4	1420	794.1	990
651.8	1020	728.3	1000	797.7	980
670.5	750	731.1	1110	799.5	1200
675.0	720	732.5	1520	802.6	1080
677.0	700	735.3	1240	805.1	1510
679.8	730	737.5	1110	808.2	1120
681.6	710	740.0	780	811.8	1590
700.6	700	742.2	700	813.7	1100
684.9	860	745.0	640	817.2	1360
686.6	770	747.0	640	819.8	940

TABLE 7 (continued)

ABSORPTION COEFFICIENTS OF O_2

λ = 605Å to λ = 1059Å

Method: Photoelectric Detection

Ref: R. Huffman, et al., J. Chem. Phys. 40, 356 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
823.2	830	910.5	490	985.9	210
824.9	730	913.6	180	988.5	170
826.0	900	914.7	210	989.8	160
827.8	380	917.3	750	992.9	670
829.6	730	923.1	310	993.5	740
832.5	980	924.5	720	1004.5	200
834.5	340	927.6	130	1006.2	70
836.3	500	929.1	160	1008.2	60
839.1	780	930.6	760	1012.5	60
840.5	340	932.4	800	1014.2	80
843.8	370	934.5	180	1020.9	70
845.9	580	936.2	120	1023.8	80
848.5	250	937.5	140	1027.0	90
850.6	300	939.3	1390	1029.4	90
853.2	390	942.7	140	1031.0	70
857.3	320	947.7	1680	1033.2	70
861.0	240	952.1	110	1035.0	60
864.6	290	953.4	130	1039.0	120
870.0	250	955.9	1640	1040.7	120
871.4	320	957.0	1020	1042.5	90
878.1	410	960.7	180	1047.7	80
885.8	530	961.9	420	1048.8	100
891.6	340	963.8	300	1049.3	110
894.0	350	965.5	1400	1051.9	80
897.3	240	972.9	1400	1054.9	60
901.1	430	975.3	790	1055.3	50
903.8	290	979.4	120	1056.3	80
909.6	480	983.3	1290	1058.6	50

TABLE 8

ABSORPTION COEFFICIENTS OF O_2

λ = 842Å to λ = 1751Å

Method: Photoelectric Detection

Ref: See end of Table

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
841.9	240	860.3	200	877.8	320
843.6	310	862.1	190	878.7	280
844.6	250	862.6	180	879.0	260
845.3	260	863.4	200	879.5	220
846.1	410	863.7	330	880.1	180
847.1	250	864.3	210	880.6	170
847.4	310	864.7	240	881.0	160
848.0	210	865.1	320	881.7	230
849.1	210	865.6	210	882.1	140
849.7	230	866.0	190	882.5	170
850.2	250	866.2	190	883.3	150
850.6	260	866.9	230	883.5	140
851.0	240	867.4	160	884.1	150
851.5	220	867.9	170	884.5	160
852.2	230	868.5	190	885.0	230
852.8	320	869.0	170	885.2	350
853.2	340	869.5	200	885.8	400
853.5	270	869.9	240	886.5	260
854.1	240	870.3	250	887.2	180
854.5	260	871.4	230	887.7	150
854.9	190	871.7	270	888.1	150
855.3	200	872.1	320	888.3	140
855.7	190	872.9	190	889.0	140
856.1	220	873.6	180	889.6	150
856.4	220	873.8	200	889.8	140
857.0	240	874.3	210	890.3	180
857.9	200	875.1	150	891.2	240
858.1	210	875.8	170	891.5	300
858.5	250	876.2	200	891.8	250
859.5	180	876.7	230	892.4	220
859.8	180	877.4	210	893.4	230

TABLE 8 (continued)

ABSORPTION COEFFICIENTS OF O_2

λ = 842Å to λ = 1751Å

Method: Photoelectric Detection

Ref: See end of Table

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
894.6	260	911.8	150	926.0	210
894.8	220	912.2	130	926.8	120
895.5	170	913.5	140	927.3	110
896.2	190	914.2	120	927.8	98
896.5	200	914.8	200	928.1	82
897.1	190	915.6	110	928.8	100
897.9	180	916.0	110	929.6	100
898.2	140	916.3	150	930.0	94
898.6	150	917.0	500	930.2	210
899.6	160	917.2	490	930.7	640
900.2	210	917.8	420	931.0	390
900.7	350	918.7	200	931.4	310
901.3	360	919.0	160	931.7	330
901.7	310	919.2	130	932.1	370
902.3	230	919.5	110	932.5	780
902.8	210	920.0	100	933.3	210
903.7	220	920.2	92	933.8	150
904.1	210	920.4	90	934.5	120
904.6	170	921.2	93	934.9	110
905.5	120	921.4	100	935.6	86
905.8	120	921.6	110	935.8	81
906.7	110	922.2	150	936.1	77
907.4	110	922.5	170	936.4	80
907.7	120	922.8	240	936.9	77
908.1	120	923.2	270	937.1	98
908.6	170	923.5	240	937.6	96
909.6	430	924.0	360	937.8	100
910.4	410	924.3	400	938.1	130
910.6	390	924.7	490	938.8	850
911.2	200	925.1	400	939.3	1150
911.5	150	925.5	300	940.3	460

TABLE 8 (continued)

ABSORPTION COEFFICIENTS OF O_2

$\lambda = 842\text{Å}$ to $\lambda = 1751\text{Å}$

Method: Photoelectric Detection

Ref: See end of Table

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
941.1	220	956.7	750	972.0	180
941.6	120	956.9	870	972.5	820
942.2	95	957.3	690	973.4	770
943.3	100	957.8	340	974.1	210
943.5	100	958.4	230	974.5	150
943.8	67	958.8	120	974.8	190
944.1	75	959.4	73	975.1	440
944.5	72	959.7	70	975.5	560
944.8	65	960.0	74	975.9	420
945.2	79	960.7	160	976.2	340
946.0	88	961.7	230	976.7	160
946.7	180	962.0	350	977.3	85
947.4	940	962.3	270	977.7	74
947.8	1400	962.8	130	977.9	78
948.1	1400	963.1	130	978.5	73
948.4	600	963.6	230	979.2	87
948.7	430	964.1	260	979.5	86
949.1	340	964.8	460	979.8	95
949.7	140	965.4	820	980.1	85
950.9	93	965.6	880	980.5	58
951.3	81	966.0	970	981.3	66
951.6	73	967.3	280	981.7	100
951.9	92	967.6	200	982.1	160
952.3	87	967.9	120	982.6	760
952.6	88	968.3	94	983.3	850
952.8	89	969.2	71	983.8	390
953.6	85	969.9	69	984.6	120
954.8	120	970.2	68	985.2	120
955.6	960	970.4	65	985.8	180
955.9	1200	971.0	68	986.1	170
956.5	740	971.4	88	986.6	160

TABLE 8 (continued)

ABSORPTION COEFFICIENTS OF O_2

λ = 842Å to λ = 1751Å

Method: Photoelectric Detection

Ref: See end of Table

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
986.9	150	1001.5	47	1014.5	42
987.5	110	1001.9	38	1015.4	46
988.0	80	1002.4	41	1015.8	47
988.5	60	1002.6	55	1016.0	32
989.3	53	1003.2	120	1016.4	37
989.6	40	1004.0	170	1016.9	29
990.1	63	1004.3	150	1017.2	43
990.6	60	1004.6	170	1017.8	26
991.2	53	1005.0	83	1018.3	41
991.7	47	1005.5	76	1018.6	34
992.0	55	1005.8	57	1018.8	29
992.9	450	1006.2	44	1019.4	38
993.3	660	1006.4	43	1020.4	32
993.5	560	1006.8	37	1020.8	43
994.2	360	1007.3	40	1021.1	35
994.4	220	1007.6	44	1021.6	44
994.8	130	1007.9	49	1021.9	41
995.2	78	1008.3	48	1022.4	35
995.7	50	1008.8	43	1023.4	50
996.1	47	1009.1	38	1023.8	46
996.5	41	1009.4	41	1024.3	38
997.2	39	1010.0	36	1024.6	27
997.6	39	1010.5	32	1025.3	48
998.0	42	1011.4	35	1025.7	50
998.4	42	1011.6	32	1026.6	34
998.8	46	1012.3	29	1027.1	35
999.3	44	1012.5	31	1027.8	29
999.7	38	1013.0	34	1028.2	18
1000.0	40	1013.5	36	1028.8	25
1000.7	38	1013.9	30	1029.3	51
1000.9	41	1014.2	37	1030.2	22

TABLE 8 (continued)

ABSORPTION COEFFICIENTS OF O_2

λ = 842Å to λ = 1751Å

Method: Photoelectric Detection

Ref: See end of Table

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1030.8	39	1046.1	14	1062.0	16
1031.0	40	1046.6	22	1062.6	11
1031.3	39	1047.1	69	1063.4	20
1031.9	32	1047.8	38	1063.6	35
1032.3	27	1048.6	64	1064.2	82
1033.1	29	1048.9	65	1064.8	47
1033.6	24	1049.5	67	1065.1	50
1034.3	43	1050.1	11	1065.7	77
1034.9	45	1050.6	15	1066.4	92
1035.5	18	1051.1	30	1066.7	57
1036.5	14	1051.9	22	1067.0	6.4
1036.9	26	1052.4	58	1067.6	4.4
1037.2	18	1054.0	21	1067.9	4.3
1038.0	51	1054.2	16	1068.5	3.4
1038.2	29	1054.6	18	1068.9	3.2
1038.8	19	1054.8	53	1069.9	3.6
1039.1	26	1055.3	19	1070.7	6.2
1039.4	48	1055.6	8.5	1071.4	21
1040.5	36	1056.4	11	1072.2	20
1040.9	26	1056.8	11	1072.7	29
1041.1	24	1057.0	14	1073.2	29
1041.6	31	1058.0	22	1073.5	39
1041.9	33	1058.3	28	1073.9	54
1042.5	29	1058.7	17	1074.3	24
1042.9	16	1059.6	31	1074.6	20
1043.5	7.2	1060.1	25	1075.2	8.7
1043.8	3.3	1060.6	23	1075.9	5.8
1044.3	4.2	1060.9	31	1076.6	5.8
1044.9	4.4	1061.1	16	1077.0	3.7
1045.3	11	1061.4	18	1077.4	12
1045.7	13	1061.7	31	1077.7	11

TABLE 8 (continued)

ABSORPTION COEFFICIENTS OF O_2

λ = 842Å to λ = 1751Å

Method: Photoelectric Detection

Ref: See end of Table

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1078.0	23	1107.8	0.32	1188.3	0.39
1078.4	15	1108.3	0.11	1188.9	0.64
1078.8	21	1108.9	0.25	1190.0	6.2
1079.7	59	1109.9	0.35	1191.5	5.0
1081.4	41	1110.5	0.48	1192.5	10.1
1081.8	62	1126.9	0.53	1193.0	6.7
1082.3	21	1142.8	0.26	1194.5	12.7
1083.0	51	1143.0	0.33	1195.5	16.5
1084.1	29	1144.3	0.65	1198.0	32
1084.5	59	1145.3	0.70	1200.0	51
1085.2	72	1157.0	0.51	1201.5	90
1086.0	16	1157.4	0.60	1202.0	104
1086.3	10	1166.1	0.52	1203.5	230
1086.8	7.3	1166.8	0.27	1205.0	500
1087.1	9.9	1167.2	0.35	1206.0	480
1087.5	21	1168.0	1.0	1206.5	460
1088.6	14	1169.0	2.1	1208.5	330
1089.9	14	1172.0	44	1209.0	130
1090.5	11	1174.5	38	1210.0	87
1091.1	3.0	1175.0	36	1211.0	24
1091.8	2.1	1176.0	24	1213.0	17
1092.4	2.3	1177.0	23	1213.5	11
1092.8	2.7	1178.0	11	1214.8	0.70
1093.5	2.8	1180.5	5.6	1215.0	0.50
1094.0	3.5	1181.5	11	1215.7	0.27
1094.7	1.8	1182.5	6.1	1216.5	0.40
1096.0	3.5	1184.0	7.1	1217.3	0.60
1097.2	7.3	1186.0	3.9	1217.5	0.80
1097.6	5.1	1186.6	0.35	1218.5	2.5
1098.0	5.7	1187.1	0.18	1220.0	5.2
1099.5	6.7	1187.8	0.25	1221.0	5.9

TABLE 8 (continued)

ABSORPTION COEFFICIENTS OF O_2

λ = 842Å to λ = 1751Å

Method: Photoelectric Detection

Ref: See end of Table

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1222.0	11	1266.0	4.9	1375.0	332
1223.5	7.0	1269.0	3.2	1378.0	342
1225.0	13	1271.0	1.8	1384.0	354
1228.5	11	1274.0	2.5	1391.5	359
1229.0	12	1277.0	4.1	1394.0	366
1230.0	10	1279.5	6.7	1400.5	370
1231.5	13	1283.5	9.8	1405.0	375
1232.5	14	1287.0	12.7	1407.4	390
1233.5	20	1290.5	14.6	1408.6	388
1234.5	20	1293.0	15.7	1410.5	394
1235.0	12.3	1296.5	14.8	1412.9	392
1236.0	14	1299.0	14.0	1414.8	391
1237.5	13	1302.0	11.9	1416.3	391
1238.5	9.3	1306.0	9.6	1420.2	393
1239.5	8.1	1309.0	13.9	1423.0	393
1240.0	6.3	1312.5	19.4	1427.7	394
1240.5	4.9	1317.0	29.6	1430.0	394
1241.5	879	1321.5	42.9	1432.9	394
1243.5	940	1325.0	55.0	1436.2	393
1245.0	95	1329.0	62.1	1437.8	394
1247.0	56	1333.5	61.6	1440.9	393
1249.5	39	1336.5	59.1	1433.5	389
1252.0	28	1339.5	60.3	1446.0	386
1254.5	23	1343.0	75	1450.3	385
1256.0	19	1345.0	93	1452.1	383
1257.0	16	1349.0	155	1455.0	368
1259.5	12.5	1351.0	191	1457.5	365
1260.5	10.8	1355.0	191	1460.0	361
1262.0	11.9	1361.0	220	1463.0	355
1263.5	9.2	1366.0	259	1467.5	355
1264.5	6.5	1369.0	303	1473.5	350

TABLE 8 (continued)

ABSORPTION COEFFICIENTS OF O_2

λ = 842Å to λ = 1751Å

Method: Photoelectric Detection

Ref: See end of Table

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1479.0	338	1577.5	165	1667.0	42
1486.0	324	1581.0	158	1671.0	39
1489.0	318	1585.5	155	1677.5	35
1491.5	319	1589.0	144	1682.0	32
1495.0	307	1591.0	137	1687.0	30
1499.0	304	1596.0	133	1689.0	26.5
1504.0	294	1602.0	125	1697.0	24.0
1510.5	285	1608.0	112	1702.0	21.8
1517.0	274	1613.0	104	1705.0	20.3
1522.5	266	1620.5	92	1712.0	18.2
1532.0	249	1623.5	89	1717.0	16.4
1537.5	233	1628.5	80	1722.0	15.0
1541.5	227	1633.5	75	1727.0	13.6
1544.5	219	1636.5	72	1732.0	11.9
1547.0	217	1638.5	69	1737.0	10.6
1551.0	209	1644.0	63	1742.0	9.5
1555.5	204	1648.0	60	1747.0	8.3
1562.5	194	1654.0	54	1749.0	7.2
1569.5	175	1658.5	49	1751.0	6.5
1572.0	171	1663.0	46		

Reference: K. Watanabe, et al:

840 to 1100Å: Hawaii Institute of Geophysics, Contr. No. 33, Dec. 1961.

1100 to 1166Å, curve; 1100 to 1166Å, windows; (1166 to 1217Å), windows: "UV Absorption Processes in Upper Atmosphere," Advances in Geophysics, 5, 181-221 (1958).

1166 to 1407Å; 1452 to 1751Å; 1751 to 1900Å, curve: AFCRC Tech. Rep. 53-23, Geo. Res. Papers No. 21, June 1953.

1407 to 1452Å: J. Chem. Phys., 25, 965 (1956).

TABLE 9

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF O_2 AT INTENSE SOLAR EMISSION LINES

λ = 304Å to λ = 1038Å

Method: Photoelectric Detection

Ref: J.A.R. Samson and R.B. Cairns, J. Geo. Res. 69, 4583 (1964)

k in Reciprocal Centimeters

σ in Megabarns

Source Line λ	k	σ	γ (%)
303.781 He II	446*	16.6	100
429.918 O II 430.041 O II 430.177 O II	480*	17.8	100
434.975 O III	561	20.9	100
498.431 O VI	619	23.0	100
507.391 O III 507.683 O III	622	23.1	97
508.182 O III	638	23.7	97
519.610 O VI	678	25.2	100
522.208 He I	561	20.9	99
525.795 O III	659	24.5	97
537.024 He I	571	21.2	98
553.328 O IV	705	26.2	93
554.074 O IV	685	25.2	97
554.514 O IV	709	26.4	97
555.262 O IV	698	26.0	97
584.331 He I	625	23.2	98
597.818 O III	774	28.8	92
599.598 O III	765	28.4	97
608.395 O IV	648	24.1	94

*Estimated error ±10%

TABLE 9 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS
AND PHOTOIONIZATION YIELDS OF O_2 AT INTENSE
SOLAR EMISSION LINES

$\lambda = 304Å$ to $\lambda = 1038Å$

Method: Photoelectric Detection

Ref: J.A.R. Samson and R.B. Cairns, J. Geo. Res. 69, 4583 (1964)

k in Reciprocal Centimeters

σ in Megabarns

Source Line λ	k	σ	γ(%)
609.705 O III 609.829 O IV 610.043 O III	714	26.6	94
610.746 O III 610.850 O III	764	28.4	96
616.933 O IV 617.033 O IV 617.051 O II	655	24.4	97
624.617 O IV	681	25.3	93
625.130 O IV	661	24.6	96
625.852 O IV	814	30.3	96
629.732 O V	801	30.0	97
684.996 N III	709	26.4	100
685.513 N III 685.816 N III	496	18.4	100
686.335 N III	594	22.1	100
758.677 O V	493	18.3	57
759.440 O V	463	17.2	53
760.229 O V 760.445 O V	498	18.5	49

TABLE 9 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF O_2 AT INTENSE SOLAR EMISSION LINES

$\lambda = 304Å$ to $\lambda = 1038Å$

Method: Photoelectric Detection

Ref: J.A.R. Samson and R.B. Cairns, J. Geo. Res. 69, 4583 (1964)

k in Reciprocal Centimeters

σ in Megabarns

Source Line λ	k	σ	γ (%)
761.130 O V	547	20.3	51
762.001 O V	545	20.3	50
763.340 N III	604	22.5	58
764.357 N III	479	17.8	60
765.140 N IV	615	22.9	54
774.522 O V	382	14.2	63
779.821 O IV } 779.905 O IV }	733	27.3	33
787.710 O IV	644	24.0	54
790.103 O IV } 790.203 O IV }	744	27.7	37
832.754 O II } 832.927 O III }	707*	26.3	38
833.326 O II	-	-	-
833.742 O III	350*	13.0	39
834.462 O II	285*	10.6	38
835.096 O III } 835.292 O III }	267	9.93	37
921.982 N IV	148	5.50	79

*Estimated error ±10%

TABLE 9 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF O_2 AT INTENSE SOLAR EMISSION LINES

$\lambda = 304Å$ to $\lambda = 1038Å$

Method: Photoelectric Detection

Ref: J.A.R. Samson and R.B. Cairns, J. Geo. Res. 69, 4583 (1964)

k in Reciprocal Centimeters

σ in Megabarns

Source Line λ			k	σ	γ (%)
922.507	N	IV	171	6.36	84
923.045	N	IV	272	10.1	88
923.211	N	IV			
923.669	N	IV	246	9.15	90
924.274	N	IV	480	17.8	83
972.537	H	I	860	32.0	83
977.026	C	III	107	3.98	62
989.790	N	III	37	1.38	69
991.514	N	III	47	1.75	69
991.579	N	III			
1025.722	H	I	41	1.52	64
1031.912	O	VI	28	1.04	1*
1037.613	O	VI	21	0.78	0.1*

*Estimated error ±50%

TABLE 10

ABSORPTION CROSS SECTIONS OF ATOMIC OXYGEN

λ = 508Å to λ = 902Å

Method: Photoelectric Detection

Ref: R. B. Cairns and J. A. R. Samson, GCA Corporation, Bedford, Mass.
Private Communication (Dec. 1964).

σ in Megabarns

λ	σ	λ	σ
508.434 A III 508.595 A III	13.3	725.542 A II	16.7
551.371 A VI	13.2	735.89 Ne I	14.3
584.331 He I	11.9	743.70 Ne I	7.6
585.754 A VII	12.3	758.677 O V 759.440 O V 760.229 O V 760.445 O V 761.130 O V 762.001 O V	8.3
624.617 O IV 625.130 O IV 625.852 O IV	13.0	760.439 A IV	7.9
636.818 A III 637.282 A III	13.7	774.522 O V	7.6
683.278 A IV	11.8	779.821 P IV 779.905 O IV	11.1
684.996 N III 685.513 N III 685.816 N III 686.335 N III	17.3	822.159 A V	6.0
699.408 A IV 700.277 A IV	12.7	832.754 O II 832.927 O III 833.326 O II 833.742 O III 834.462 O II	5.3
702.332 O III 702.822 O III 702.899 O III 703.850 O III	13.0	901.168 A IV 901.804 A IV	4.7
715.599 A V 715.645 A V	12.2		

2. Ozone

a. Historical Survey [1]

Hartley [52] is usually credited with identifying atmospheric ozone as the cause of the abrupt cutoff of the ultraviolet solar spectrum at about 3000Å. Ultraviolet absorption coefficients were first measured by Fabry and Buisson [53]. Fabry and Buisson [54] confirmed the solar spectrum ultraviolet cutoff by ozone. Subsequent measurements in the ultraviolet and visible spectral regions were made by Ny and Choong [55], Vigroux [56], Inn and Tanaka [57], and Hearn [58], and in the far ultraviolet by Tanaka *et al*. [59] and Ogawa and Cook [60].

b. Spectral Region 2000Å to 3000Å [1,58]

Hartley [52] discovered a strong system of bands and an associated continuum in ozone in the spectral range 2100Å to 3200Å. The system consists of a series of diffuse bands extending from 3200Å to 2340Å, followed by a strong absorption continuum to 2100Å. The weaker Huggins bands, 3200Å to 3400Å, were discovered by Huggins [61] in the spectrum of Sirius. Fowler and Strutt [62] found the Huggins bands in the low-sun spectrum and in the laboratory spectrum of ozone. The absorption coefficients in this region have been measured in detail by Ny and Choong [63], whose data stood as the best until the experiments conducted by Inn and Tanaka [57] and Vigroux [64]. Hearn [58] made measurements of the absorption coefficients at the wavelengths of six mercury lines in the region, the results of which agreed generally with the measurements of Inn and Tanaka, who measured a continuum f-value of 0.088.

c. Spectral Region 1000Å to 2000Å [19,59]

Above 1300Å, there appear to be continua with maxima at 1330Å, 1450Å, and 1725Å. The continuum that peaks at 1725Å merges at about 2000Å with the strong Hartley continuum which has a maximum at 2550Å. A number of bands appear in the region from 1060Å to 1350Å, but, because of the weakness of these bands and the presence of the continuum, a determination of the progressions is difficult. The bands are probably members of a Rydberg series. The peaks of the continua occur at 1120Å and 1215Å. In the Schumann-Runge continuum, ozone absorption is almost as strong as oxygen absorption.

d. Spectral Region 520Å to 1000Å [60]

Preliminary absorption coefficient measurements of ozone were made from 520Å to 1350Å by Ogawa and Cook [60]. The pressures were not directly determined, but only relative changes were measured. Thus, only relative absorption coefficients were directly determined. They obtained absolute values by matching the coefficient at Lyman-alpha with that obtained by Tanaka *et al*. [59]. Some weak bands overlapping the continuum were found from 520Å to 750Å.

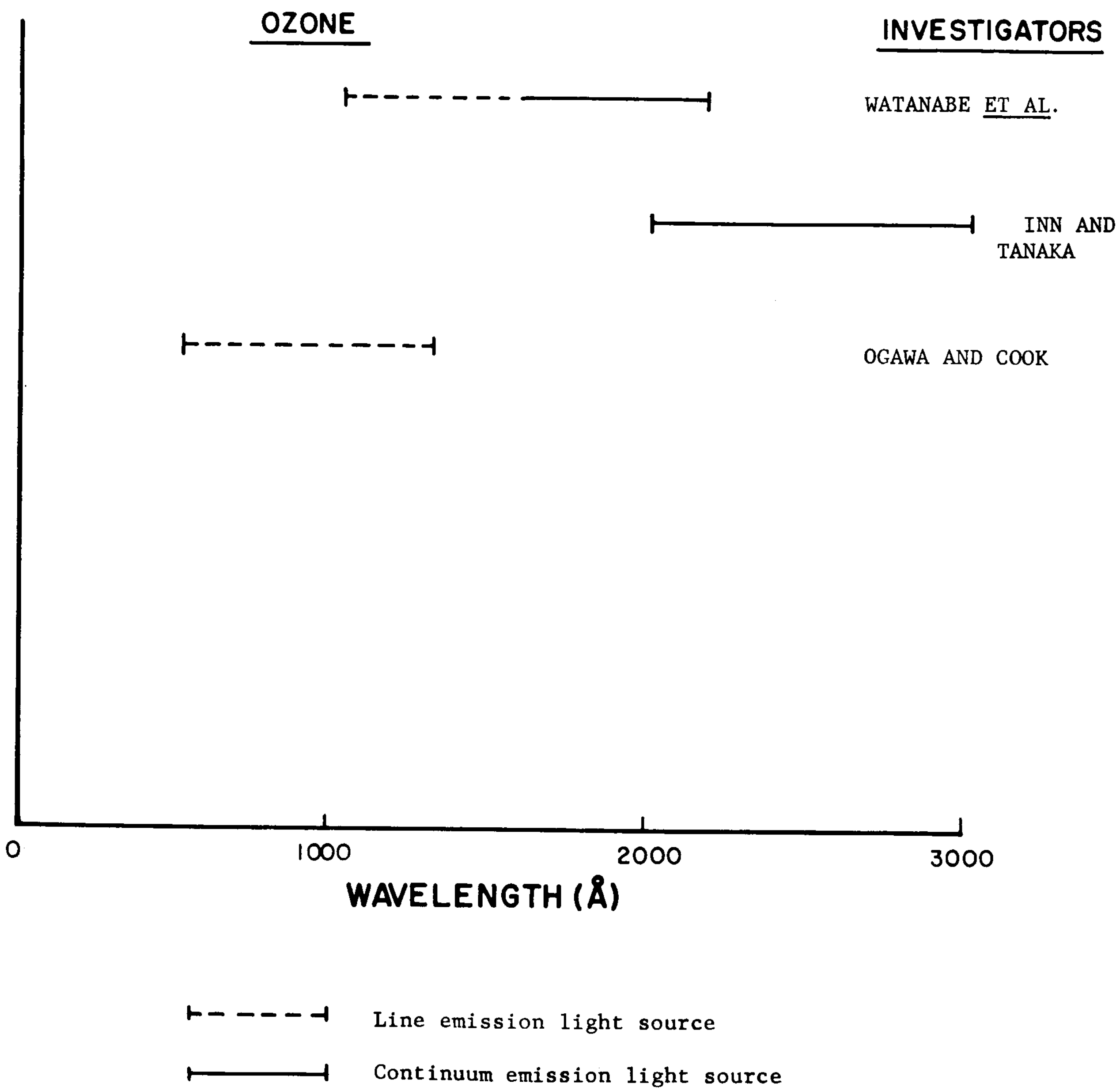


Figure 8. Spectral ranges of data obtained with line and continuum light sources: Ozone (Figures 9 and 10 and Tables 11 and 12).

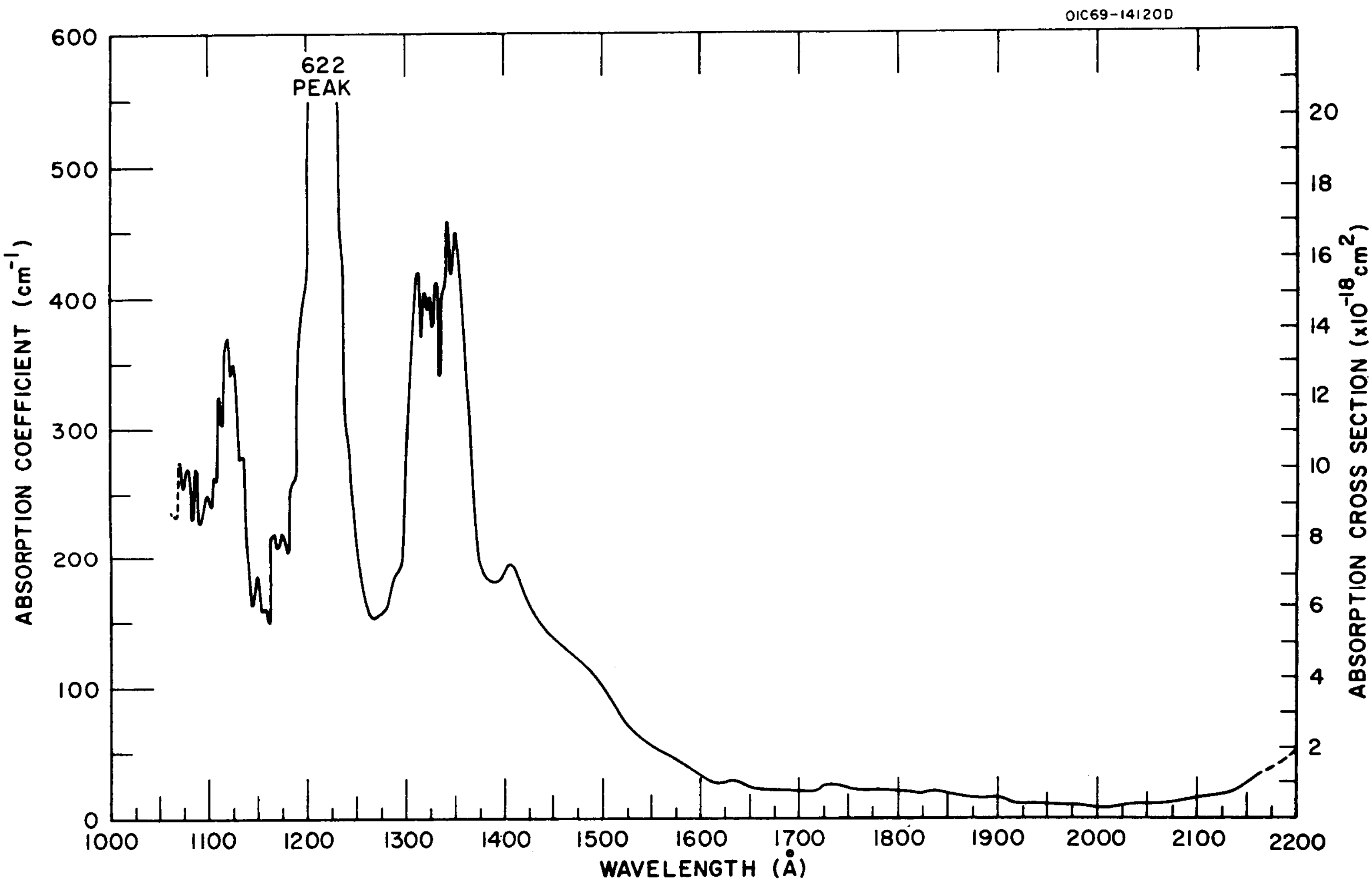


Figure 9. Absorption coefficients and cross sections of O_3.
λ = 1050Å to λ = 2200Å
Method: Photoelectric detection
Ref: K. Watanabe, et al., AFCRC Tech. Rpt. No. 53-23, Geo. Res. Paper No. 21 (1953)
Experimental error: ±10%

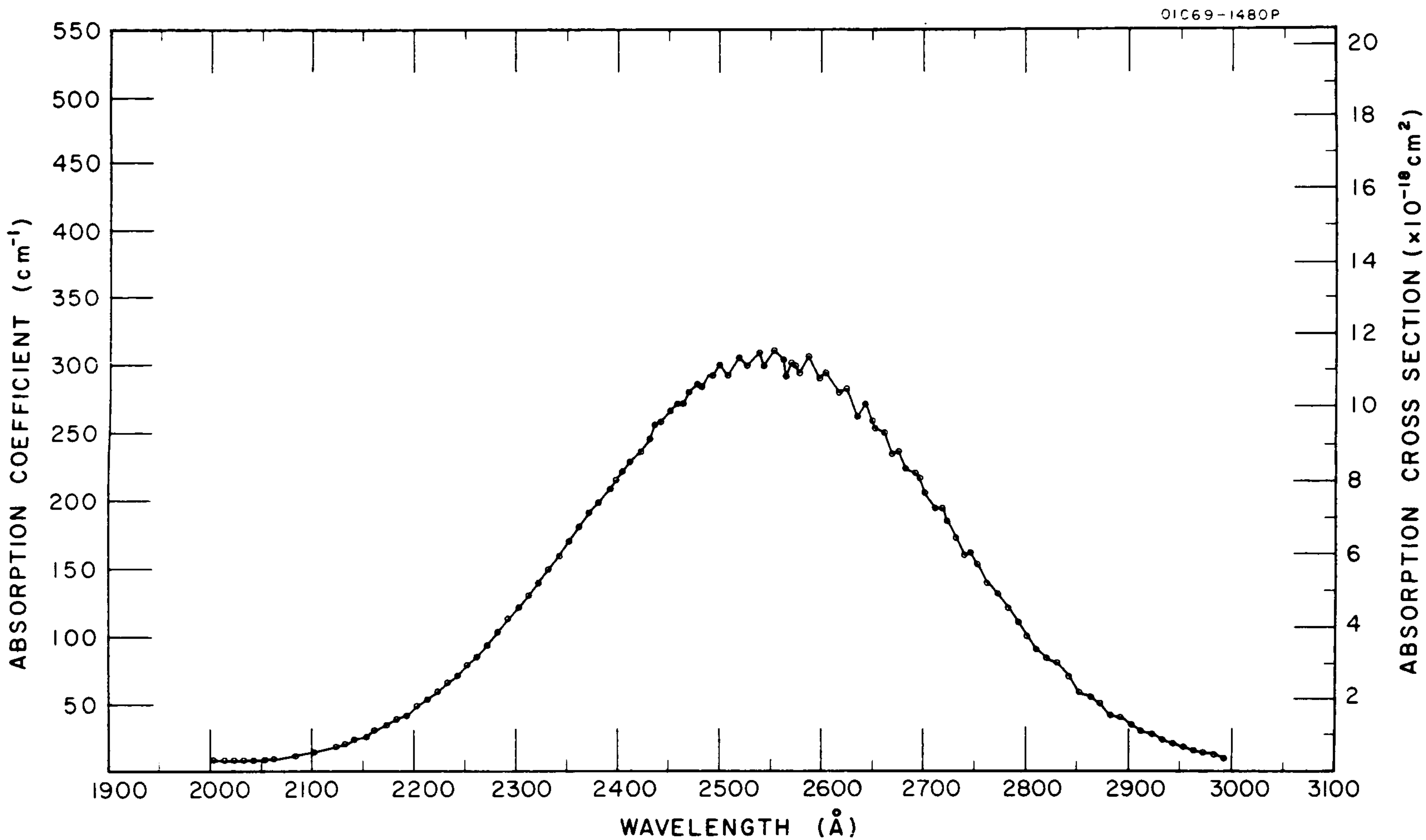


Figure 10. Absorption coefficients and cross sections of O_3.
λ = 2000Å to λ = 3000Å
Method: Photoelectric detection
Ref: E.C.Y. Inn, Y. Tanaka, "Ozone Absorption Coefficients," Advances in Chemistry Series No. 21 (1959)
Experimental error: ±5%

TABLE 11

ABSORPTION COEFFICIENTS OF O_3

$\lambda = 526Å$ to $\lambda = 1305Å$

Method: Photoelectric Detection

Ref: M. Ogawa and G.R. Cook, J. Chem. Phys. 28, 173 (1958)

k in Reciprocal Centimeters

λ	k	λ	k
526	817	773	940
539	864	797	803
555	827	834	673
581	862	879	503
600	949	916	352
617	935	980	257
645	100	990	215
672	949	1085	248
686	980	1135	340
703	111	1216	614
718	119	1243	288
749	985	1305	234

TABLE 12

ABSORPTION COEFFICIENTS OF O_3

λ = 2000Å to λ = 3000Å

Method: Photoelectric Detection

Ref: E. C. Y. Inn and Y. Tanaka, "Ozone Absorption Coefficients," Advances in Chemistry Series No. 21, 1959.

k in Reciprocal Centimeters (Base e)

λ	k	λ	k	λ	k
2002	8.61	2302	122	2543	299
2012	8.52	2312	130	2553	311
2022	8.36	2322	140	2562	304
2032	8.54	2332	149	2566	292
2042	8.82	2342	159	2571	302
2052	9.26	2352	170	2575	299
2062	10.0	2362	180	2579	295
2072	11.2	2372	192	2587	306
2082	12.0	2382	198	2597	290
2092	13.4	2392	208	2604	295
2102	14.7	2400	216	2617	279
2112	16.5	2402	219	2624	283
2122	18.6	2412	228	2635	262
2132	21.2	2422	237	2643	272
2142	23.7	2432	246	2650	258
2152	26.9	2438	256	2654	256
2162	30.2	2444	258	2662	249
2172	33.6	2452	267	2669	235
2182	38.0	2458	272	2675	237
2192	42.1	2463	272	2682	223
2202	48.4	2472	281	2692	220
2212	53.0	2478	286	2695	218
2222	58.5	2482	283	2702	205
2232	65.4	2490	292	2712	194
2242	71.2	2492	292	2718	194
2252	79.0	2500	299	2722	184
2262	86.6	2508	292	2732	174
2272	94.2	2519	306	2742	158
2282	103	2527	299	2746	160
2292	113	2539	309	2752	153

TABLE 12 (continued)

ABSORPTION COEFFICIENTS OF O_3

λ = 2000Å to λ = 3000Å

Method: Photoelectric Detection

Ref: E. C. Y. Inn and Y. Tanaka, "Ozone Absorption Coefficients," Advances in Chemistry Series No. 21, 1959.

k in Reciprocal Centimeters (Base e)

λ	k	λ	k	λ	k
2762	140	2842	70.0	2922	28.3
2772	131	2852	63.3	2932	24.6
2782	121	2862	56.0	2942	21.7
2792	111	2872	51.1	2952	19.2
2802	100	2882	44.4	2962	16.7
2812	91.4	2892	40.0	2972	14.6
2822	83.8	2902	35.7	2982	12.7
2830	81.1	2912	31.1	2992	11.0

3. Carbon Dioxide

a. Historical Survey [65]

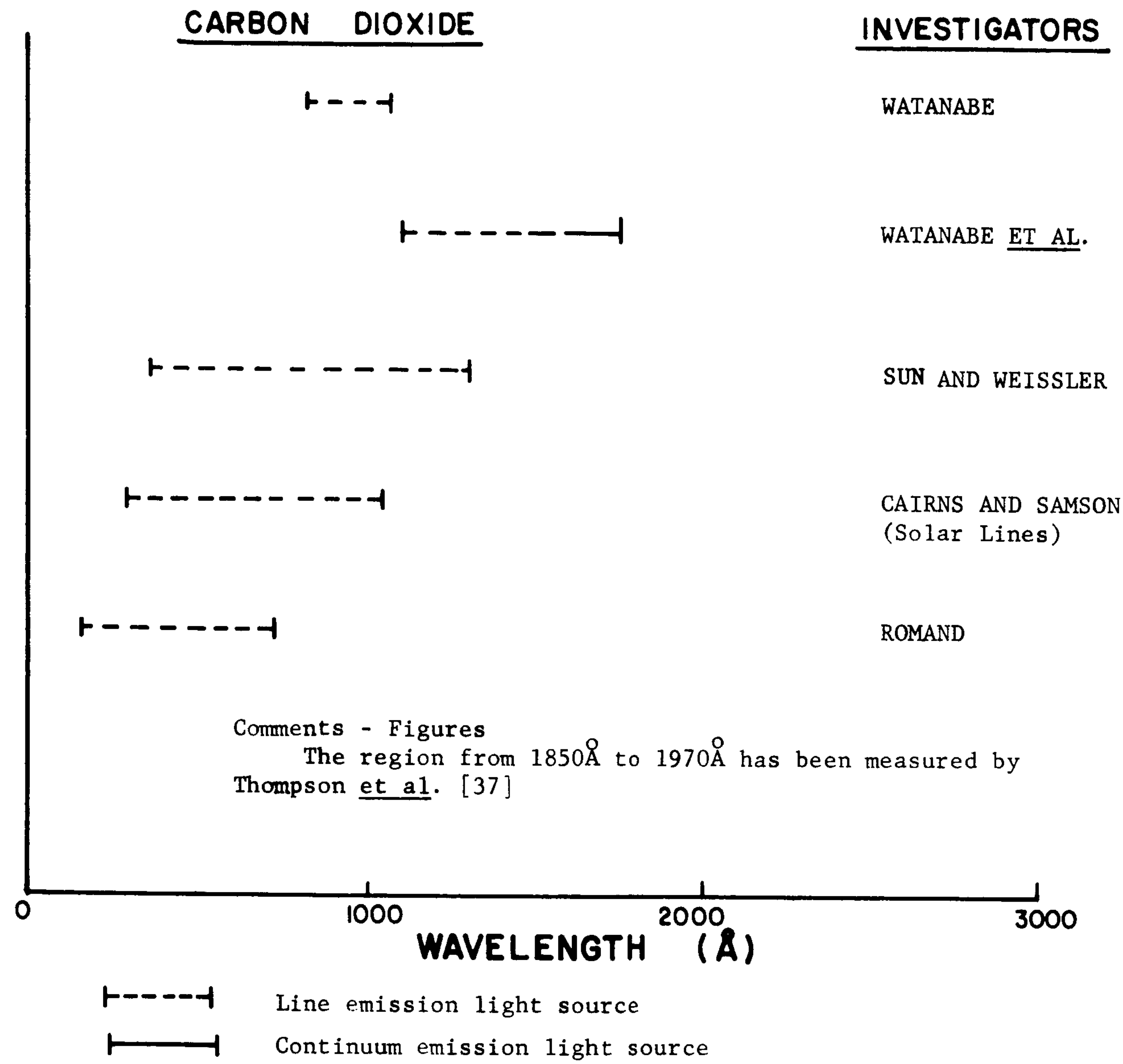
Several investigators studied the structure and systematics of the resonance absorption bands of CO_2 in the vacuum ultraviolet and reported some measurements for the absorption cross sections. The bands were studied by Lyman [66], Leifson [67], Henning [68], Rathenau [69], and Price and Simpson [70]. Wilkinson and Johnston [71] measured absorption cross sections between 1440Å and 1670Å, and separately, Inn et al. [43] carried out a more detailed study for the same region down to 1060Å. Preston [12] obtained data at Lyman-α. Measurements in the region from 375Å to 1300Å were made by Sun and Weissler [65] and Romand [72] provided data for the region from 150Å to 750Å. Recently, Watanabe [73] carefully made measurements between 850 and 1100Å, whereas Thompson et al. [37] extended the measurements of absorption coefficients from 1850 to 1970Å.

b. Spectral Region 1000Å to 1800Å [43]

Inn et al. [43] reported three and possibly four continua in this region. They calculated an f-value of 0.0043 for the continuum that peaks at 1475Å. The more intense continuum (λ_{max} at 1332Å) gave an f-value of 0.0053. The low f-values of these continua seem to indicate forbidden electronic transitions. The strong continuum (λ_{max} at 1121Å) gave an f-value of 0.12, indicating an allowed electronic transition. Bands in this region have been shown by Price and Simpson [70] to contain the second members of a Rydberg series, which converges to the first ionization potential at 903Å, as determined by the authors [43].

c. Spectral Region below 1000Å [3,65,74]

A continuum with superimposed bands starts at about 860Å, the value determined by Sun and Weissler [65] as the first ionization potential. Strongly preionized bands are in evidence between 750 and 850Å. From 700Å toward shorter wavelengths, the contour of the continuum is better defined and smooth. Sun and Weissler [65] give an f-value of 4.4 for this continuum, which is probably due to photoionization of the molecule since no conspicuous bands from dissociative ionization reactions were observed [65]. Indication of a small discontinuity in the absorption contour near 700Å seems due to the appearance of O^+. Furthermore, CO^+ appears at about 645Å [74].



Comments - Figures
The region from 1850Å to 1970Å has been measured by Thompson et al. [37]

Figure 11. Spectral ranges of data obtained with line and continuum light sources: Carbon dioxide (Figures 11-13 and Tables 13-17).

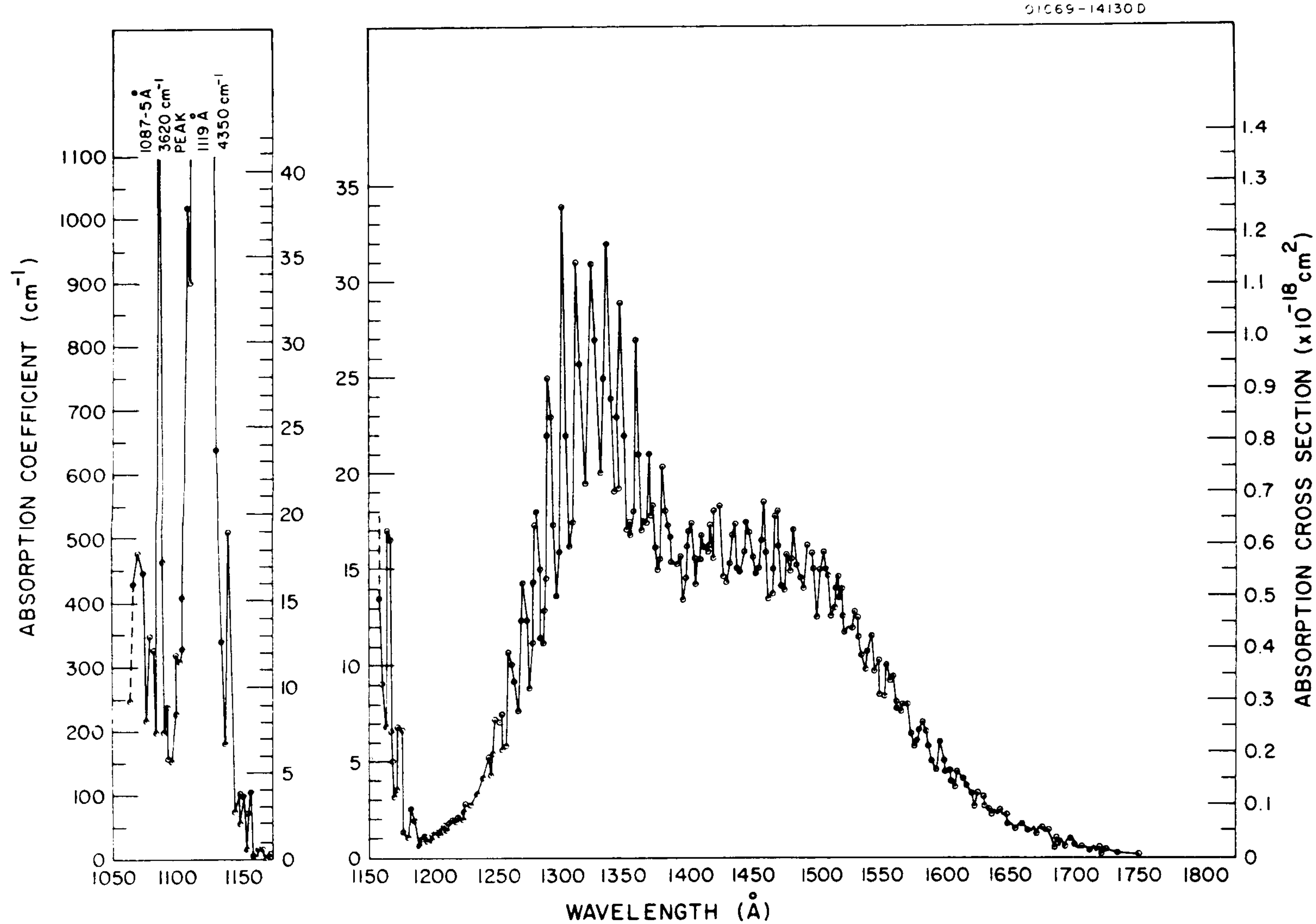


Figure 12. Absorption coefficients and cross sections of CO_2.
λ = 1050Å to λ = 1750Å
Method: Photoelectric detection
Ref: K. Watanabe et al., AFCRC Tech. Rpt. No. 53-23, Geo. Res. Paper No. 21 (1953)

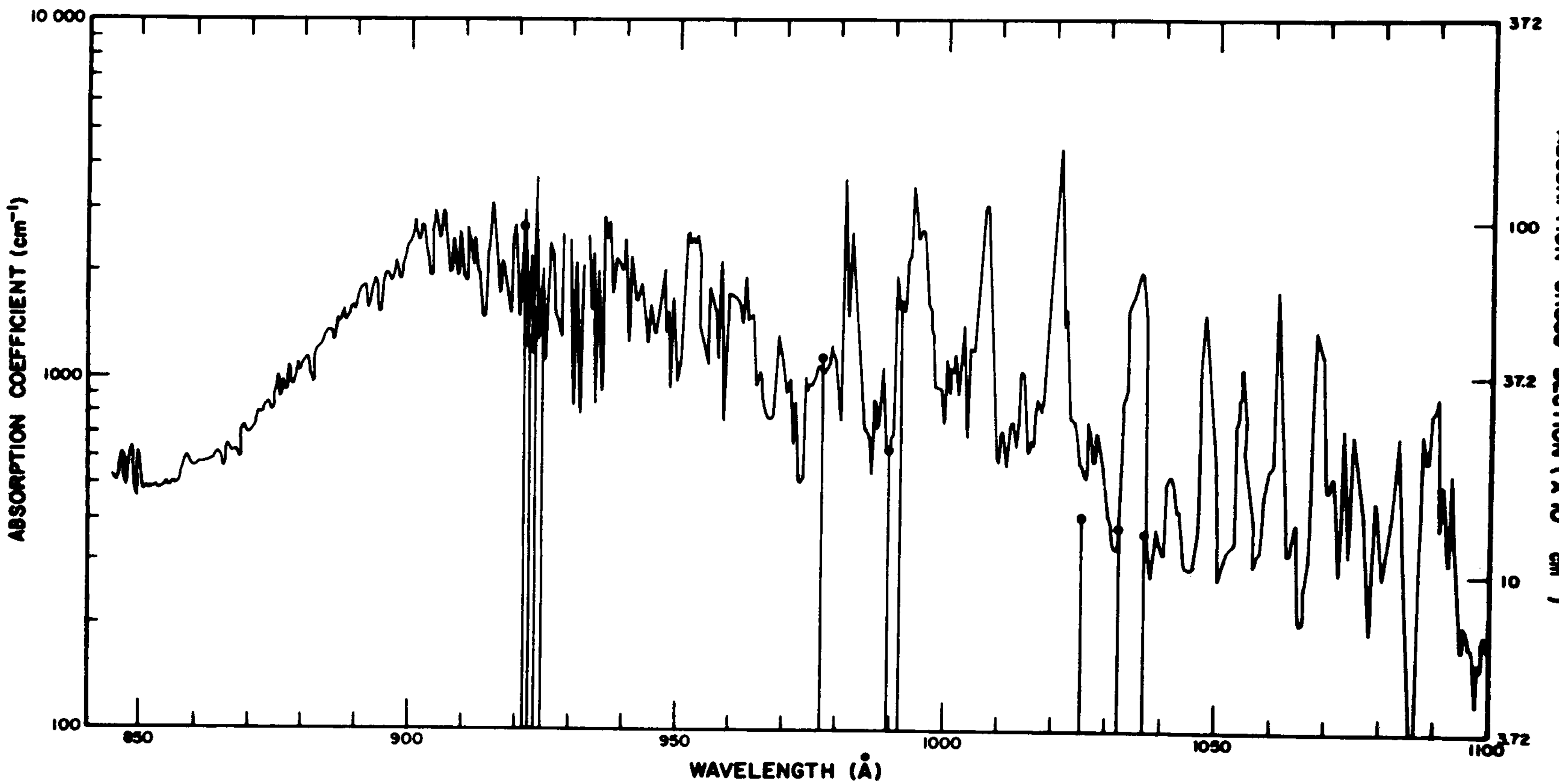


Figure 13. Absorption coefficients and cross sections of CO_2.
λ = 845Å to λ = 1100Å
Method: Photoelectric detection
Ref: K. Watanabe, Univ. of Hawaii, Hawaii, Private Communication (1963)

TABLE 13

ABSORPTION COEFFICIENTS OF CO_2

λ = 165Å to λ = 733Å

Method: Photographic Detection

Ref: J. Romand, Laboratoires de Bellevue, France, Private communication (1962)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
165	460	224	700	301	440
165.5	340	230.5	540	302	760
166	160	231	580	304	380
167	*	234	500	304.5	340
168	*	235.2	660	312.5	400
171	330	236.5	600	317	370
172	390	238	520	322	440
173	500	238.6	720	327	480
177	220	241	680	335	610
178	180	245	600	344	650
180	380	246	580	346.5	720
181	400	247	560	352	880
183	640	249	700	354	670
185	560	251	760	359	810
186.5	320	264	600	361	750
188.5	620	266	720	366	800
189.5	480	277	640	368	750
193	540	278	740	369	720
194.8	400	289	680	370	680
195	370	290.2	690	372	630
196	640	290.5	500	373	630
197	740	291	420	377	690
201	520	292	600	383	730
207	460	293	680	389	570
210	440	293.7	500	395	650
211	480	294	220	398	650
212	660	295	800	401	500
216	640	296	500	402	600
217	620	297	680	403	680
218	740	298	640	408	500
221	480	299	680	411	570

*No significant absorption for the pressures and pathlengths employed.

TABLE 13 (continued)

ABSORPTION COEFFICIENTS OF CO_2

λ = 165Å to λ = 733Å

Method: Photographic Detection

Ref: J. Romand, Laboratoires de Bellevue, France, Private communication (1962)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
416	460	443	760	554	1160
419	510	446	660	555	840
420	460	459	680	620	760
427	460	479	650	633	940
429	510	483	680	645	615
430	530	500	820	653	600
431	540	504	920	685	500
426	640	505	1020	694	410
438	660	507	820	701	420
440	600	508	740	710	520
442	700	526	720	733	390

TABLE 14

ABSORPTION COEFFICIENTS OF CO_2

λ = 373Å to λ = 1306Å

Method: Photographic Detection

Ref: H. Sun, G. L. Weissler; J. Chem. Phys., 23, 1625 (1955)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
373.8	830	660.3	780	833.7	240
374.3	720	671.4	910	835.1	130
434.0	700	671.8	860	835.3	94
434.3	700	672.0	960	903.6	880
507.4	880	672.9	830	904.5	880
507.7	830	673.8	780	915.9	2040
508.2	800	685.0	530	916.0	1390
509.9	830	685.5	780	916.7	940
525.8	800	685.8	700	922.5	3030
537.8	880	686.3	640	923.0	1070
538.4	880	702.3	1100	923.2	3140
539.1	800	702.9	620	923.7	1370
539.5	830	703.9	530	924.3	1500
539.9	830	718.6	510	955.3	1980
553.3	1070	745.8	830	977.0	700
554.5	940	747.0	460	979.9	750
555.0	970	764.3	910	989.8	270
555.1	940	764.4	1530	991.5	1260
555.3	1020	765.1	2010	1084.0	240
580.4	800	771.5	1040	1122.3	670
581.0	830	771.9	720	1127.8	2580
582.2	750	772.4	640	1134.4	560
597.8	960	773.0	780	1135.0	530
599.6	830	776.0	620	1183.0	0
616.3	910	787.7	720	1184.5	0
617.1	940	790.1	350	1199.5	0
635.2	800	796.7	480	1200.2	0
644.1	910	799.7	860	1200.7	0
644.6	890	799.9	750	1243.3	0
644.8	960	832.8	190	1302.2	160
645.2	960	833.3	320	1304.9	61
				1306.0	43

TABLE 15

ABSORPTION COEFFICIENTS OF CO_2

$\lambda = 1000Å$ to $\lambda = 1100Å$

Method: Photoelectric Detection

Ref: K. Watanabe, Univ. of Hawaii, Hawaii, Preliminary Data, Private Communication (1963)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1000.70	1061	1012.53	829	1026.8	736
1000.88	1053	1013.01	710	1027.05	701
1000.98	1148	1013.50	733	1027.84	552
1001.54	1036	1013.94	892	1028.02	553
1001.85	851	1014.32	930	1028.20	679
1002.39	956	1014.51	1025	1028.77	546
1002.63	1051	1015.36	766	1029.04	513
1003.19	1406	1015.77	671	1029.31	475
1003.45	1060	1016.04	651	1030.22	393
1003.99	827	1016.37	612	1030.77	330
1004.26	665	1016.88	632	1030.96	335
1004.61	848	1017.15	672	1031.33	329
1005.04	1183	1017.82	627	1031.89	382
1005.52	1175	1018.29	863	1032.30	514
1005.80	1017	1018.57	823	1032.68	692
1006.19	1383	1018.82	744	1033.05	724
1006.49	1770	1019.35	801	1033.64	1040
1006.97	2129	1019.80	1059	1034.32	1585
1007.34	2500	1020.35	2358	1034.85	1685
1007.58	2958	1020.78	3496	1035.17	1688
1007.91	2703	1021.09	3533	1035.47	1735
1008.33	1896	1021.51	2184	1036.18	2085
1008.78	1441	1021.89	1311	1036.48	1493
1009.10	1255	1022.41	1433	1036.91	712
1009.40	943	1023.36	838	1037.24	463
1009.99	601	1023.77	762	1037.98	298
1010.50	781	1024.31	754	1038.18	267
1011.04	796	1024.60	566	1038.78	301
1011.53	650	1025.34	561	1039.05	342
1011.72	655	1025.73	514	1039.45	385
1012.33	818	1026.55	686	1039.86	326

TABLE 15 (continued)

ABSORPTION COEFFICIENTS OF CO_2

λ = 1000Å to λ = 1100Å

Method: Photoelectric Detection

Ref: K. Watanabe, Univ. of Hawaii, Hawaii, Preliminary Data, Private Communication (1963)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1040.52	307	1054.83	578	1068.48	1215
1040.93	451	1055.21	498	1068.94	699
1041.24	536	1055.63	443	1069.85	470
1041.55	536	1056.32	408	1070.65	533
1041.86	524	1056.77	358	1071.41	404
1042.17	494	1057.01	285	1072.23	262
1042.49	426	1057.51	316	1072.71	334
1042.87	441	1058.02	312	1073.16	573
1043.54	276	1058.30	374	1073.53	583
1043.82	292	1058.77	422	1073.83	743
1044.09	293	1059.51	538	1074.25	545
1044.30	309	1060.12	556	1074.54	313
1044.94	313	1060.57	669	1075.20	678
1045.34	323	1060.91	1513	1075.92	599
1045.72	359	1061.14	1876	1076.60	360
1046.06	429	1061.42	1168	1076.95	344
1046.60	548	1061.66	838	1077.74	185
1047.05	697	1061.99	605	1078.36	200
1047.42	967	1062.59	310	1078.82	225
1047.79	1523	1063.36	390	1079.24	454
1048.63	1300	1063.61	399	1079.69	310
1048.94	869	1063.92	322	1081.03	259
1049.45	701	1064.24	284	1081.44	321
1050.12	383	1064.76	235	1081.75	341
1050.64	256	1065.07	200	1082.33	624
1051.10	283	1065.69	219	1082.95	700
1051.89	313	1066.35	253	1084.13	332
1052.40	327	1066.65	274	1084.53	276
1053.97	811	1067.02	496	1084.82	264
1054.24	1177	1067.57	1089	1085.22	97
1054.65	686	1067.85	1315	1085.97	76

TABLE 15 (continued)

ABSORPTION COEFFICIENTS OF CO_2

λ = 1000Å to λ = 1100Å

Method: Photoelectric Detection

Ref: K. Watanabe, Univ. of Hawaii, Hawaii, Preliminary Data, Private Communication (1963)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1086.33	116	1091.75	319	1096.60	177
1086.78	159	1092.00	297	1097.15	178
1087.10	254	1092.40	391	1097.55	120
1087.54	735	1092.80	540	1097.95	158
1088.57	577	1093.45	298	1098.15	155
1089.87	826	1093.95	268	1098.70	173
1090.45	890	1094.70	204	1099.20	189
1090.75	373	1095.25	170	1099.45	174
1091.10	506	1095.80	199	1100.10	160
1091.35	548	1096.00	175		

TABLE 16

ABSORPTION COEFFICIENTS OF CO_2

λ = 1064Å to λ = 1752Å

Method: Photoelectric Detection

Ref: K. Watanabe, et al., AFCRC Tech. Rep. No. 53-23, Geo. Res. Paper No. 21, (1953)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1064.0	250	1132.0	640	1198.5	0.99
1068.0	430	1136.5	340	1201.5	1.22
1071.0	480	1138.0	182	1203.0	1.34
1074.5	450	1142.0	510	1206.0	1.24
1076.5	220	1146.0	74	1208.5	1.46
1079.5	350	1149.0	104	1209.5	1.69
1082.5	330	1151.5	56	1210.5	1.54
1084.0	200	1152.0	102	1211.5	1.64
1087.5	3620	1155.0	17	1213.0	1.83
1089.5	470	1156.0	73	1215.6	1.97
1092.0	200	1158.0	108	1218.5	1.99
1092.5	240	1159.0	13.5	1221.0	2.10
1094.0	156	1161.5	9.1	1223.0	2.15
1096.0	154	1163.5	6.8	1224.0	2.44
1099.0	230	1165.5	17.0	1226.5	2.78
1101.0	320	1167.5	16.6	1230.0	2.83
1102.5	310	1168.5	6.8	1235.5	3.4
1104.5	330	1169.5	5.1	1239.5	4.2
1106.5	410	1171.0	3.2	1243.5	5.3
1108.0	600	1172.5	3.6	1246.0	4.3
1110.0	1020	1173.5	6.8	1247.5	5.5
1111.0	900	1176.0	6.7	1250.0	7.2
1114.5	1220	1178.0	1.37	1251.5	7.1
1116.0	1630	1179.5	1.33	1253.5	7.5
1118.0	3660	1181.0	1.22	1255.5	5.7
1119.0	4350	1183.0	2.6	1257.0	5.8
1120.0	3780	1185.5	1.89	1260.0	10.8
1121.5	1900	1189.5	0.75	1261.5	10.1
1124.0	1630	1191.0	0.99	1264.0	9.2
1126.0	2470	1192.5	1.15	1267.0	7.7
1128.5	2520	1197.0	0.94	1268.5	12.4

TABLE 16 (continued)

ABSORPTION COEFFICIENTS OF CO_2

λ = 1064Å to λ = 1752Å

Method: Photoelectric Detection

Ref: K. Watanabe, et al., AFCRC Tech. Rep. No. 53-23, Geo. Res. Paper No. 21, (1953)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1271.0	14.3	1339.5	24	1401.0	17.0
1273.5	12.3	1343.0	19.1	1403.0	17.4
1276.5	8.9	1344.5	23	1405.0	15.5
1278.0	11.2	1346.0	19.2	1406.5	14.3
1279.0	14.4	1348.0	29	1408.0	15.4
1281.0	17.2	1351.5	22	1409.0	15.5
1283.0	18.1	1353.5	17.1	1411.0	16.8
1284.5	15.1	1354.5	17.4	1413.5	16.1
1286.5	11.4	1356.5	16.7	1415.5	16.0
1287.5	11.2	1357.5	18.1	1416.5	16.1
1288.5	12.9	1360.0	27	1418.0	17.3
1289.5	14.6	1362.5	21	1420.5	15.6
1290.5	22	1364.0	17.0	1421.5	18.1
1291.5	25	1366.5	17.4	1423.4	18.2
1293.5	23	1368.0	17.4	1425.5	18.3
1295.5	17.3	1370.0	21	1428.0	14.5
1297.0	13.7	1372.0	17.8	1430.5	14.3
1300.0	15.9	1373.0	18.3	1433.5	16.0
1302.5	34	1375.0	16.1	1435.5	16.8
1305.5	22	1377.0	15.0	1437.0	17.3
1307.5	16.2	1378.0	15.6	1438.5	15.0
1311.5	17.5	1381.0	20.4	1441.5	14.9
1313.0	31	1383.0	18.1	1444.0	16.0
1315.5	25.8	1384.5	17.3	1446.5	17.4
1319.5	19.5	1386.5	16.7	1448.0	16.9
1323.5	25	1388.0	15.4	1451.0	15.7
1325.5	31	1391.5	15.3	1453.0	14.7
1327.5	27	1394.5	15.7	1455.5	15.0
1331.5	20	1397.0	13.5	1457.0	16.5
1334.5	25	1398.0	14.6	1458.5	18.5
1336.5	32	1399.5	16.2	1461.0	15.9

TABLE 16 (continued)

ABSORPTION COEFFICIENTS OF CO_2

λ = 1064Å to λ = 1752Å

Method: Photoelectric Detection

Ref: K. Watanabe, et al., AFCRC Tech. Rep. No. 53-23, Geo. Res. Paper No. 21, (1953)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1463.5	13.5	1523.0	11.7	1585.5	6.6
1465.0	13.7	1524.5	11.8	1587.5	5.9
1466.0	15.0	1526.5	12.0	1588.5	5.7
1468.0	17.8	1528.5	11.9	1590.0	5.0
1469.5	18.0	1530.5	12.8	1591.0	4.8
1471.5	16.2	1532.0	12.5	1593.5	4.6
1473.5	14.1	1533.5	11.5	1596.0	6.0
1475.0	14	1536.0	10.5	1599.0	5.0
1477.5	15.8	1538.5	9.8	1602.5	4.4
1479.0	14.9	1540.5	10.7	1604.5	4.5
1480.5	15.6	1543.0	11.6	1606.5	3.9
1482.5	17.1	1546.0	9.7	1608.0	3.7
1484.5	15.4	1547.0	10.0	1610.5	4.4
1488.0	14.5	1548.5	10.2	1612.0	4.2
1490.5	14.0	1550.0	8.5	1613.5	4.1
1493.0	16.3	1551.5	8.6	1616.0	4.1
1495.5	16.1	1553.5	8.4	1616.5	3.7
1496.5	15.9	1554.5	10.0	1618.0	3.5
1498.5	15.0	1556.0	9.9	1621.0	3.3
1501.0	12.5	1558.5	9.2	1623.5	2.7
1503.0	14.9	1560.0	9.3	1625.5	3.3
1506.0	15.9	1562.0	8.1	1628.5	3.2
1507.5	14.9	1563.0	7.8	1630.5	3.2
1509.0	14.7	1566.5	7.7	1631.5	2.69
1512.0	12.6	1568.5	7.9	1634.0	2.35
1514.5	13.0	1571.5	7.9	1634.5	2.35
1516.0	13.9	1574.0	6.4	1636.5	2.23
1517.0	14.6	1577.0	5.8	1638.5	2.27
1518.5	13.6	1578.5	6.1	1640.5	2.17
1519.5	13.9	1580.5	6.6	1641.5	2.18
1521.0	12.5	1583.5	7.1	1643.0	2.39

TABLE 16 (continued)

ABSORPTION COEFFICIENTS OF CO_2

λ = 1064Å to λ = 1752Å

Method: Photoelectric Detection

Ref: K. Watanabe, et al., AFCRC Tech. Rep. No. 53-23, Geo. Res. Paper No. 21, (1953)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1644.5	2.25	1677.5	1.43	1710.0	0.51
1645.5	2.33	1679.5	1.25	1712.5	0.39
1647.5	2.15	1681.5	1.15	1715.0	0.47
1649.5	1.76	1683.5	0.97	1717.0	0.33
1650.5	1.77	1684.0	0.78	1719.5	0.43
1654.0	1.47	1685.5	0.97	1721.5	0.34
1656.5	1.63	1686.5	0.90	1724.0	0.39
1657.5	1.60	1688.5	0.72	1727.0	0.30
1660.0	1.74	1690.0	0.89	1729.5	0.28
1663.0	1.66	1691.0	0.93	1732.0	0.25
1665.0	1.42	1693.5	0.73	1734.5	0.26
1667.5	1.41	1695.5	0.79	1737.0	0.21
1669.0	1.55	1697.0	0.66	1740.0	0.22
1670.5	1.25	1699.0	0.63	1742.5	0.22
1672.0	1.27	1702.0	0.57	1747.0	0.17
1673.5	1.45	1705.5	0.51	1752.0	0.15
1674.5	1.51	1708.0	0.52		

TABLE 17

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF CO_2 AT INTENSE SOLAR EMISSION LINES

λ = 304Å to λ = 1038Å

Method: Photoelectric Detection

Ref: R.B. Cairns and J.A.R. Samson, J. Geo. Res. 70, 99 (1965)

k in Reciprocal Centimeters

σ in Megabarns

Source Line γ	k	σ	γ(%)
303.781 He II	630*	23.4*	100
434.975 O III	743	27.6	100
507.391 O III 507.683 O III	807	30.0	100
508.182 O III	778	28.9	100
522.208 He I	802	29.8	98
525.795 O III	838	31.2	100
537.024 He I	845	31.4	96
553.328 O IV	909	33.8	100
554.074 O IV	818	30.4	100
554.514 O IV	894	33.2	100
555.262 O IV	911	33.9	100
584.331 He I	919	34.2	99
597.818 O III	953	35.4	100
599.598 O III	952	35.4	100
608.395 O IV	951	35.4	100
609.705 O III 609.829 O IV 610.043 O III	949	35.3	100
610.746 O III 610.850 O III	953	35.4	100

*Estimated error ± 10%

TABLE 17 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF CO_2 AT INTENSE SOLAR EMISSION LINES

λ = 304Å to λ = 1038Å

Method: Photoelectric Detection

Ref: R.B.Cairns and J.A.R. Samson, J. Geo. Res. 70, 99 (1965)

k in Reciprocal Centimeters

σ in Megabarns

Source Line γ	k	σ	γ(%)
616.933 O IV 617.033 O IV 617.051 O II	947	35.2	100
624.617 O IV	918	34.1	100
625.130 O IV	927	34.5	100
625.852 O IV	954	35.5	100
629.732 O V	922	34.3	100
684.996 N III	968*	36.0*	96
685.513 N III 685.816 N III	918	34.1	97
686.335 N III	948*	35.2*	93
758.677 O V	1009	37.5	86
759.440 O V	839	31.2	89
760.229 O V 760.445 O V	1185	44.1	89
761.130 O V	1206	44.8	86
762.001 O V	1147	42.6	92
763.340 N III	1238*	46.0*	90
764.357 N III	1635*	60.8	91
765.140 N IV	2527	93.9	92
774.522 O V	996	37.0	77
779.821 O IV 779.905 O IV	1216	45.2	86

*Estimated error ± 10%

TABLE 17 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS
AND PHOTOIONIZATION YIELDS OF CO_2 AT INTENSE
SOLAR EMISSION LINES

$\lambda = 304Å$ to $\lambda = 1038Å$

Method: Photoelectric Detection

Ref: R.B. Cairns and J.A.R. Samson, J. Geo. Res. 70, 99 (1965)

k in Reciprocal Centimeters

σ in Megabarns

Source Line γ	k	σ	γ(%)
787.710 O IV	857	31.9	84
790.103 O IV 790.203 O IV	624	23.2	80
832.754 O II 832.927 O III	359*	13.8*	89
833.742 O III	277*	10.3*	87
834.462 O II	341	12.7	88
835.096 O III 835.292 O III	385	14.3	87
921.982 N IV	2695	100	0
922.507 N IV	1240	46.1	0
923.045 N IV 923.211 N IV			
923.669 N IV	1516	56.4	0
924.274 N IV	1526	56.7	0
972.500 H I			
977.000 C III	1154	42.9	0
989.790 N III	623	23.2	0

*Estimated error ± 20%

TABLE 17 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF CO_2 AT INTENSE SOLAR EMISSION LINES

$\lambda = 304Å$ to $\lambda = 1038Å$

Method: Photoelectric Detection

Ref: R.B. Cairns and J.A.R. Samson, J. Geo. Res. 70, 99 (1965)

k in Reciprocal Centimeters

σ in Megabarns

Source Line γ	k	σ	γ(%)
991.514 N III 991.579 N III	1603	59.6	0
1025.720 H I	407	15.1	0
1031.912 O IV	383	14.2	0
1037.613 O VI	367	13.6	0

4. Carbon Monoxide

a. Historical Survey [65]

Vacuum ultraviolet absorption bands of CO were investigated by Hopfield and Birge [75], Henning [68], and Tanaka and Takamine [46,76]. Apparently, little work was done on absorption coefficients. Watanabe *et al*. [36] obtained relative absorption intensity data between 1050 and 1650Å, and Sun and Weissler [65] measured absorption coefficients at 105 wavelengths between 1306 and 374Å using a line emission light source. Huffman *et al*. [77] have measured the cross sections in the 1006 to 600Å region; however, from 1006 to 1050Å, no data are available. Absorption coefficients have been determined for the narrow Cameron bands 3,0 to 0,0 from 1860 to 2060Å by Thompson *et al*. [37].

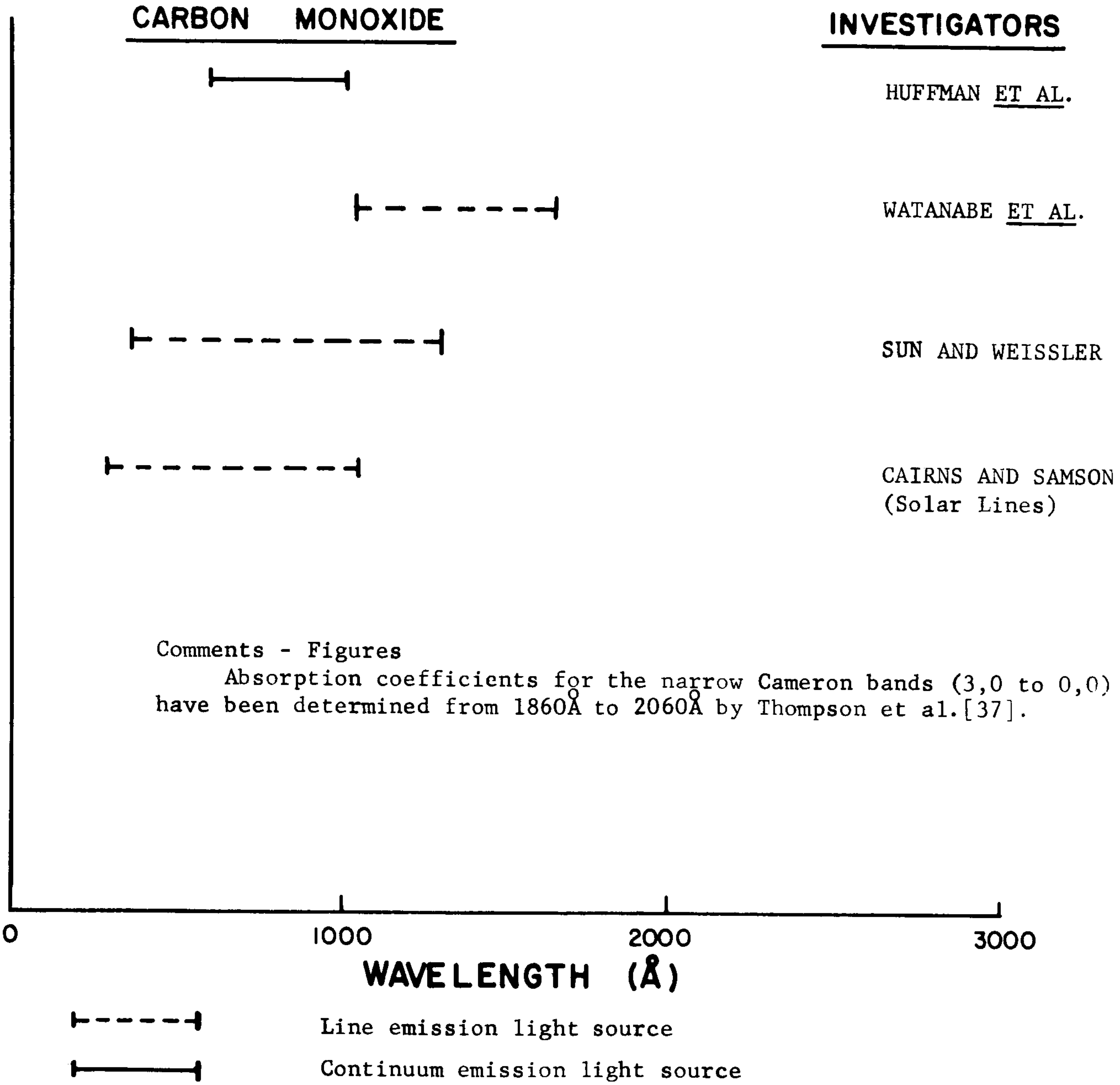
b. Spectral Region 1000Å to 1600Å [36]

Carbon monoxide has a very rich absorption spectrum in the spectral region between 1100 and 1600Å with many strong bands, particularly the well-known IVth positive bands, $X^1\Sigma \rightarrow A^1\Pi$. Because of their sharpness, however, very little quantitative data are available. A weak continuum between 1300 and 1600Å, which resembles the Schumann-Runge continuum, is apparent in the results obtained by Watanabe *et al*. [36]. It is possible that this continuum was due to the presence of O_2 in the CO sample. The absorption coefficients measured by the authors were apparent ones and were obtained with insufficient absorption [36]. The wavelengths of many of the strong absorption bands from 1060 to 1170Å agree with those of the $X \rightarrow C$ and $X \rightarrow E$ transitions found by Hopfield and Birge [75]. In this latter region a continuum was observed [36] to begin at about 1140Å with moderately strong intensity at 1060Å.

c. Spectral Region below 1000Å [65]

Prominent resonance bands appear at 924Å and extend to 600Å. Tanaka and Takamine [46,76] measured three Rydberg series and five progressions of CO between 638 and 938Å. Henning [68] found 26 members of bands between 726 and 881Å. Below 600Å, no bands have been observed.

An absorption continuum begins at about 960Å as observed by Huffman *et al*. [77] and gradually becomes stronger toward shorter wavelengths. This continuum probably results from photodissociation and appears to extend beyond the ionization threshold at 884.7Å. It reaches a maximum around 870Å and gradually decreases toward shorter wavelengths and then begins to rise again toward even shorter wavelengths. The ionization continuum associated with $A^2\Pi_i CO^+$ state should begin at the ionization threshold of 749.7Å; however, the underlying continuum begins to rise at about 760Å and not as predicted.



Comments - Figures

Absorption coefficients for the narrow Cameron bands (3,0 to 0,0) have been determined from 1860Å to 2060Å by Thompson et al.[37].

Figure 14. Spectral ranges of data obtained with line and continuum light sources: Carbon monoxide (Figures 15-17 and Tables 18-20).

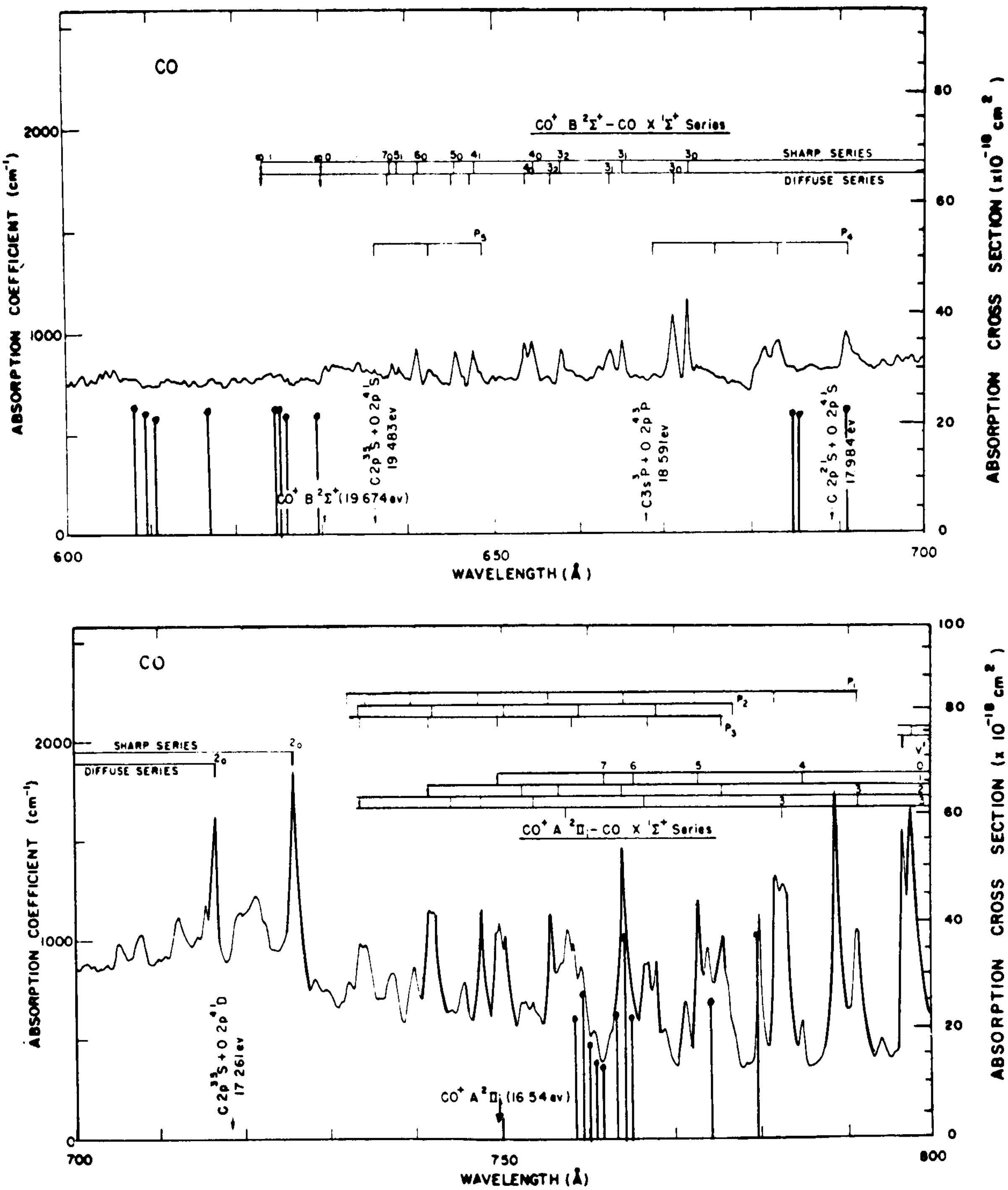
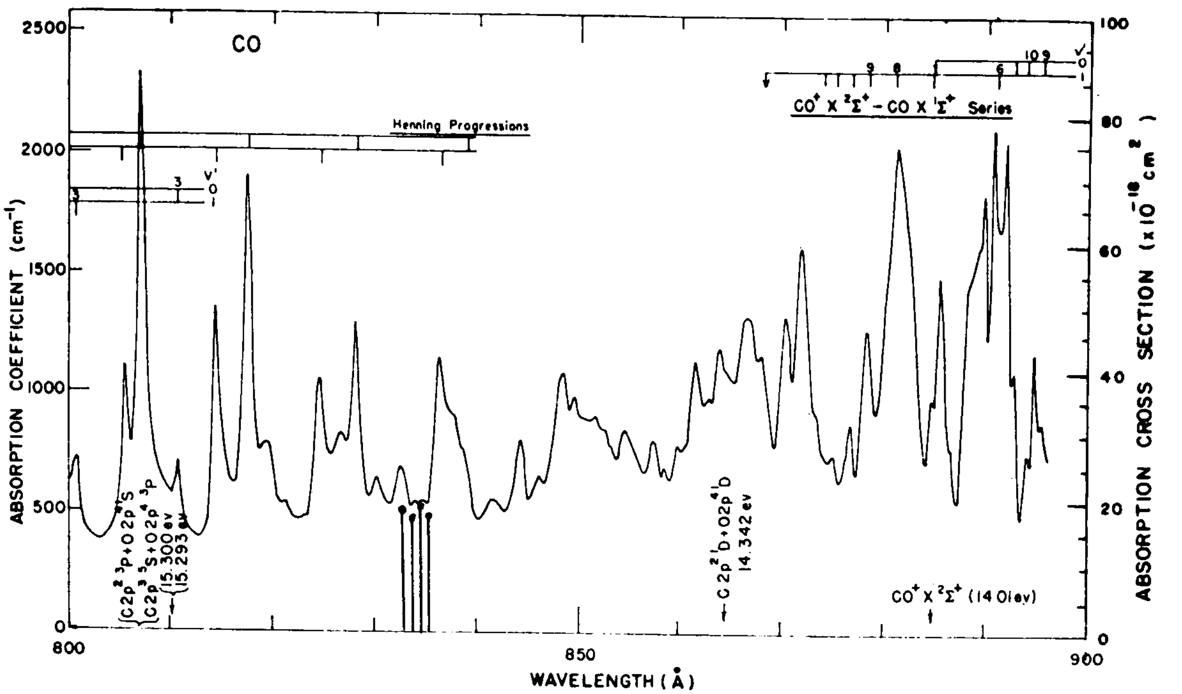


Figure 15. Absorption coefficients and cross sections of CO.
λ = 600Å to λ = 800Å
Method: Photoelectric detection
Ref: R. Huffman et al., J. Chem. Phys. 40, 2261 (1964)
Experimental error: ±10%



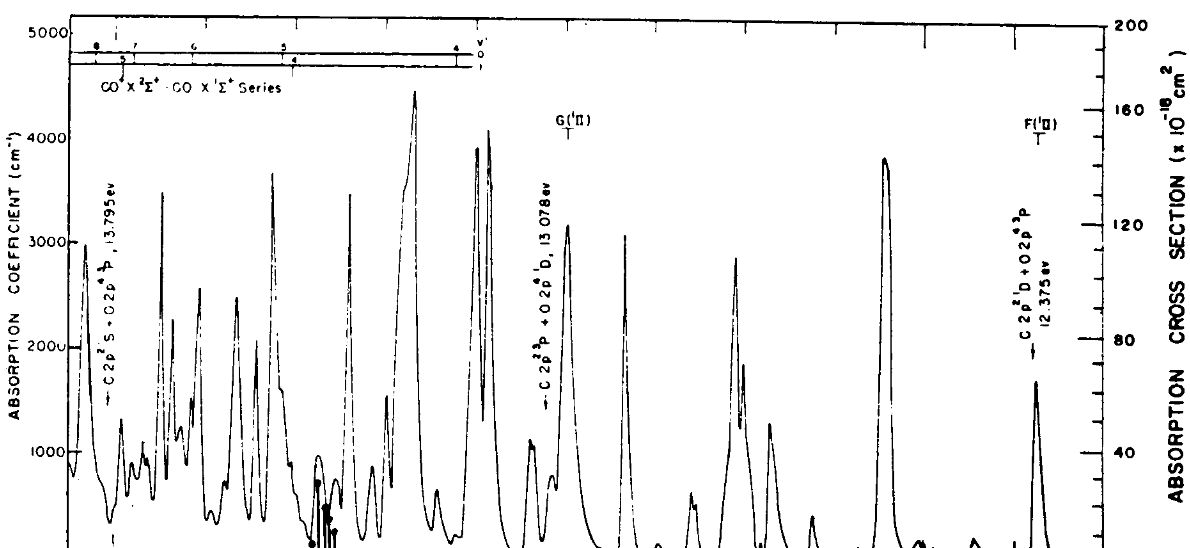


Figure 16. Absorption coefficients and cross sections of CO.
λ = 800Å to λ = 1006Å
Method: Photoelectric detection
Ref: R. Huffman et al., J. Chem. Phys. 40, 2261 (1964)
Experimental error: For k values between 50 and 2000 cm^{-1}, ±10%
For 20-50 and 2000-4000 cm^{-1}, ±20%

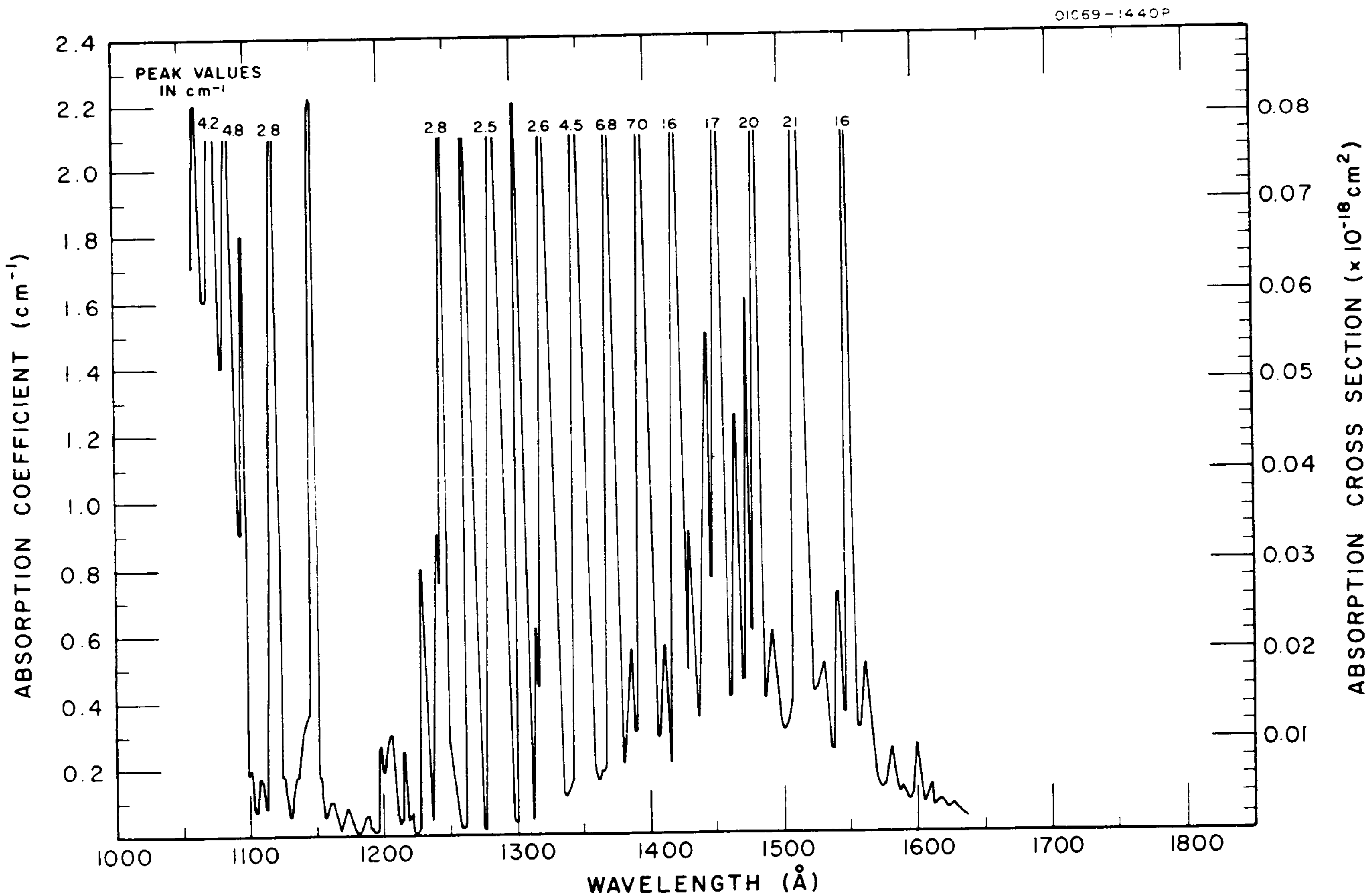


Figure 17. Absorption coefficients and cross sections of CO.
λ = 1050Å to λ = 1650Å
Method: Photoelectric detection
Ref: K. Watanabe et al., AFCRC Tech. Rpt. 53-23, Geo. Res. Paper No. 21 (1953)

TABLE 18

ABSORPTION COEFFICIENTS OF CO

λ = 373Å to λ = 1306Å

Method: Photographic Detection

Ref: H. Sun, G. L. Weissler; J. Chem. Phys., 23, 1626 (1955)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
373.8	430	629.4	560	790.1	430
374.3	350	635.2	590	796.7	1230
434.0	460	644.1	430	799.7	510
434.3	460	644.6	430	799.9	460
507.4	510	644.8	430	832.8	510
507.7	460	645.2	460	833.3	480
508.2	460	660.3	460	834.5	480
509.6	510	671.4	670	835.1	380
525.8	510	671.6	510	903.6	510
529.5	480	671.8	480	904.5	480
529.7	530	672.0	460	915.9	620
529.9	510	672.9	530	916.0	1290
537.8	510	685.0	430	916.7	230
538.3	510	686.3	430	922.5	0
539.1	510	702.3	460	923.0	940
539.5	510	702.9	480	923.2	620
539.9	530	703.9	460	923.7	300
553.3	560	718.6	510	924.3	300
554.5	510	745.8	530	955.3	0
555.3	480	747.0	480	979.9	0
574.7	480	763.3	530	1006.0	0
580.4	480	764.4	780	1135.0	0
581.0	480	765.1	560	1152.2	0
582.2	480	771.5	460	1175.5	0
597.8	510	772.4	590	1184.5	0
599.6	480	773.0	620	1276.7	0
616.3	530	776.0	670	1306.0	0
617.1	530	787.7	590		

TABLE 19

ABSORPTION COEFFICIENTS OF CO

λ = 602Å to λ = 1002Å

Method: Photoelectric Detection

Ref: R. Huffman, et al., J. Chem. Phys. 40, 2261 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
601.9	790	700.0	860	757.4	1060
604.1	800	701.6	880	758.1	990
604.8	810	702.1	870	759.0	850
605.8	830	705.2	990	760.5	550
631.6	840	707.8	1030	762.1	500
634.4	850	712.3	1110	763.9	1460
636.5	810	714.5	1010	766.5	880
638.4	840	715.6	1180	766.9	890
639.2	840	716.7	1630	767.7	900
641.2	920	719.2	1120	768.8	550
642.7	820	721.5	1210	771.2	690
645.7	900	722.6	1080	772.6	1210
646.6	780	725.9	1740	773.8	960
647.9	910	728.3	790	775.4	1020
650.0	780	732.2	780	776.1	780
653.6	940	733.5	980	776.9	520
654.6	960	734.1	980	779.8	1120
656.3	770	737.3	840	781.8	1320
657.9	910	739.7	860	782.6	1250
663.3	880	741.5	1150	784.8	580
663.6	910	742.0	1140	788.7	1750
665.0	960	744.0	650	791.2	1040
668.6	780	745.6	790	794.1	480
670.9	1080	747.5	1160	795.6	410
672.6	1170	749.2	1020	796.7	1550
680.6	840	749.6	1080	797.7	1650
681.6	920	750.3	1020	800.8	700
683.2	960	752.2	680	805.5	1100
691.0	1000	752.6	680	807.0	2320
695.2	840	753.4	690	810.8	700
697.0	870	755.4	1140	814.4	1340
698.8	870	756.5	860	817.5	1890

TABLE 19 (continued)

ABSORPTION COEFFICIENTS OF CO

λ = 602Å to λ = 1002Å

Method: Photoelectric Detection

Ref: R. Huffman, et al., J. Chem. Phys. 40, 2261 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
819.4	780	873.3	900	910.8	440
821.4	530	874.9	730	912.2	700
824.5	1050	876.5	870	913.6	2470
826.6	810	878.2	1260	915.7	2020
828.0	1280	880.2	1500	917.5	3650
830.2	630	881.1	2040	918.7	1550
832.5	680	884.6	970	919.6	920
833.9	530	885.4	1490	920.3	560
834.5	540	886.6	760	921.1	350
836.2	1130	888.1	1440	922.6	980
837.7	890	888.5	1510	924.5	760
838.6	740	889.1	1600	925.9	3470
841.4	540	889.7	1830	928.5	900
844.1	800	890.6	2120	930.1	1570
846.0	640	891.8	2060	931.9	3500
848.3	1070	892.6	1090	933.2	4470
849.4	980	894.0	740	935.7	680
851.6	900	894.7	1180	937.7	230
852.4	840	895.3	900	940.0	3920
853.2	760	895.4	890	941.2	4120
854.5	840	896.9	2970	945.9	1190
857.2	810	898.8	660	946.3	1110
858.3	680	900.1	480	948.3	820
859.7	770	900.8	1310	950.1	3210
861.4	1130	902.0	890	954.1	120
862.7	960	903.2	1100	956.3	3160
863.8	1180	903.7	940	959.5	120
864.5	1090	905.2	3450	960.4	160
866.6	1300	906.4	2210	964.1	660
867.9	1150	907.4	1220	964.6	550
870.2	1320	908.5	1530	968.1	930
871.7	1620	909.3	2550	968.9	2900

TABLE 19 (continued)

ABSORPTION COEFFICIENTS OF CO

λ = 602Å to λ = 1002Å

Method: Photoelectric Detection

Ref: R. Huffman, *et al.*, J. Chem. Phys. 40, 2261 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
969.8	1870	977.5	440	990.1	160
970.5	940	982.5	120	990.9	130
971.8	160	985.5	3840	995.8	250
972.9	1320	986.0	3650	1000.0	80
973.4	800	989.4	220	1002.5	1740

TABLE 20

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF CO AT INTENSE SOLAR EMISSION LINES

$\lambda = 304\text{Å}$ to $\lambda = 1308\text{Å}$

Method: Photoelectric Detection

Ref: R. B. Cairns and J. A. R. Samson, J. Geo. Res. 70, 99 (1955)

k in Reciprocal Centimeters

σ in Megabarns

Source Line λ	k	σ	γ(%)
303.781 He II	307*	11.4*	93*
434.975 O III	519	19.3	100
507.391 O III 507.683 O III	574	21.4	100
508.182 O III	568	21.1	98
522.208 He I	576	21.4	100
525.795 O III	580	21.6	97
537.024 He I	610	22.7	98
553.328 O IV	599	22.3	97
554.074 O IV	595	22.1	97
554.514 O IV	590	21.9	97
555.262 O IV	608	22.6	98
584.331 He I	609	22.6	97
597.818 O III	615	22.9	97
599.598 O III	616	22.9	97
608.395 O IV	611	22.7	98
609.705 O III 609.829 O IV 610.043 O III	601	22.4	98
610.746 O III 610.850 O III	593	22.1	98
616.933 O IV 617.033 O IV 617.051 O II	507	22.6	97
624.617 O IV	610	22.7	98
625.130 O IV	607	22.6	98

*Estimated error ±10%

TABLE 20 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF CO AT INTENSE SOLAR EMISSION LINES

$\lambda = 304\text{Å}$ to $\lambda = 1308\text{Å}$

Method: Photoelectric Detection

Ref: R. B. Cairns and J. A. R. Samson, J. Geo. Res. 70, 99 (1955)

k in Reciprocal Centimeters

σ in Megabarns

Source Line λ	k	σ	γ(%)
625.852 O IV	593	22.1	98
629.732 O V	593	22.1	98
684.996 N III	596	22.2	100
685.513 N III 685.816 N III	595	22.1	100
686.335 N III	590	21.9	100
758.677 O V	616	22.9	57
759.440 O V	724	26.9	65
760.229 O V 760.445 O V	457	17.0	64
761.130 O V	374	13.9	75
762.001 O V	353	13.1	78
763.340 N III	628	23.4	68
764.357 N III	1011	37.6	46
765.140 N IV	626	23.3	57
774.522 O V	678	25.2	56
779.821 O IV 779.905 O IV	1049	39.0	67
787.710 O IV	434	16.1	67
790.103 O IV 790.203 O IV	540	20.1	74
832.754 O II 832.927 O III	514*	19.1*	80
833.742 O III	486*	18.1*	88

*Estimated error ±20%

TABLE 20 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS
AND PHOTOIONIZATION YIELDS OF CO AT INTENSE
SOLAR EMISSION LINES

λ = 304Å to λ = 1308Å

Method: Photoelectric Detection

Ref: R. B. Cairns and J. A. Samson, J. Geo. Res. 70, 99 (1955)

k in Reciprocal Centimeters

σ in Megabarns

Source Line λ	k	σ	γ(%)
834.462 O II	510	19.0	92
835.096 O III 835.292 O III	474	17.6	94

At the following wavelengths, which are longer than the ionization threshold of CO, the measured cross sections of CO were pressure dependent. In these cases, three values of the cross section are given.

Source Line λ	k	σ	γ(%)
921.982 N IV	239 173 166	8.88 6.43 6.17	0 0 0
922.507 N IV	1214 885 733	45.1 32.9 27.3	0 0 0
923.045 N IV 923.211 N IV	896 815 669	33.3 30.3 24.9	0 0 0
923.669 N IV	426 389 368	15.8 14.5 13.7	0 0 0
924.274 N IV	406 313 253	15.1 11.6 9.40	0 0 0
972.500 H I	129 102 94.8	4.80 3.79 3.52	0 0 0

TABLE 20 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS
AND PHOTOIONIZATION YIELDS OF CO AT INTENSE
SOLAR EMISSION LINES

λ = 304Å to λ = 1308Å

Method: Photoelectric Detection

Ref: R. B. Cairns and J. A. Samson, J. Geo. Res. 70, 99 (1955)

k in Reciprocal Centimeters

σ in Megabarns

Source Line λ	k	σ	γ (%)
	10.5	0.39	0
977.000 C III	9.5	0.35	0
	7.4	0.28	0
	163	6.06	0
989.790 N III	76	2.83	0
	66.4	2.45	0
991.514 N III	42.6	1.58	0
991.579 N III	32.4	1.20	0
	32.2	1.20	0
1025.720 H I	<0.4	<0.015	0
1031.912 O IV	<0.4	<0.015	0
1037.613 O VI	<0.4	<0.015	0

5. Water Vapor

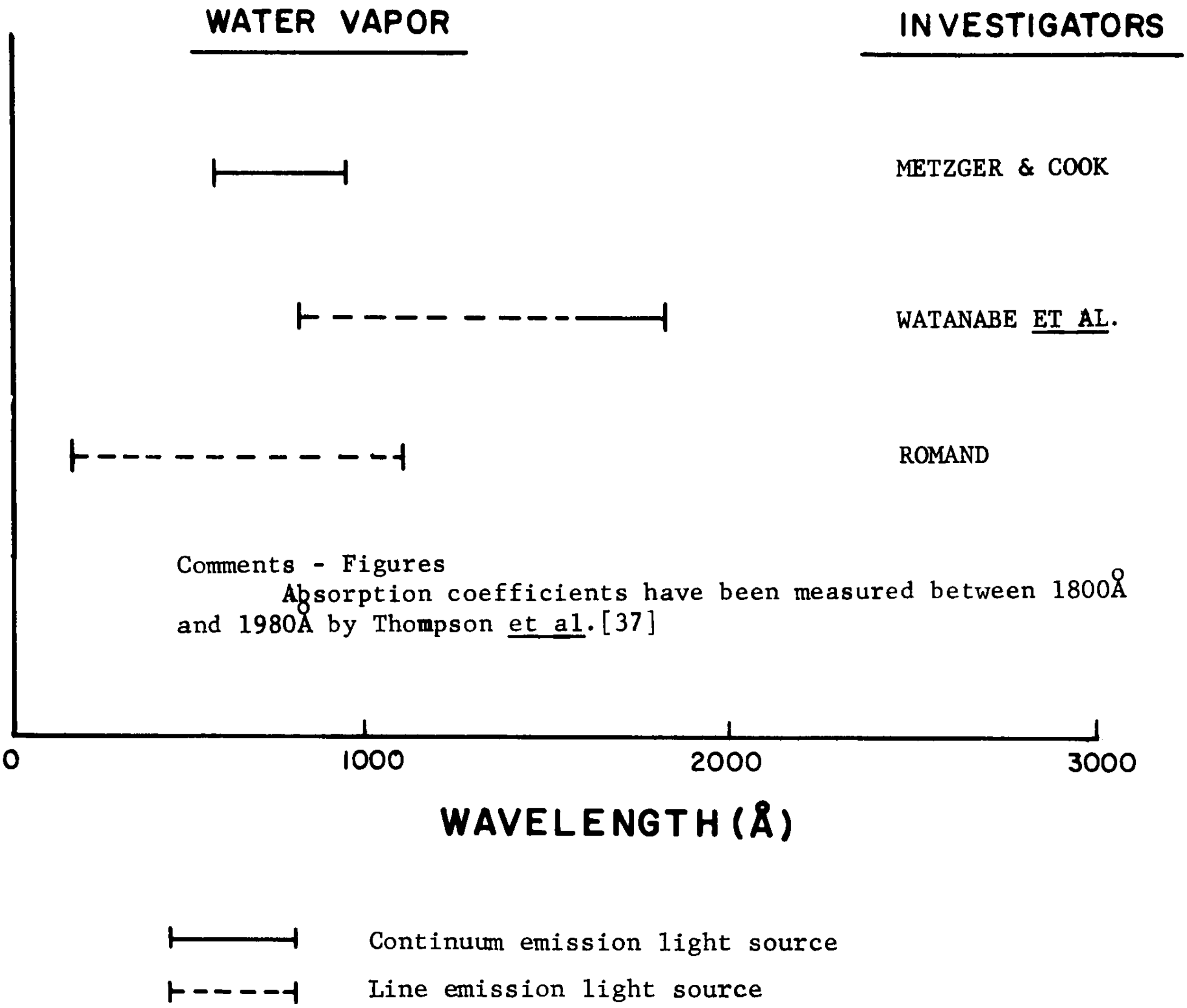
a. Historical Survey [3,16,36]

Water vapor is important because of its nearly universal appearance, and yet surprisingly little work has been done on it. The early work on the absorption spectrum of H_2O vapor in the ultraviolet by Liefson [67], who observed a broad continuum between 1610 and 1870Å and another beginning at 1392Å, was extended by Henning [68], who observed two continua and a number of diffuse bands in the region from 600 to 1100Å. Rathenau [69] reported continuous absorption and bands between 500 and 1750Å. Preston [12] studied the Lyman-α line (1216Å). Price [78] established the first ionization potential at 985Å by identifying two Rydberg series in the region from 1000 to 1250Å. Wilkinson and Johnston [71] reported absorption coefficients in the region from 1450 to 1850Å. Other investigations were made by Harrison et al., [79]; Johannin-Giles [80]; Watanabe and Zelikoff [81], 1050 to 1850Å; Watanabe and Jursa [82], 850 to 1100Å; Astoin et al., [83,84], 160 to 1100Å; and Wainfan et al., [21], 475 to 1000Å. Watanabe et al., [36] undertook a detailed investigation of the region 1050 to 1860Å.

Thompson et al., [37] have measured absorption coefficients from 1850 to 1980Å extending the results of Watanabe et al., [36] by more than two orders of magnitude. Metzger and Cook [85] have reported measurements between 600 and 1000Å.

b. Ultraviolet Spectral Region [16,82]

Twelve weak diffuse bands forming a progression in the region from 1250 to 1450Å and a number of bands in the region from 1060 to 1250Å appear. Price [78] identified two Rydberg series in the latter region, one of them yielding an accurate value of the first ionization potential (982.51Å). Watanabe and Zelikoff [81] calculated f-values of 0.05 for the continuum 1150 to 1430Å and 0.041 for the continuum 1430 to 1860Å. They also reported that no pressure effect was observed except for a few bands. The ionization threshold, as measured by Watanabe and Jursa [81], is at about 983Å or 12.62 ± 0.02 eV which is in agreement with the convergence limit (12.02 eV) of the mean of the C and D Rydberg series identified by Price [78]. Metzger and Cook [51] indicated that a maximum at 900Å probably corresponds to the ionization continuum $H_2O + h\nu \rightarrow H_2O^+ + e^-$.



Comments - Figures

Absorption coefficients have been measured between 1800Å and 1980Å by Thompson *et al.*[37]

Figure 18. Spectral ranges of data obtained with line and continuum light sources: Water vapor (Figures 19 and 20 and Tables 21 and 22).

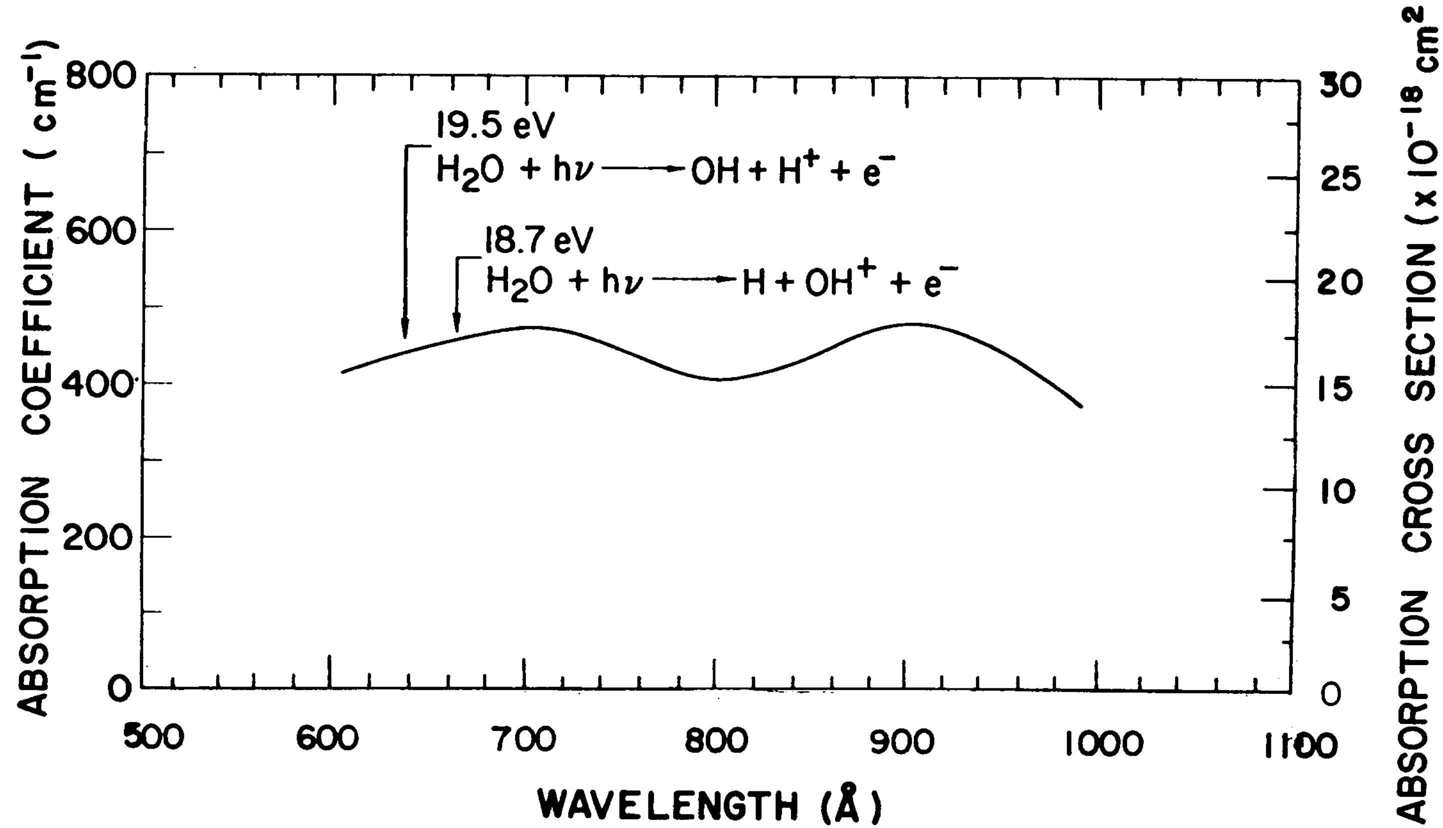


Figure 19. Absorption coefficients and cross sections of H_2O.
λ = 600Å to λ = 985Å
Method: Photoelectric detection
Ref: P. Metzger and G. Cook, J. Chem. Phys. 41, 642 (1964)
Experimental error: ±10%

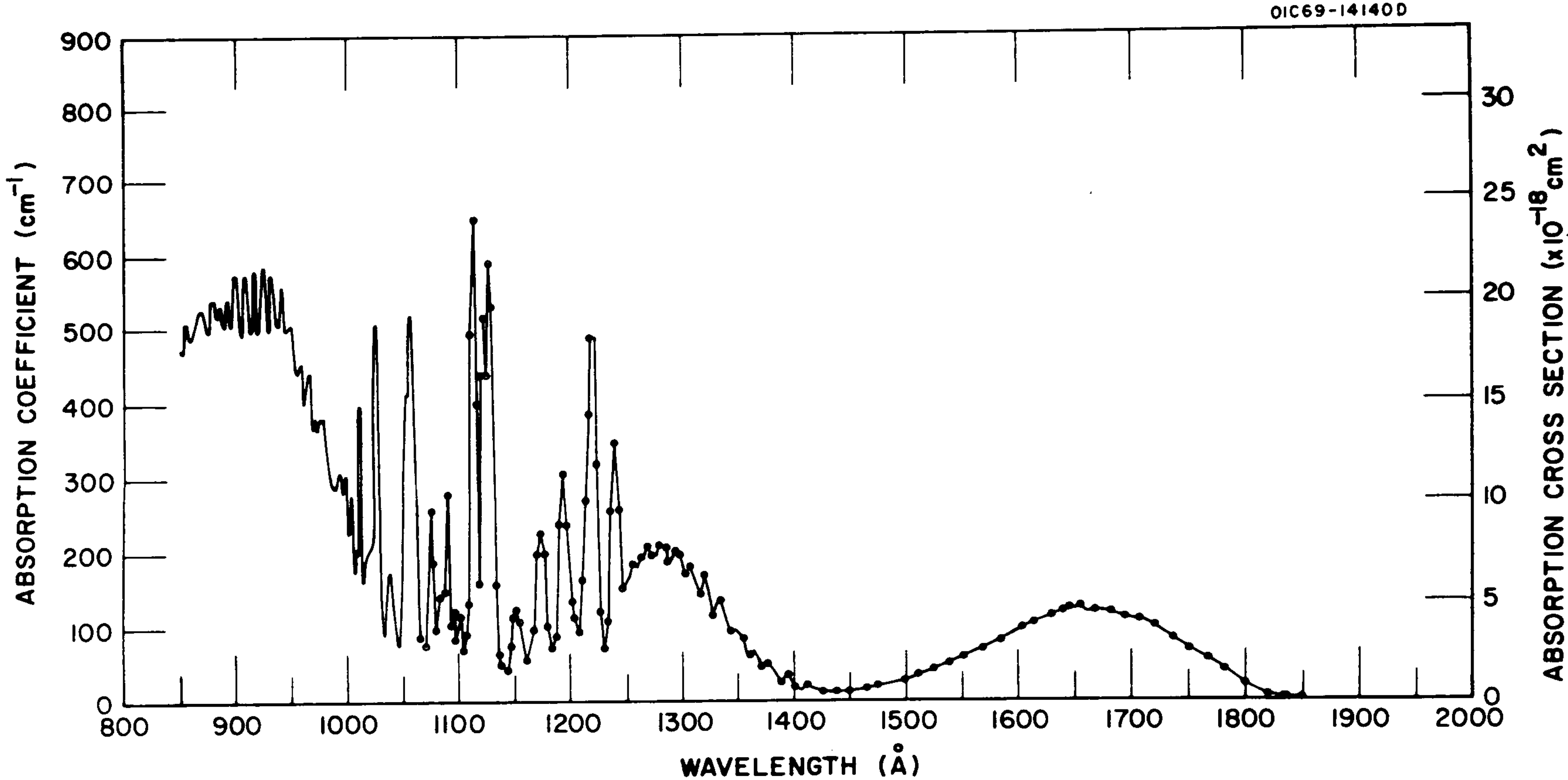


Figure 20. Absorption coefficients and cross sections of H_2O.
λ = 850Å to λ = 1850Å
Method: Photoelectric detection
Ref: K. Watanabe <u>et al</u>. 850Å-1065Å: Advances in Geophysics 5, 199 (1958)
1065Å-1850Å: AFCRC Tech. Rep. No. 53-23, Geo. Res. Paper No. 21 (1953)

TABLE 21

ABSORPTION COEFFICIENTS OF H_2O

$\lambda = 195 Å$ to $\lambda = 1085 Å$

Method: Photographic Detection

Ref: J. Romand, Laboratoires de Bellevue, France, Private communication (1962)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
194.8	100	310	520	390	640
196	200	312.5	540	393	700
197	400	322	580	394	760
200	500	325	620	395	700
201	340	328.5	600	398	700
204	360	333	600	401	720
210	120	335	620	402	700
214	540	337	600	403	740
216	420	338	620	408	760
217	360	340	620	410	820
230.5	180	340.5	620	411	780
231	500	344	660	416	740
234.4	180	346	620	419	720
234.8	320	346.5	680	427	780
235.2	280	352	660	429	720
238.6	1060	358	660	434	800
241	220	359	760	436	800
244	340	360	740	438	840
245	240	361	760	440	820
246	340	364	680	442	800
249	520	366	700	446	820
264	480	367	700	468	720
278	500	368	640	505	640
280	380	369	640	508	300
289	880	370	680	509	780
290.2	760	371	620	526	760
291	860	372	680	528	900
293.7	860	373	640	535	700
295	940	374	600	539	600
296	740	377	660	541	680
297	860	383	660	547	540
299	1040	389	600	550	560

TABLE 21 (continued)

ABSORPTION COEFFICIENTS OF H_2O

λ = 195Å to λ = 1085Å

Method: Photographic Detection

Ref: J. Romand, Laboratoires de Bellevue, France, Private communication (1962)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
554.5	720	740	560	866	620
572	600	743	840	868	540
587	460	749	380	871	840
601	900	750	1000	876	780
602	990	754	740	881	460
603	580	790	1320	886	760
608	840	810	980	892	780
629	660	812	940	898	300
630	780	820	940	912	640
660	920	823	1060	935	520
701	400	832.9	1040	963	420
715	920	833.7	960	975	260
717	920	835.1	600	1018	860
730	720	836.3	680	1042	380
733	840	864	540	1085	240

TABLE 22

ABSORPTION COEFFICIENTS OF H_2O

λ = 1065Å to λ = 1855Å

Method: Photoelectric Detection

Ref: K. Watanabe, et al., AFCRC Tech. Rep. No. 53-23, Geo. Res. Paper No. 21 (1953)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1065	88	1127	590	1190.5	240
1066	91	1128.5	530	1192.5	310
1068.5	65	1132.5	157	1195.5	270
1070.5	78	1135	114	1196.5	240
1071.5	115	1137	64	1198.5	193
1073.5	188	1140	49	1202	135
1075.5	260	1142	45	1203	115
1077	188	1146	75	1205	95
1080.5	96	1148	99	1208	123
1081.5	130	1149	114	1210	166
1083	141	1150	115	1211	182
1086.5	147	1151	123	1213	270
1088.5	270	1152.5	111	1215.6	387
1090.5	280	1153.5	107	1218.5	490
1091	134	115	105	1221	490
1093	103	1157.5	84	1222.5	410
1095.5	120	1161	56	1223.5	320
1098	86	1163.5	66	1226	123
1100	115	1165	78	1230	69
1102.5	83	1166	98	1234	108
1104	70	1168	146	1236	260
1106	91	1169	153	1239	350
1108	132	1170.5	198	1243	260
1109.5	180	1172	230	1244	205
1111.5	490	1173	230	1247.5	153
1114.5	650	1175.5	200	1249.5	158
1116.5	400	1178	138	1252.5	168
1118.5	161	1179	104	1254	175
1120.5	440	1180.5	68	1256	183
1122	520	1182.5	70	1257.5	185
1123.5	470	1185.5	89	1260	183
1125.5	440	1189.5	132	1262	183

TABLE 22 (continued)

ABSORPTION COEFFICIENTS OF H_2O

λ = 1065Å to λ = 1855Å

Method: Photoelectric Detection

Ref: K. Watanabe, et al., AFCRC Tech. Rep. No. 53-23, Geo. Res. Paper No. 21 (1953)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1264.	194	1314.5	144	1367	61
1266	198	1315.5	143	1368	56
1270	209	1318	157	1369.5	52
1272	201	1319.5	169	1371.5	46
1273.5	197	1321.5	165	1374.5	47
1274.5	193	1323.5	149	1377.5	49
1275.5	195	1325	137	1379.5	45
1277.5	201	1327	125	1381	42
1278.5	203	1328.5	114	1383.5	35
1280	210	1329.5	116	1386	30
1281.5	209	1331.5	128	1388	28
1283.	209	1332.5	128	1389.5	30
1284	208	1334.5	134	1391	31
1286	199	1336	128	1392	33
1287.5	189	1337	121	1394	32
1289	189	1338.5	114	1395	30
1291	192	1340.5	106	1396.5	29
1292.5	196	1342.5	99	1399.5	24
1294	202	1344	93	1400.5	21
1296	198	1346	95	1403	17.8
1298	192	1347.5	96	1406	16.5
1299	185	1349	93	1407.5	17.4
1300	178	1351	90	1409.5	19.4
1301.5	173	1352	87	1411	20.2
1303	171	1354	85	1413.5	19
1305	173	1355.5	78	1416	17.9
1306	181	1358	67	1418.5	16.6
1308	187	1359	64	1420.5	15.4
1309.5	180	1361.5	61	1423.5	14.4
1311.5	161	1363.5	66	1425	13.3
1313	150	1365.5	64	1428	13

TABLE 22 (continued)

ABSORPTION COEFFICIENTS OF H_2O

λ = 1065Å to λ = 1855Å

Method: Photoelectric Detection

Ref: K. Watanabe, et al., AFCRC Tech. Rep. No. 53-23, Geo. Res. Paper No. 21 (1953)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1430.5	13.2	1505	32	1584.5	82
1433.5	13.2	1509	34	1586	84
1437	13	1511.5	35	1587	84
1440	13.2	1512.5	36	1589.5	88
1441.5	13.5	1515.5	36	1591.5	89
1444	13.5	1518	38	1593.5	90
1446.5	13.7	1521.5	40	1596.5	92
1449	13.6	1523.5	42	1599.5	95
1450.5	13.6	1527	44	1602.5	98
1452.5	13.4	1529	45	1605	99
1455.5	14.3	1532.5	47	1608	103
1458	14.9	1535	48	1612	103
1461	15.5	1538	50	1613	104
1464	17	1540	52	1616.5	107
1466	17.7	1542	53	1618.5	108
1468	18.1	1545	55	1621	109
1470	18.1	1548	57	1623.5	111
1471.5	18.5	1551	59	1626	111
1474	19.1	1554	61	1628.5	111
1476.5	20.1	1557	63	1630.5	113
1478	20.3	1559.5	63	1632	115
1480	20.4	1563	64	1634	117
1482	21.1	1564.5	64	1636.5	120
1484	22.4	1566.5	70	1639	122
1487	23.4	1568	69	1640	120
1489.5	23.9	1570	71	1643	121
1492	25.2	1572.5	73	1644.5	123
1495.5	26.4	1575	75	1647.5	125
1498	27.9	1578	78	1650	124
1500	28.9	1580	78	1652	123
1502.5	30.4	1581.5	79	1654.5	127

TABLE 22 (continued)

ABSORPTION COEFFICIENTS OF H_2O

λ = 1065Å to λ = 1855Å

Method: Photoelectric Detection

Ref: K. Watanabe, et al., AFCRC Tech. Rep. No. 53-23, Geo. Res. Paper No. 21 (1953)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1658	122	1720	99	1795	26
1660	122	1725	95	1800	21
1663	123	1730	91	1805	17
1665	122	1735	85	1810	13
1668	121	1740	78	1815	10
1672	122	1745	74	1820	7.7
1675	119	1750	70	1825	5.9
1680	119	1755	68	1830	4.6
1685	114	1760	64	1835	3.4
1690	114	1765	58	1840	2.6
1695	114	1770	54	1845	1.8
1700	111	1775	49	1850	1.5
1706.5	110	1780	43	1855	1.0
1710	107	1785	39		
1715	106	1790	33		

6. Nitrogen

a. Historical Survey [1,3]

The absorption spectrum of molecular nitrogen was first studied by Lyman [86] and later by Birge and Hopfield [87]. N_2 is practically transparent at all wavelengths longer than 1450Å. No dissociative continua have been found, but in the far ultraviolet very intense ionization continua exist. In a detailed spectroscopic analysis Worley [88], Tanaka and Takamine [46], and others were able to group most of the strong and sharp resonance bands between 600 and 1000Å into a Rydberg series converging on the first ionization potential at 796Å and the Hopfield-Rydberg series converging on the limit at 661Å. Absorption coefficient measurements were made by Clark [18], 840 to 1000Å; Weissler et al. [89], 300 to 1300Å; Curtis [90], 150 to 1000Å; Lee [2], 900 to 1050Å; Watanabe and Marmo [22], 850 to 1000Å; and Astoin and Granier [91], 125 to 1000Å. Watanabe's [17] very detailed study of the region from 850 to 1000Å showed a pressure effect at all wavelengths. Recently, Huffman et al. [92] and Cook and Metzger [24] refined the measurements for the 600 to 1000Å region. Samson [25] and Samson and Cairns [26] extended the data down to 200Å.

b. Spectral Region 800Å to 1450Å [1,16,89]

This region is comprised primarily of the weak Lyman-Birge-Hopfield bands, which correspond to the forbidden transition $X^1\Sigma_g^+ \rightarrow {}^1\Pi_g$. Tanaka [93] suggested that the appearance of other bands was due to the transition $X^1\Sigma_g^+ \rightarrow C^3\Pi_u$. Weissler et al. [89] suggested a possible continuum in the region from 800 to 1300Å, but more detailed studies -- for example, that of Watanabe [17] -- failed to confirm its existence. Many strong, discrete bands forming numerous progressions occupy the area between 800 and 1000Å. Above 910Å, Lee [2] found narrow areas of very low absorption coefficients, which agree with the atmospheric windows estimated by Hopfield [94].

c. Spectral Region Below 800Å [1,89]

From 300 to 800Å the discrete band absorption superimposes a background of continuous absorption. Apparently, two ionization continua exist: one adjoins the Worley-Jenkins series with a maximum near its long wavelength limit at 796Å ($N_2^+ X^2\Sigma_g^+$), and a much weaker continuum adjoins the Hopfield series with a separate maximum near its long wavelength limit at 661Å ($N_2^+ B^2\Sigma_u^+$). Weissler et al. [89] calculated effective oscillator strengths of 3.0 for the stronger Worley-Jenkins continuum and 0.3 for the weaker Hopfield continuum.

Huffman et al. [92], observed that from 1000 to 796Å, the first ionization threshold (N_2^+, $X^2\Sigma_g^+$), a number of sharp intense bands are present with no evidence of a dissociation continuum. Below 796Å, the ionization continuum appears to rise slowly. At 661Å, the absorption coefficient rises abruptly and remains relatively constant at this level to 580Å, the cut-off of their data. Cook and Metzger [24] report, on the other hand, that three major continua become evident below 828Å in addition to the ionization continuum.

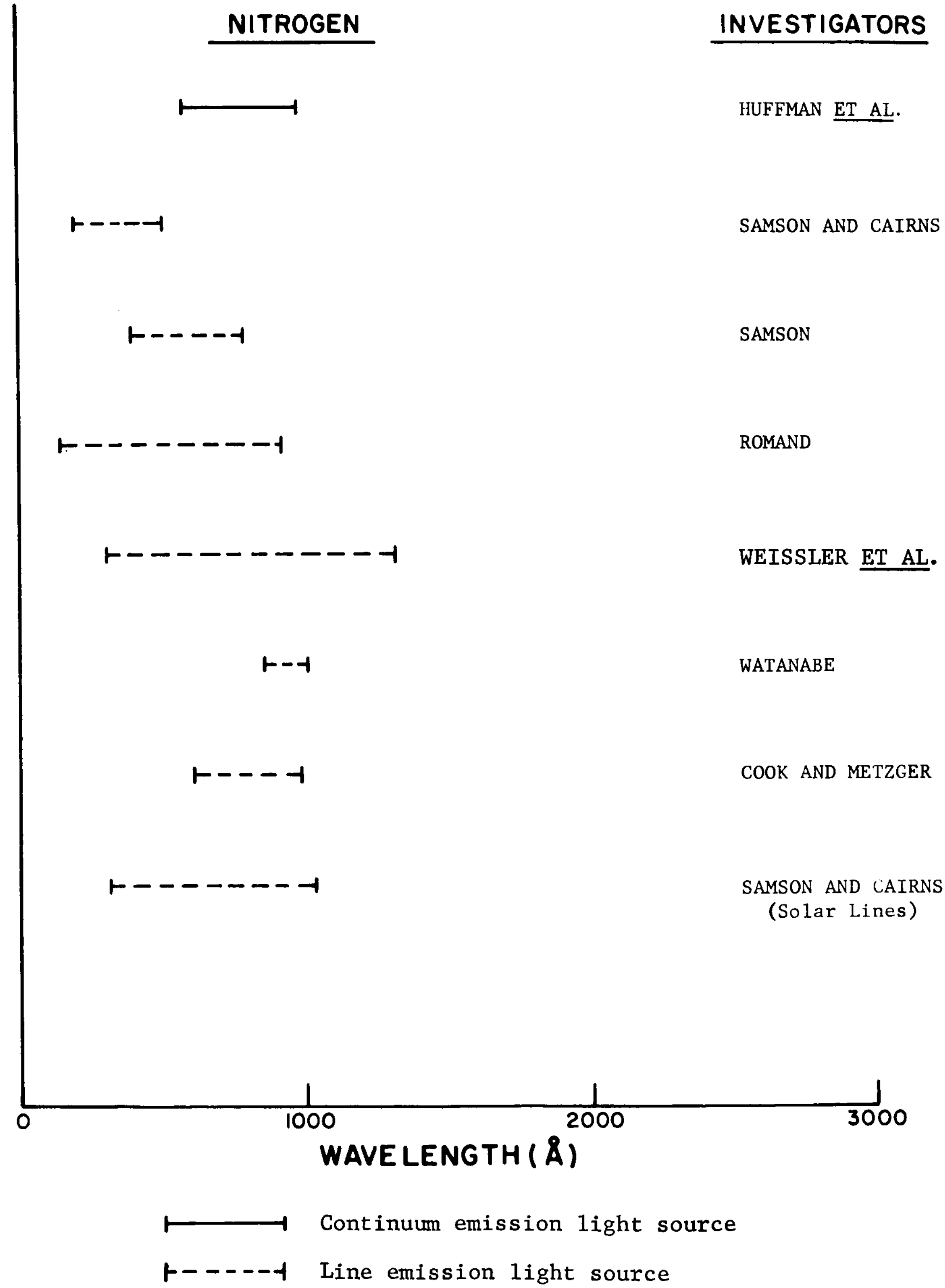


Figure 21. Spectral ranges of data obtained with line and continuum light sources: Nitrogen (Figures 22 and 23 and Tables 23-30).

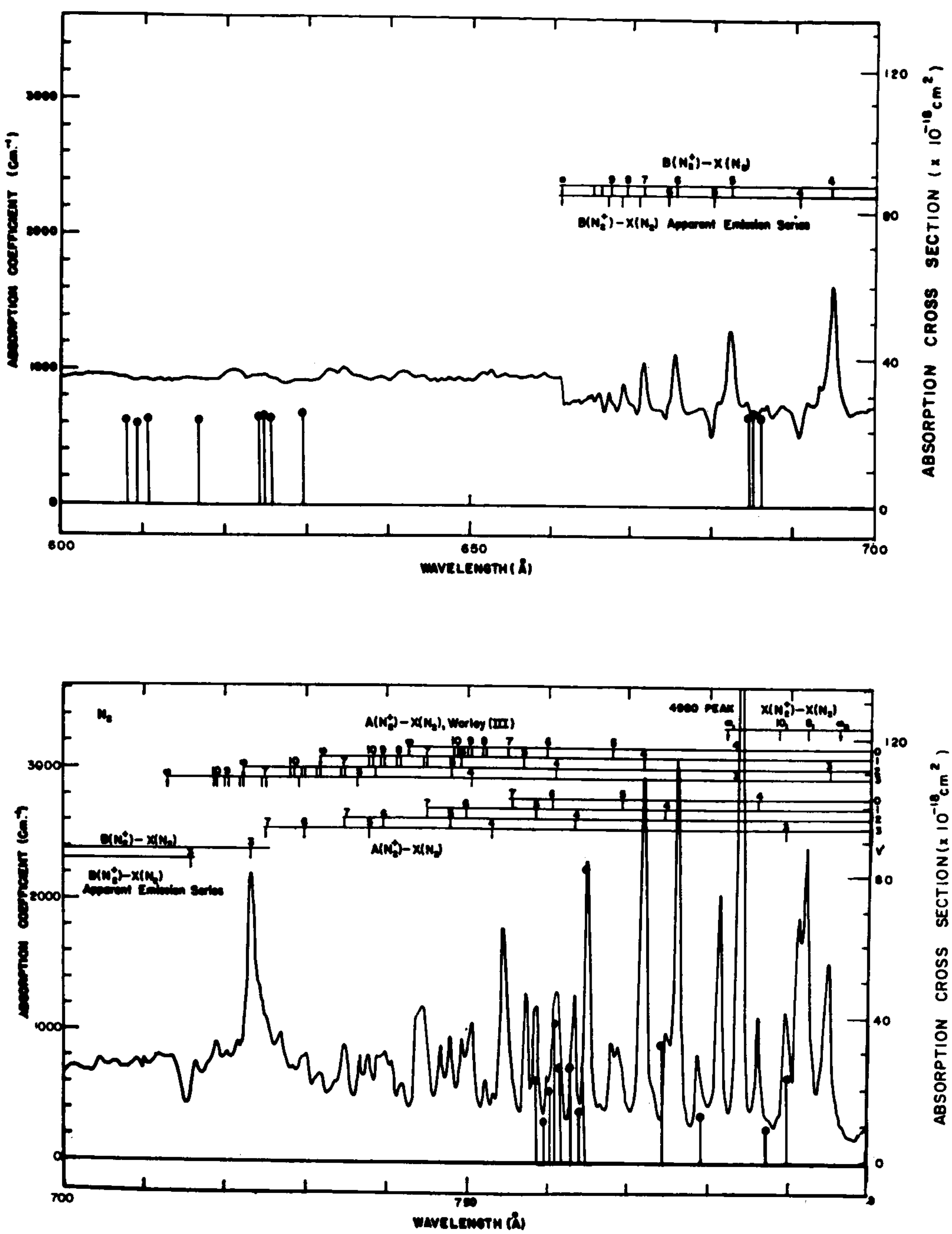
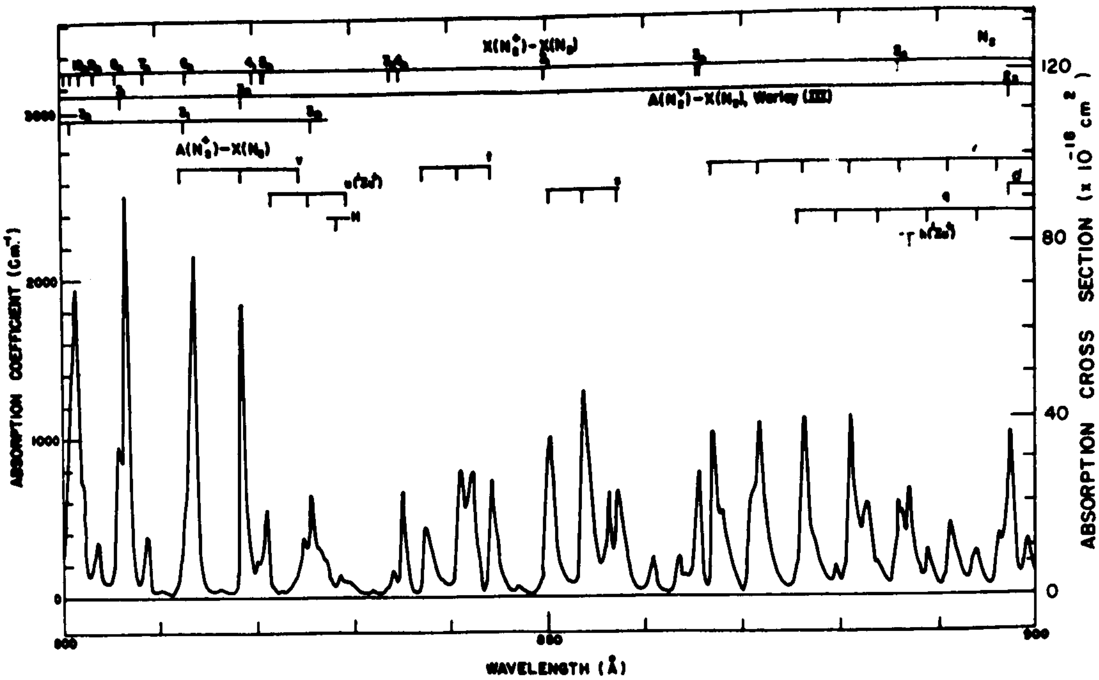


Figure 22. Absorption coefficients and cross sections of N_2.
λ = 600Å to λ = 800Å
Method: Photoelectric detection
Ref: R. Huffman et al., J. Chem. Phys. 39, 910 (1963)
Experimental error: 630Å-796Å ±10% for k values between 50 and 2000 cm^{-1}
796Å-800Å ±10% for absorption minima larger than 50 cm^{-1} between the strong bands.



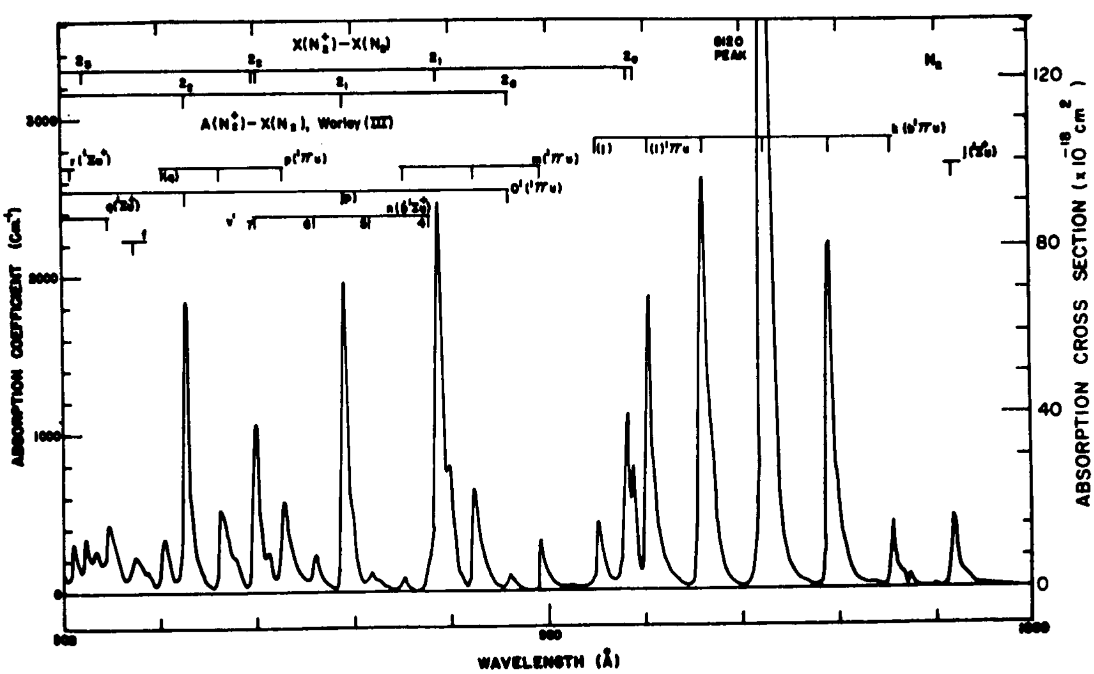


Figure 23. Absorption coefficients and cross sections of N_2. λ = 800Å to λ = 1000Å
Method: Photoelectric detection
Ref: R. Huffman et al., 39, 910 (1963)
Experimental error: ±10% for absorption minima larger than 50 cm^{-1} between the strong bands.

TABLE 23

ABSORPTION COEFFICIENTS OF N_2

$\lambda = 145\text{Å}$ to $\lambda = 929\text{Å}$

Method: Photographic Detection

Ref: J. Romand, Laboratoires de Bellevue, France, Private Communication (1962)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
145.0	400	202.0	430	252.0	340
150.0	570	203.0	530	256.0	310
151.0	290	203.5	300	258.0	365
152.0	350	204.0	340	259.0	320
155.0	380	207.0	325	260.0	310
156.0	310	209.0	380	264.0	320
157.5	470	210.0	420	266.0	390
158.0	420	212.0	380	272.0	290
159.0	470	214.0	300	278.0	350
160.0	530	215.0	360	280.0	285
161.0	390	216.0	380	284.0	265
163.0	440	217.0	340	287.0	265
165.5	320	219.0	450	289.0	220
166.0	480	220.5	440	290.2	270
168.0	360	221.0	410	291.0	295
169.0	320	224.0	445	292.0	255
120.0	400	230.5	360	293.0	265
171.0	480	231.0	360	293.7	340
172.0	450	232.0	360	294.0	285
180.0	250	233.0	530	295.0	270
185.0	150	234.0	440	296.0	520
186.5	170	234.4	550	297.0	550
188.5	220	235.2	440	298.0	275
189.5	350	238.6	470	299.0	510
191.7	170	240.0	385	299.5	245
192.0	390	241.0	620	301.0	340
193.0	350	243.3	660	302.0	260
194.8	330	244.0	360	303.8	275
196.0	230	245.0	480	305.8	370
197.0	390	246.0	450	308.5	520
200.0	350	249.0	345	309.0	350
201.0	270	251.0	385	311.0	430

TABLE 23 (continued)

ABSORPTION COEFFICIENTS OF N_2

λ = 145Å to λ = 929Å

Method: Photographic Detection

Ref: J. Romand, Laboratoires de Bellevue, France, Private Communication (1962)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
312.5	280	408.0	390	602.0	420
320.0	280	411.0	400	608.0	480
321.0	270	416.0	390	610.0	300
322.0	380	419.5	390	620.0	470
327.0	275	427.0	450	645.0	255
328.0	280	429.0	400	653.0	260
330.0	285	430.0	510	664.0	230
335.0	295	431.0	500	685.0	300
340.5	285	436.0	445	694.0	420
342.0	310	438.0	450	701.0	345
344.0	320	440.0	450	733.0	390
346.0	350	442.0	445	740.0	390
346.5	345	446.0	450	754.0	440
352.0	340	459.0	420	759.0	360
359.0	330	468.0	435	786.0	430
361.0	360	479.0	420	770.0	270
362.0	380	483.0	430	776.0	470
366.0	380	504.0	320	810.0	560
368.0	375	505.0	320	823.0	660
369.0	360	507.0	360	826.0	180
370.0	390	508.0	420	827.0	210
372.0	375	508.5	440	829.0	150
373.0	390	512.0	480	835.1	200
377.0	380	513.0	150	863.0	200
389.0	400	526.0	440	872.0	360
395.0	400	541.0	430	876.0	390
398.0	385	554.0	720	881.0	270
401.0	420	555.0	480	929.0	320
402.0	400	584.0	400		
403.0	425	601.0	330		

TABLE 24

ABSORPTION COEFFICIENTS OF N_2

$\lambda = 209Å$ to $\lambda = 512Å$

Method: Photoelectric Detection

Ref: J. A. R. Samson and R. B. Cairns, GCA Corporation, Bedford, Mass., Private Communication (Dec. 1964)

k in Reciprocal Centimeters

λ	k	λ	k
209.3	175	335.1	378
225.2	-	345.1	402
234.2	-	358.5	425
239.6	-	362.9	436
247.2	264	374.4	469
260.5	-	387.4	504
266.3	284	428.2	598
283.5	295	434.3	605
297.6	312	452.2	611
303.1	315	463.7	612
314.9	337	508.2	619
323.6	355	512.1	630

TABLE 25

ABSORPTION COEFFICIENTS OF N_2

λ = 304Å to λ = 1306Å

Method: Photographic Detection

Ref: G. L. Weissler, et al., J. Opt. Soc. Am., 42, 84 (1952)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
303.9	110	685.5	730	904.1	490
374.1	320	685.8	810	904.5	520
395.6	340	686.3	860	915.96	180
418.7	360	702.3	610	916.01	360
418.9	300	702.8	800	916.7	860
507.4	440	703.8	720	971.2	570
507.8	440	718.6	750	971.3	460
508.2	440	745.8	790	977.0	460
515.5	610	747.0	840	979.8	720
515.6	500	748.4	680	989.8	120
525.8	490	763.3	910	991.5	69
537.8	580	764.4	640	1025.7	60
539.5	670	765.1	2760	1036.0	310
580.4	710	771.6	2160	1036.3	260
584.4	700	771.9	1420	1084.0	130
616.3	720	772.4	1100	1084.6	130
617.0	760	773.0	950	1085.5	130
635.2	710	776.0	2550	1134.2	110
644.2	720	787.7	250	1134.4	93
644.6	720	790.2	670	1135.0	140
644.8	720	796.7	420	1199.5	120
645.2	720	832.8	92	1200.2	160
660.3	690	833.3	260	1200.7	98
671.0	820	833.7	230	1215.1	66
671.4	1030	834.5	140	1243.3	65
671.6	800	835.1	510	1302.2	48
671.8	790	835.3	120	1304.9	100
672.0	610	879.1	440	1306.0	6.7
673.8	550	903.6	460		
685.0	730	904.0	480		

TABLE 26

ABSORPTION COEFFICIENTS OF N_2

λ = 406Å to λ = 795Å

Method: Photoelectric Detection

Ref: J. A. R. Samson, GCA Corporation, Bedford, Mass., Preliminary Data, Private Communication (1963)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
406	580	512	688	608	640
409	605	514	672	610	640
410	607	517	672	613	658
415	618	519	686	615	655
422	641	522	695	617	645
426	652	525	702	619	632
429	630	527	685	625	658
435	640	529	718	630	640
437	635	532	714	634	654
442	645	534	703	637	660
445	646	536	714	641	658
447	645	539	696	644	660
449	640	542	718	649	660
457	647	545	691	651	679
459	650	549	684	660	672
463	648	552	684	663	678
465	656	555	679	665	704
468	650	559	681	668	684
471	648	562	670	670	625
474	660	564	659	674	851
476	652	568	664	677	649
480	651	570	642	680	680
484	660	573	650	683	696
486	659	577	647	684	650
488	664	580	640	689	660
492	652	583	631	693	670
497	650	586	616	696	1110
499	659	588	632	700	610
501	650	594	628	703	630
506	660	597	629	705	659
509	661	600	648	709	660
510	688	603	646	713	684

TABLE 26 (continued)

ABSORPTION COEFFICIENTS OF N_2

λ = 406Å to λ = 795Å

Method: Photoelectric Detection

Ref: J. A. R. Samson, GCA Corporation, Bedford, Mass., Preliminary Data, Private Communication (1963)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
715	443	742	481	774	532
718	671	745	818	777	576
721	668	748	591	780	375
725	890	751	567	783	770
727	708	755	820	787	265
731	629	760	495	790	603
735	581	765	906	792	815
737	586	767	402	795	484
739	661	772	688		

TABLE 27

ABSORPTION COEFFICIENTS OF N_2

λ = 841Å to λ = 986Å

Method: Photoelectric Detection

Ref: K. Watanabe, Hawaii Inst. of Geophys. Contr. No. 29, Dec. 1961

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
840.6	1309.6	894.1	70.0	930.8	64.0
841.9	1021.0	901.6	130.0	931.4	10.1
843.6	18.6	903.8	30.0	937.8	370.0
845.3	1031.0	905.4	30.0	948.8	170.0
846.1	41.0	909.2	90.0	955.5	90
849.7	723.8	910.3	150.0	960.5	1600
852.8	40.5	911.3	640.0	966.0	1600
855.6	580.0	914.1	35.0	972.6	10000.0
859.0	170.0	916.0	35.0	980.5	1100
863.4	19.3	916.8	350.0	982.1	10.9
868.8	80.0	919.1	4.0	984.3	0.6
880.6	700.0	920.0	280.0	985.6	240
886.1	540.0	923.9	400.0		
890.7	100.0	926.2	260.0		

TABLE 28

ABSORPTION COEFFICIENTS OF N_2

λ = 600Å to λ = 978Å

Method: Photoelectric Detection

Ref: G. Cook and P. Metzger, J. Chem. Phys. 41, 321 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
600.0	735	742.6	410	778.5	720
610.0	760	743.7	760	780.0	400
620.0	780	744.7	680	781.0	1200
630.0	785	745.5	430	782.5	390
640.0	790	746.5	680	783.5	2300
650.0	790	747.0	570	785.2	405
660.0	750	747.6	680	786.2	800
670.0	595	748.4	560	788.0	200
671.4	640	749.3	750	789.5	790
674.1	580	749.6	710	790.5	555
675.1	690	750.8	870	792.0	1390
679.7	580	752.0	421	793.5	550
681.9	780	752.5	560	795.0	1140
690.9	560	752.9	520	798.0	95
694.9	950	754.3	1390	801.0	1480
700.0	640	756.5	420	802.2	112
710.0	680	757.3	960	804.0	220
715.3	620	757.7	610	805.0	130
721.3	720	758.5	870	806.0	445
723.4	1320	759.5	420	806.3	405
726.0	690	761.5	1040	806.5	1400
729.5	795	762.7	345	808.0	118
733.0	705	763.6	780	809.0	200
734.8	715	764.5	620	810.0	42
735.9	590	765.0	1260	810.5	140
736.8	620	767.0	305	811.5	60
737.4	470	768.5	780	813.5	1300
737.8	610	770.5	275	815.0	130
738.4	460	771.5	1700	816.0	168
739.7	630	774.0	280	817.5	30
740.5	420	776.0	1700	819.0	1140
741.4	430	777.5	260	820.3	117

TABLE 28 (continued)

ABSORPTION COEFFICIENTS OF N_2

λ = 600Å to λ = 978Å

Method: Photoelectric Detection

Ref: G. Cook and P. Metzger, J. Chem. Phys. 41, 321 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
821.0	328	859.8	14.9	894.0	238
822.5	10.2	860.0	10.2	895.5	11.8
824.5	320	860.8	198	897.2	670
825.2	40	861.3	12.2	898.3	139
826.0	450	862.0	156	899.0	250
828.0	20.3	862.5	12.3	900.5	14.6
828.5	198	863.3	200	901.2	260
831.5	8.1	864.2	16.1	902.3	15.2
832.0	180	865.0	450	903.0	299
833.0	16.7	866.1	16.3	904.0	15.6
833.5	195	866.8	590	905.0	270
834.5	52.0	870.0	14.2	907.0	16.6
835.0	495	871.5	840	908.0	200
936.5	15.5	873.2	70.5	910.0	16.5
837.5	440	874.2	12.2	910.8	150
840.0	25.5	875.0	7.4	912.0	20.5
840.8	580	876.5	710	912.6	960
841.5	349	878.3	15.1	916.0	5.1
842.0	600	879.2	150	917.7	297
843.5	30	880.2	15.1	919.3	11.3
844.2	570	881.0	1200	920.0	450
846.2	20	882.0	220	922.0	10.7
846.9	148	882.6	400	923.0	297
848.2	11	885.0	9.6	925.0	17.4
850.0	765	885.8	248	927.0	120
852.5	31	886.4	20.2	927.7	7.0
853.5	900	887.0	450	928.7	900
855.0	50	888.3	13	931.5	16.0
856.2	500	889.2	249	932.5	100
856.7	40.5	890.5	11.2	934.3	1.5
857.1	590	892.2	330	935.0	98
859.0	89	893.2	11.6	937.0	1.4

TABLE 28 (continued)

ABSORPTION COEFFICIENTS OF N_2

$\lambda = 600Å$ to $\lambda = 978Å$

Method: Photoelectric Detection

Ref: G. Cook and P. Metzger, J. Chem. Phys. 41, 321 (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
938.5	1800	951.2	1.28	960.0	790
940.5	10.2	952.0	2.8	963.5	4.30
942.5	350	953.0	1.18	965.5	1300
945.5	6.1	954.0	2.0	970.0	5.0
946.7	150	954.5	1.12	972.5	5200
948.0	2.05	955.5	50	976.0	2.55
949.22	18.9	957.0	2.02	978.0	1470
950.0	1.55	958.0	500		
950.2	10.0	959.3	2.55		

TABLE 29

ABSORPTION COEFFICIENTS OF N_2

λ = 665Å to λ = 1000Å

Method: Photoelectric Detection

Ref: R. Huffman et al., J. Chem. Phys., 39, 910 (1963)

k in Reciprocal Centimeters

(a) Absorption Minima

λ	k	λ	k	λ	k
798.0	160	879.0	49	931.2	74
804.5	90	885.2	47	934.5	14
808.0	120	888.5	95	936.0	20
811.5	40	890.3	47	941.9	37
817.5	12	893.0	51	945.5	38
823.0	10	895.7	46	947.5	15
831.0	24	898.7	78	953.0	10
833.0	13	900.8	51	957.0	56
836.5	43	902.1	100	959.8	110
840.0	54	903.2	130	965.0	36
843.6	77	904.2	110	970.0	23
848.0	14	909.7	31	977.0	15
852.8	72	911.8	60	983.0	14
859.7	43	915.6	17	990.0	30
862.5	25	919.2	29	997.0	5
866.5	63	922.0	59	1000.0	10
870.3	35	925.6	67		
874.7	31	928.2	21		

(b) Maxima of Nitrogen Bands

λ	k	λ	k	λ	k
665.2	840	719.0	940	737.7	820
666.1	850	720.3	840	738.9	810
667.3	850	721.6	930	739.7	840
669.1	920	723.2	2210	740.6	770
671.6	1080	727.1	1000	742.0	610
675.4	1130	730.0	830	744.4	1200
682.0	1300	731.8	690	746.7	900
694.8	1660	733.6	620	747.9	980
716.5	770	734.7	900	749.3	930
718.1	770	736.7	820	750.5	1070

TABLE 29 (continued)

ABSORPTION COEFFICIENTS OF N_2

$\lambda = 665\text{Å}$ to $\lambda = 1000\text{Å}$

Method: Photoelectric Detection

Ref: R. Huffman et al., J. Chem. Phys., 39, 910 (1963)

k in Reciprocal Centimeters

(b) Maxima of Nitrogen Bands (continued)

λ	k	λ	k	λ	k
752.2	630	813.7	2220	875.5	300
753.3	540	818.6	1830	876.2	1120
754.4	1780	820.1	230	877.4	360
755.5	730	821.2	560	879.6	180
757.1	1310	822.6	30	881.1	1120
758.4	1220	823.3	40	882.7	580
759.9	680	824.9	370	883.9	200
761.3	1320	825.7	660	886.0	590
763.7	1300	826.4	220	886.3	520
765.0	2300	828.6	130	886.9	680
768.0	930	829.3	90	888.9	290
768.7	900	832.0	30	891.1	230
769.2	840	834.1	150	894.0	280
771.8	2940	835.1	710	896.2	370
774.8	1000	837.4	440	897.2	1020
775.9	3080	840.9	810	899.3	350
778.7	850	842.2	790	899.8	240
779.3	680	842.9	320	901.3	320
781.1	2050	844.1	740	902.5	360
783.6	4980	847.0	80	903.6	450
786.1	1130	849.7	530	904.7	450
789.4	1170	850.1	1000	907.6	240
791.1	1920	853.7	1280	910.6	360
791.9	2300	856.3	660	912.7	1860
794.6	1520	857.2	660	916.4	530
801.5	1970	860.8	250	920.0	1060
802.3	740	863.5	250	921.3	250
803.7	350	865.4	770	922.8	600
805.8	950	867.0	1020	926.1	230
806.6	2560	868.1	530	929.0	1980
808.8	400	870.9	610	931.9	120
812.5	490	871.7	1100	935.3	90

TABLE 29 (continued)

ABSORPTION COEFFICIENTS OF N_2

$\lambda = 665\text{Å}$ to $\lambda = 1000\text{Å}$

Method: Photoelectric Detection

Ref: R. Huffman et al., J. Chem. Phys., 39, 910 (1963)

k in Reciprocal Centimeters

(b) Maxima of Nitrogen Bands (continued)

λ	k	λ	k	λ	k
937.9	290	955.1	430	979.1	2250
938.8	2460	958.2	1120	985.7	430
939.9	810	958.8	810	987.5	80
942.5	670	960.3	1900	991.9	480
946.2	130	965.8	2690		
949.2	310	972.4	8120		

TABLE 30

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF N_2 AT INTENSE SOLAR EMISSION LINES

$\lambda = 304\text{Å}$ to $\lambda = 1038\text{Å}$

Method: Photoelectric Detection

Ref: J. A. R. Samson and R. B. Cairns, J. Geo. Res. 69, 4583 (1964)

k in Reciprocal Centimeters

σ in Megabarns

Source Line λ	k	σ	γ(%)
303.781 He II	326*	12.1	100
429.918 O II 430.041 O II 430.177 O II	564*	21.0	100
434.975 O III	637	23.7	100
498.431 O VI	652	24.2	100
507.391 O III 507.683 O III	654	24.3	100
508.182 O III	598	22.2	100
519.610 O VI	693	25.8	98
522.208 He I	635	23.6	97
525.795 O III	703	26.2	98
537.024 He I	678	25.2	97
553.328 O IV	669	24.9	96
554.074 O IV	680	25.3	93
554.514 O IV	660	24.6	93
555.262 O IV	666	24.8	95
584.331 He I	620	23.1	100
597.818 O III	629	23.4	97
599.598 O III	629	23.4	95
608.395 O IV	630	23.4	100
609.705 O III 609.829 O IV 610.043 O III	636	23.7	100

*Estimated error ±10%

TABLE 30 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF N_2 AT INTENSE SOLAR EMISSION LINES

$\lambda = 304\text{Å}$ to $\lambda = 1038\text{Å}$

Method: Photoelectric Detection

Ref: J. A. R. Samson and R. B. Cairns, J. Geo. Res. 69, 4583 (1964)

k in Reciprocal Centimeters

σ in Megabarns

Source Line λ	k	σ	γ(%)
610.746 O III 610.850 O III	626	23.3	99
616.933 O IV 617.033 O IV 617.051 O II	637	23.7	98
624.617 O IV	645	24.0	97
625.130 O IV	642	23.9	97
625.852 O IV	644	24.0	98
629.732 O V	652	24.2	97
684.996 N III	653	24.3	95
685.513 N III 685.816 N III	670	24.9	95
686.335 N III	648	24.1	95
758.677 O V	643	23.9	75
759.440 O V	313	11.6	86
760.229 O V 760.445 O V	531	19.8	57
761.130 O V	1077	40.1	55
762.001 O V	747	27.8	46
763.340 N III	734	27.3	80
764.357 N III	364*	13.5	69
765.140 N IV	2295	85.4	77
774.522 O V	914	34.0	40
779.821 O IV 779.905 O IV	344	12.8	65

*Estimated error ±10%

TABLE 30 (continued)

ABSORPTION COEFFICIENTS, CROSS SECTIONS AND PHOTOIONIZATION YIELDS OF N_2 AT INTENSE SOLAR EMISSION LINES

λ = 304Å to λ = 1038Å

Method: Photoelectric Detection

Ref: J. A. R. Samson and R. B. Cairns, J. Geo. Res. <u>69</u>, 4583 (1964)

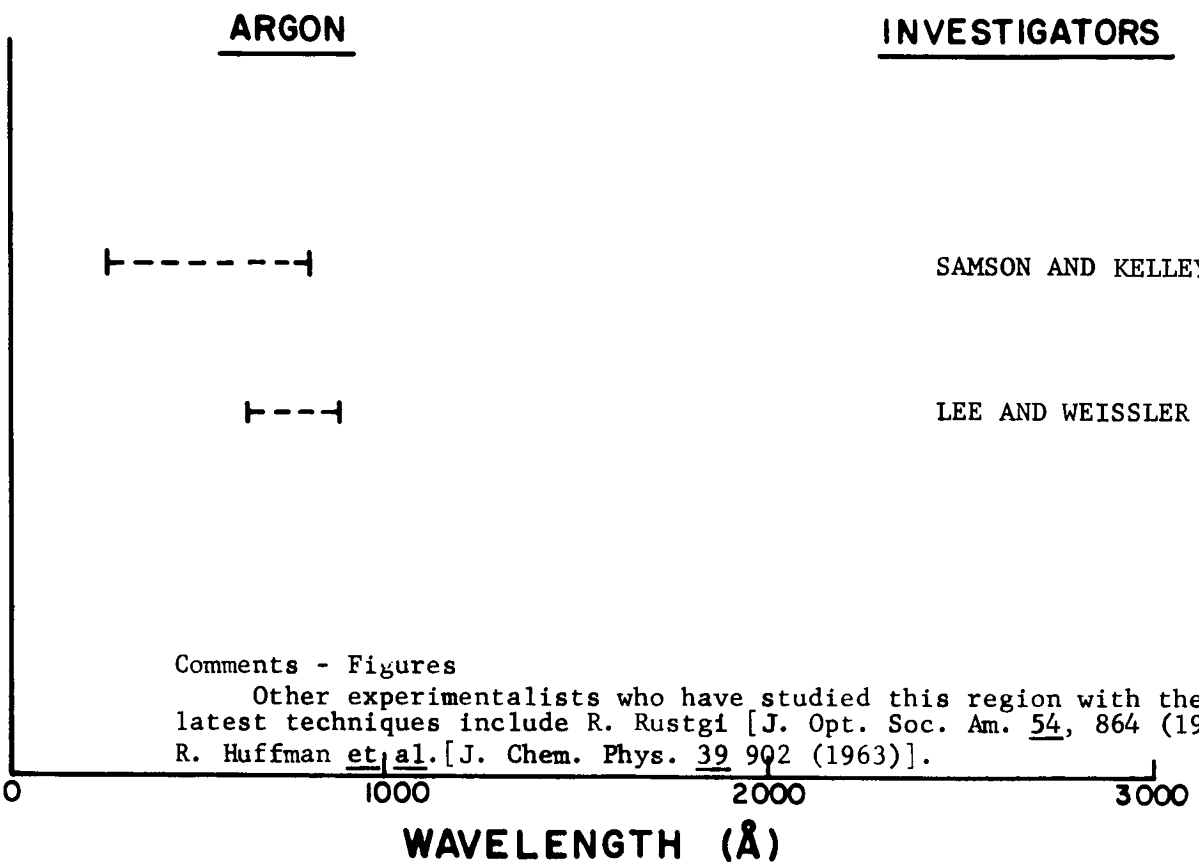
k in Reciprocal Centimeters

σ in Megabarns

Source Line λ	k	σ	γ(%)
787.710 O IV	226	8.41	89
790.103 O IV 790.203 O IV	610	22.7	45
832.754 O II 832.927 O III	Variable (see reference)		0
833.326 O II			
833.742 O III			0
834.462 O II			0
835.096 O III 835.292 O III			0
921.982 N IV			0
922.507 N IV			0
923.045 N IV 923.211 N IV			0
923.669 N IV			0
924.274 N IV			0
972.537 H I			0
977.026 C III	2.2	0.082	0
989.790 N III	4.5	0.167	0
991.514 N III 991.579 N III	2.0	0.074	0
1025.722 H I	0.027	0.0010	0
1031.912 O VI	<0.02	0.00074	0
1037.613 O VI	<0.02	0.00074	0

7. Argon [95]

Lee and Weissler [95] measured the absorption coefficients of argon at various wavelengths between 240 and 1000Å and Wainfan *et al.* [21] from 473 to 1100Å. Huffman *et al.* [92] reported data between 600 and 800Å, using a continuum light source. Rustgi [96] and Samson [97] extended the measurements to cover the region between 200 and 800Å. The spectrum obtained by Lee and Weissler shows three sharp absorption edges: one (M_3) at 787Å, the first ionization limit; another (M_2) at 778Å; and a third (M_1) at 424Å. A group of resonance absorption lines at longer wavelengths due to the transitions 3p → nd and 3p → ms were found [94], but the lines were much smaller than those in the continuous absorption. Samson [97] computed the oscillator strength in the ionization continuum and found f = 5.65 for the contribution from ionization of the 3s and 3p electrons. Similarly the integration of the experimental curve of cross sections versus wave number by Rustgi [96] from the ionization limit of argon down to 170Å was f = 5.5.



Comments - Figures

Other experimentalists who have studied this region with the latest techniques include R. Rustgi [J. Opt. Soc. Am. 54, 864 (1964)], R. Huffman et al. [J. Chem. Phys. 39 902 (1963)].

├----┤ Line emission light source

├────┤ Continuum emission light source

Figure 24. Spectral ranges for data obtained with line and continuum light sources: Argon (Figure 25 and Tables 31 and 32).

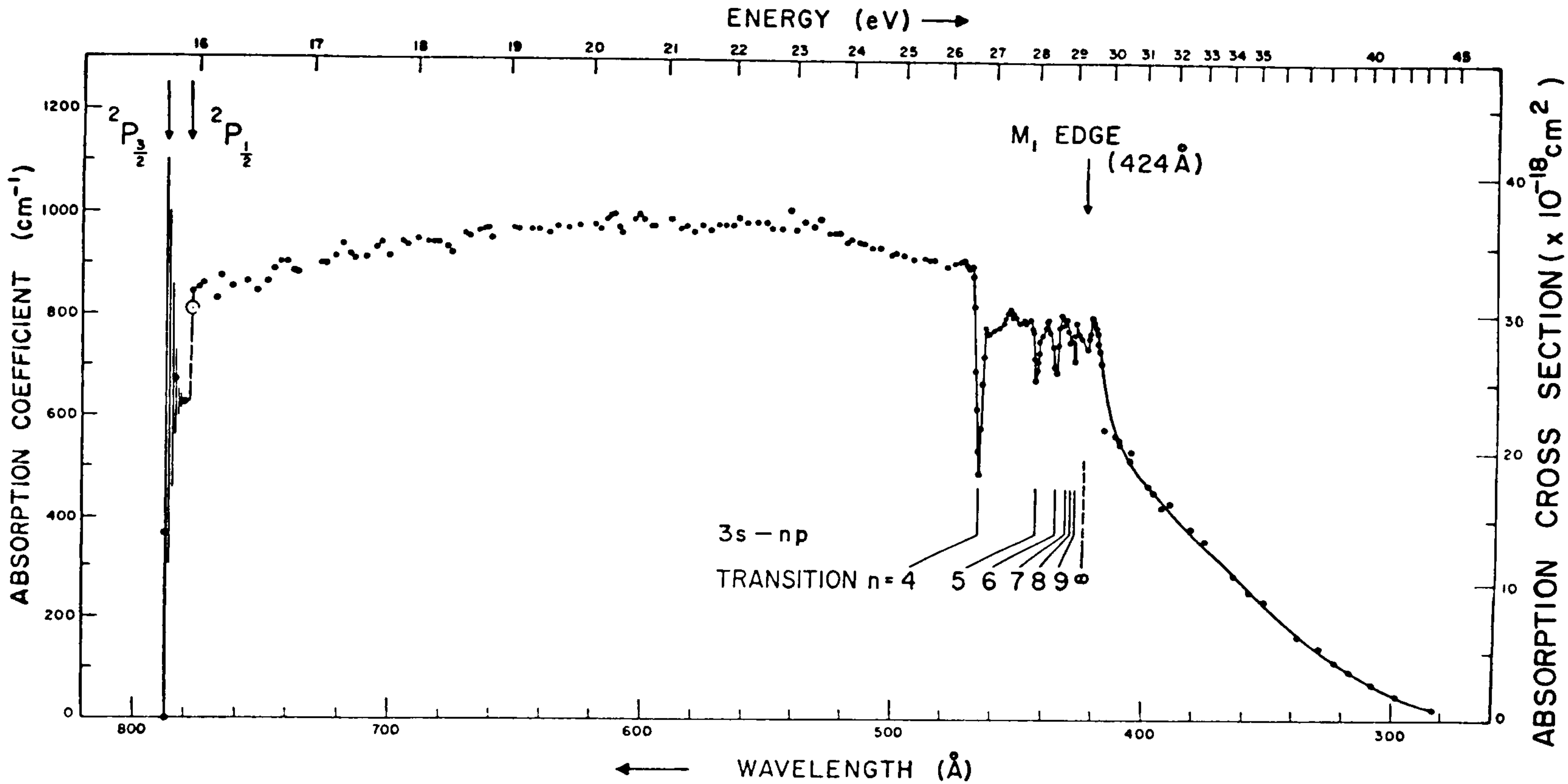


Figure 25. Absorption coefficients and cross sections of A.
λ = 283Å to λ = 788Å
Method: Photoelectric detection
Ref: J. A. R. Samson and F. Kelley, GCA Technical Report No. 64-3N, GCA Corporation, Bedford, Mass. (1964)
Experimental error: ±5%.

TABLE 31

ABSORPTION COEFFICIENTS OF ARGON

λ = 603Å to λ = 844Å

Method: Photographic Detection

Ref: P. Lee and G. L. Weissler, Phys. Rev., 99, 540 (1955)

k in Reciprocal Centimeters

λ	k	λ	k
602.8	850	745.8	940
617.1	850	747.0	940
625.8	860	769.1	890
637.2	900	771.9	970
644.1	900	772.3	920
660.3	900	776.0	960
671.7	940	779.8	515
683.2	940	781.2	520
700.3	950	827.3	0
725.5	880	843.7	0

TABLE 32

ABSORPTION COEFFICIENTS OF ARGON

$\lambda = 283Å$ to $\lambda = 788Å$

Method: Photoelectric Detection

Ref: J.A.R. Samson and F. Kelley, GCA Technical Report No. 64-3-N GCA Corporation, Bedford, Mass. (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
282.8	23	425.2	762	442.6	695
297.8	47	425.8	767	443.2	673
308.0	72	426.4	767	443.8	720
317.3	98	427.0	790	444.2	773
323.0	115	427.7	712	444.5	778
329.0	143	428.3	764	445.1	796
337.6	167	428.9	760	445.7	796
351.0	233	429.5	752	446.4	796
357.6	253	430.1	773	447.9	788
363.8	285	430.9	798	449.8	787
375.2	360	431.5	789	450.2	790
381.6	382	432.2	787	450.8	808
389.9	434	432.9	804	451.4	800
393.3	426	433.7	782	452.1	808
396.5	454	434.2	747	452.7	798
399.3	466	434.5	692	453.3	817
405.2	535	435.0	703	453.9	810
405.7	520	436.0	742	454.5	810
410.0	558	436.5	766	455.2	800
411.5	562	436.7	770	455.8	790
416.9	709	436.9	768	457.0	783
417.6	734	437.5	770	457.6	780
418.2	750	438.1	796	459.8	778
418.8	769	438.8	794	462.2	768
419.4	781	439.4	780	462.5	768
420.0	790	440.0	768	463.1	780
420.7	800	440.7	763	463.7	723
421.3	767	441.3	757	464.4	669
421.8	760	441.9	731	465.0	579
422.4	738	442.1	712	465.6	492

TABLE 32 (Continued)

ABSORPTION COEFFICIENTS OF ARGON

λ = 283Å to λ = 788Å

Method: Photoelectric Detection

Ref: J. A. R. Samson and F. Kelley, GCA Technical Report No. 64-3-N GCA Corporation, Bedford, Mass. (1964)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
466.3	536	524.2	964	613.0	998
466.6	619	526.7	964	614.8	991
466.9	695	529.3	991	616.7	703
467.6	822	532.0	978	618.8	981
468.2	882	536.0	985	625.2	978
468.7	900	539.3	971	629.8	973
468.8	897	541.8	999	634.0	978
469.5	900	544.9	973	637.0	964
470.1	897	549.3	973	641.0	971
470.8	900	551.4	985	644.1	971
471.3	900	555.1	985	649.0	971
474.0	912	558.8	985	651.0	973
475.7	909	562.1	995	660.0	952
479.4	900	564.6	981	662.7	971
484.2	912	567.9	981	664.8	968
486.8	912	570.4	981	668.3	956
487.9	915	573.7	971	670.2	960
492.5	915	577.0	978	675.2	924
496.5	924	580.0	964	677.1	936
499.4	926	583.0	978	680.5	945
501.3	924	585.5	973	683.0	945
505.8	936	588.9	990	684.8	945
509.3	936	594.1	978	688.4	950
512.1	945	596.7	978	692.8	940
514.3	945	599.5	991	694.9	945
517.5	952	603.4	991	700.0	915
519.5	945	608.5	964	703.0	945
521.9	964	610.0	973	705.4	934

TABLE 32 (Continued)

ABSORPTION COEFFICIENTS OF ARGON

λ = 283Å to λ = 788Å

Method: Photoelectric Detection

Ref: J. A. R. Samson and F. Kelley, GCA Technology Report No. 64-3-N GCA Corporation, Bedford, Mass. (1964)

k in Reciprocal Centimeters

λ	k
709.2	915
713.7	912
715.5	920
718.4	940
721.0	915
724.8	900
727.2	900
735.6	883
737.0	887
739.9	906
742.4	905
744.6	890
747.5	865
751.1	845
755.1	866
760.6	856
765.3	876
767.3	830
772.4	860
774.6	852
776.8	845
779.7	627
783.2	671
787.6	364

8. Nitric Oxide

a. Historical Survey [3,16,98]

The entire spectral region from 150 to 2300Å has been studied by various investigators who have left few major gaps. Absorption cross sections in the region above 1400Å were measured by Mayence [99] and above 1050Å by Marmo [100,101]. Later, Sun and Weissler [97] extended measurements down to 374Å. Granier and Astoin [102] made measurements down to 150Å. Metzger and Cook [103] have reported data between 600 and 960Å.

b. Spectral Region 1000Å to 2300Å [16,36,37]

The region from 1400 to 2300Å consists of several systems of sharp bands which include the $\beta\gamma\delta\epsilon$ bands. The continuum below 1380Å appears rather flat and may be due to overlapping of more than one continuum. Owing to the complexity of the absorption spectrum in the region from 1300 to 1700Å, it was not possible to identify extensive Rydberg series converging to the first ionization potential at 1343Å. Superimposed on the ionization continuum in the range 1000 to 1340Å are a number of unidentified diffuse bands. For the region above 1400Å, Marmo [100] with a resolution of 0.2Å, found a large apparent pressure effect, while below 1380Å, absorption cross section values were found to be independent of pressure. For the region between 1200 and 1400Å, Marmo [100], by subtracting the ionization continuum and the bands from the total cross section curve, obtained a smooth dissociation continuum identified with the dissociation products $N(^2D)$ and $O(^3P)$. Watanabe found the onset of ionization to occur at 1343Å.[3]

c. Spectral Region Below 1000Å [3,16,98,104]

Below 1000Å, there appears to be at least two or three continua while the presence of diffuse bands in this area is indicated by the fluctuations in cross sections with wavelength. This region was found to be generally independent of pressure. The large absorption near 920Å is probably due to the dissociation of NO caused by transitions from the ground state to the upper $^2\Pi$ state of the bands. [105] Hagstrum [106] observed the dissociative ionization reaction $NO \rightarrow N^+ + O^-$ at 19.9 ev. Weissler [3] suggests the possibility that the corresponding peak at 620Å is due to this process superimposed over the ionization continuum starting at the limit of Tanaka's [46] γ-series. The data of Metzger and Cook [103] indicate several continua which underlie the strong band structure are evident.

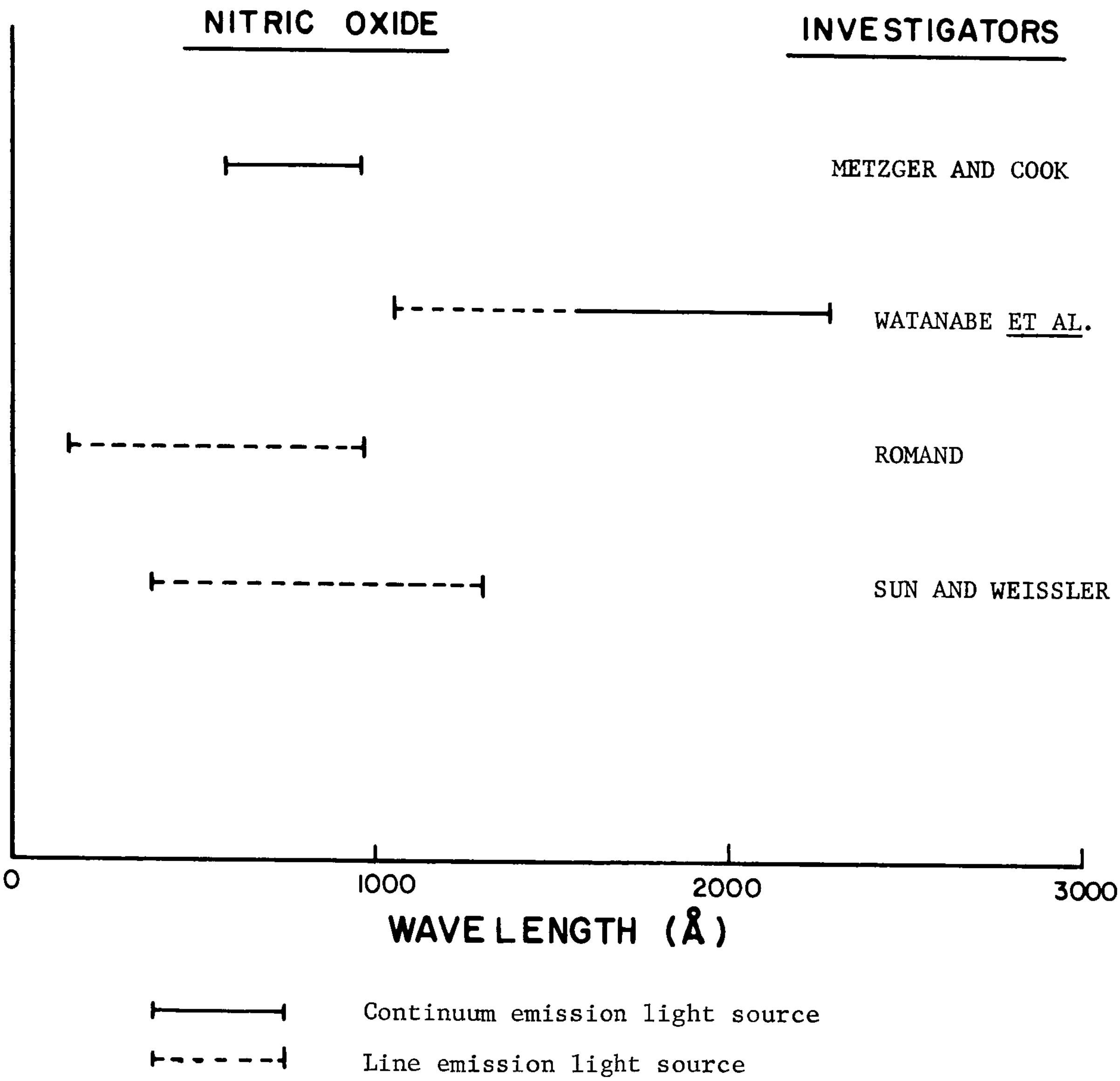


Figure 26. Spectral ranges of data obtained with line and continuum light sources: Nitric oxide (Figures 27 and 28 and Tables 33-36).

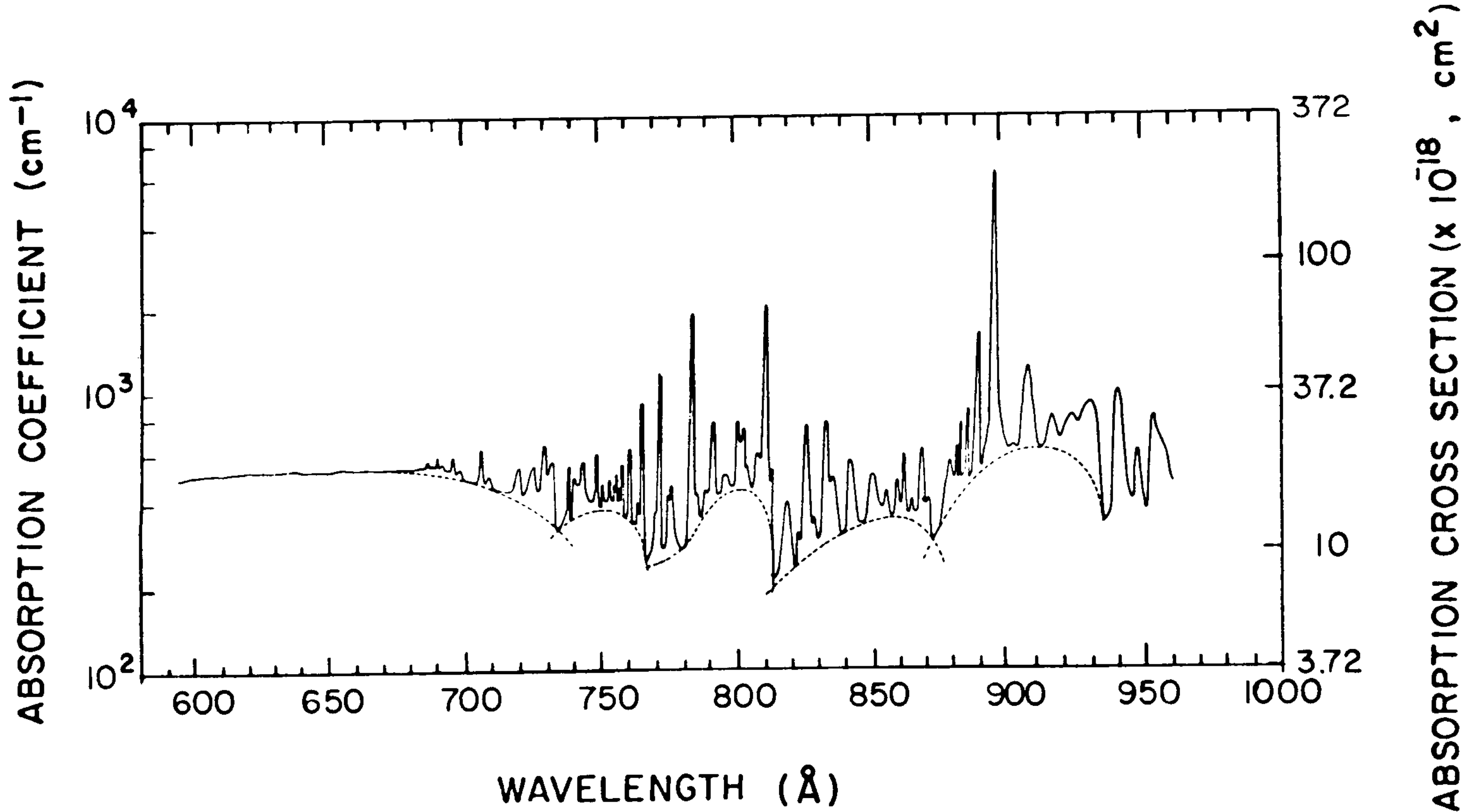


Figure 27. Absorption coefficients and cross sections of NO.
λ = 590Å to λ = 960Å
Method: Photoelectric detection
Ref: P. Metzger and G. Cook, Aerospace Corp., Technical Report No. ATN-63(9218)-7 (1963)

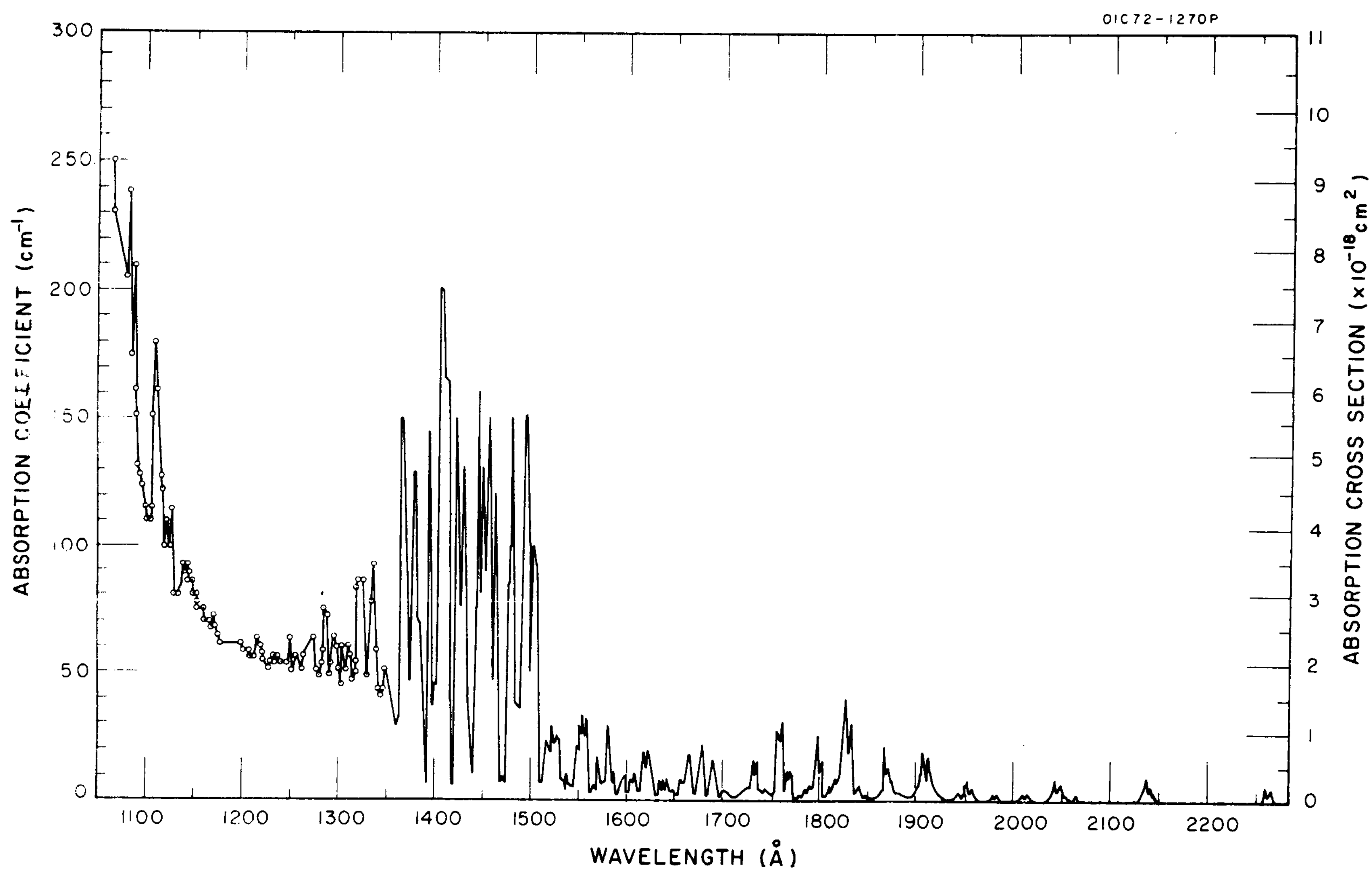


Figure 28. Absorption coefficients and cross sections of NO.
λ = 1065Å to λ = 2300Å
Method: Photoelectric detection
Ref: 1065Å-1350Å: K. Watanabe, Adv. In Geophys., 5, 193 (1958)
1350Å-2300Å: K. Watanabe *et al.*, AFCRC Tech. Rpt. No. 53-23 Geophys. Res. Paper No. 21 (1953)

TABLE 33

ABSORPTION COEFFICIENTS OF NO

λ = 168Å to λ = 975Å

Method: Photographic Detection

Ref: J. Romand, Laboratories de Bellevue, France, Private communication (1962)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k	λ	k
168	430	240.5	720	330	530	502	600
169	460	244	540	333	650	504	620
172	800	246	600	337	620	508	740
173	920	248	800	338	850	512	800
175	540	251	600	340	570	527	800
177	640	252	720	344	710	538	1000
178	820	253	710	347	650	555	660
180	500	259	670	350	690	567	540
185	680	265	670	352	530	570	660
188.5	560	278	540	353	690	601	390
191.7	520	280	640	358	680	602	620
192	750	283.7	680	361	810	629	560
192.2	420	284.5	520	364	630	630	360
193	620	286	620	367	610	637	360
194.8	340	287	740	369	590	644	360
196	710	289	700	370	660	651	640
197	600	290	520	377	570	693	740
199	340	293	640	389	590	701	680
200	680	294	660	390	540	715	300
202	360	295	480	393	580	730	800
207	520	297	600	395	640	733	720
209	330	299	420	398	660	790	760
212	560	302	620	402	630	810	620
217	650	305.8	430	408	670	833	440
219	550	308.5	380	411	660	834	560
221	390	309	460	419.5	630	865	620
225	600	311	350	425	620	870	380
230.5	840	315	520	434	620	892	580
232	680	320	560	453	580	898	640
234	520	321	430	454	630	912	540
235.2	640	322	540	461	670	935	420
236.5	800	325	510	476	610	975	620
240	780	328.5	550	480	640		

TABLE 34

ABSORPTION COEFFICIENTS OF NO

λ = 374Å to λ = 1306Å

Method: Photographic Detection

Ref: H. Sun, G.L. Weissler; J. Chem. Phys. 23, 1372 (1955)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
374.1	340	747.0	260	923.2	600
374.3	390	763.3	300	923.7	630
537.8	580	764.4	1020	924.3	640
538.3	500	765.1	200	955.3	430
539.1	600	771.5	350	977.0	560
539.5	530	771.9	250	979.9	350
539.8	560	772.4	300	1006.0	300
600.0	540	773.0	310	1037.0	220
644.1	530	776.0	400	1037.3	220
644.6	600	796.7	390	1134.4	100
644.8	570	832.9	280	1135.0	84
645.2	550	833.3	450	1199.5	74
660.3	450	833.7	280	1200.2	82
671.4	470	834.5	370	1200.7	74
672.9	570	835.3	370	1243.3	82
673.8	590	915.9	670	1276.1	56
702.3	390	916.0	650	1276.2	81
702.9	390	916.7	670	1302.2	130
703.8	390	922.5	540	1304.9	110
745.8	400	923.0	560	1306.0	100

TABLE 35

ABSORPTION COEFFICIENTS OF NO

λ = 1065Å to λ = 1345Å

Method: Photoelectric Detection

Ref: K. Watanabe, Adv. in Geophys. 5, 193-94 (1958)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1065.0	250	1166.0	69	1260.3	56
1066.0	231	1169.1	68	1261.8	54
1080.2	204	1172.1	72	1264.2	50
1081.7	239	1174.3	70	1266.4	54
1084.7	175	1175.8	69	1268.6	58
1087.1	210	1178.2	65	1270.6	57
1088.7	161	1180.4	61	1274.0	65
1090.0	151	1182.5	61	1277.1	51
1092.7	.29	1184.7	60	1278.0	49
1095.3	126	1187.8	63	1279.5	47
1097.9	121	1189.3	63	1281.1	53
1100.5	116	1191.5	63	1283.1	60
1102.1	110	1193.2	62	1284.3	76
1104.3	110	1195.6	62	1286.4	75
1105.8	116	1198.0	60	1287.5	72
1107.1	151	1200.3	62	1290.4	48
1111.0	180	1202.1	59	1293.3	54
1112.0	161	1204.9	58	1295.3	63
1114.9	126	1206.6	59	1297.2	61
1116.3	121	1209.2	57	1299.7	52
1119.0	99	1211.3	58	1302.3	46
1121.2	110	1215.6	65	1304.1	58
1124.0	99	1217.4	65	1307.2	52
1126.3	99	1219.2	64	1310.9	59
1127.5	116	1220.9	62	1312.8	57
1131.4	81	1223.4	59	1315.4	47
1133.2	81	1225.5	55	1316.8	49
1135.3	86	1228.2	51	1319.0	53
1137.5	94	1230.0	53	1323.3	84
1139.7	91	1231.9	56	1325.1	87
1141.5	94	1233.8	55	1327.6	88
1144.2	91	1235.4	54	1329.3	48

TABLE 35 (continued)

ABSORPTION COEFFICIENTS OF NO

λ = 1065Å to λ = 1345Å

Method: Photoelectric Detection

Ref: K. Watanabe, Adv. in Geophys. 5, 193-94 (1958)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1145.9	86	1239.5	54	1333.9	78
1146.9	86	1241.3	56	1335.9	93
1148.5	80	1243.2	54	1338.6	59
1150.8	80	1245.9	53	1341.3	43
1154.0	75	1247.4	54	1342.3	41
1157.0	75	1251.3	65	1343.7	43
1159.7	75	1253.6	51	1345.5	51
1161.2	70	1255.0	52		
1163.7	69	1257.2	57		

TABLE 36

ABSORPTION COEFFICIENTS OF NO FOR SOME PROMINENT RYDBERG BANDS

$\lambda = 682Å$ to $\lambda = 931Å$

Method: Photoelectric Detection

Ref: P. Metzger and G. Cook, Technical Report No. ATN-63(9218)-7, Aerospace Corporation (1963)

k in Reciprocal Centimeters

n	Series α		Series $\beta(0,0)$		Series $\gamma(0,0)$		Series $\beta(1,0)$		Series $\gamma(1,0)$	
	λ	k	λ	k	λ	k	λ	k	λ	k
2	-	-	-	-	800.5	785	-	-	789.8	440
3	931.0	1000	810.8	2000	729.0	648	802.2	740	720.3	535
4	907.5	1210	783.5	1900	705.9	620	775.4	465	697.8	530
5	896.0	6200	771.1	1160	695.8	585	763.1	400	687.5	540
6	889.3	1600	764.5	910	690.0	580	756.8	450	681.9	-
7	885.0	860	760.2	630	686.5	570	752.6	485	-	-
8	882.1	775	757.6	550	684.3	-	750.0	465	-	-
9	880.1	630	755.8	510	682.7	-	748.3	600	-	-

9. Nitrous Oxide

a. Historical Survey [16,36,104]

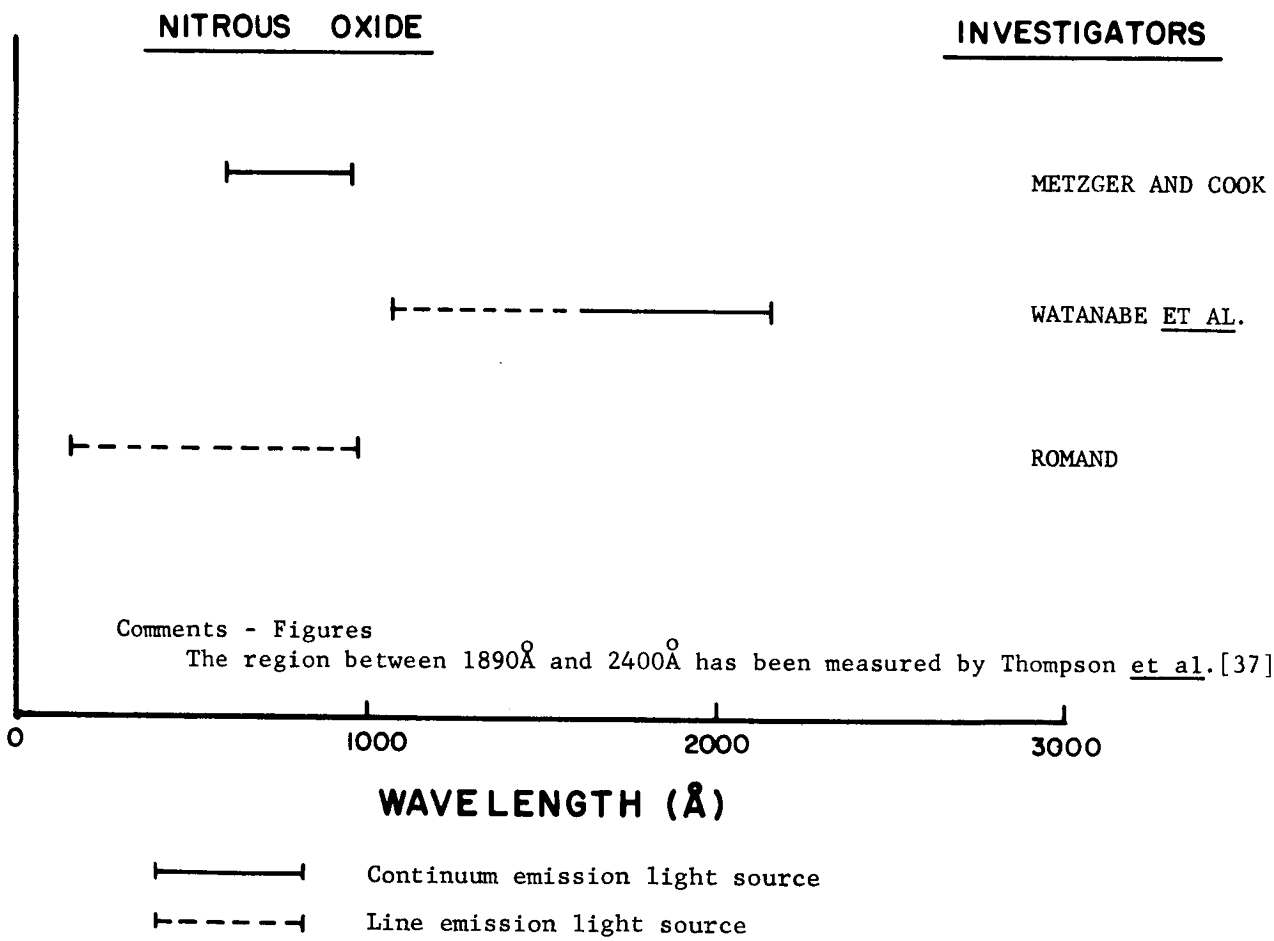
Early investigations of the vacuum ultraviolet absorption spectrum of N_2O were conducted by Leifson [67], Sen-Gupta [107], and Duncan [108]. Tanaka *et al*. [109] found five Rydberg series in the region from 600 to 900Å converging to three limits: 16.39, 16.55, and 20.10 ev. Absorption coefficients have been reported by Watanabe *et al*. [36] in the region between 1050 and 2100Å, by Walker and Weissler [104] in the region between 675 and 950Å, by Metzger and Cook [103] between 600 and 950Å and by Romand [72] down to 150Å. Measurements have also been made between 1900 to 2395Å by Thompson *et al*. [37].

b. Spectral Region 1000Å to 2200Å [3,36]

Most of the absorption of N_2O in the region from 1080Å to 1215Å may be attributed to an asymmetric continuum which apparently underlies the diffuse bands. Watanabe *et al*. [36] estimated an f-value of about 0.1 for this continuum which would indicate an allowed transition. A well-defined continuum exists from 1215 to 1380Å. The very strong absorption here is identified by Weissler [3] as the most characteristic feature of N_2O. One prominent band is superimposed upon the symmetric continuum around 1292Å; it is assumed to be a Rydberg series member. [36] Several weak bands appear at higher wavelengths. Neglecting the sharp band, Watanabe's group [36] calculated an f-value of 0.367 for the continuum. Diffuse bands overlie the symmetrical continuum between 1380 and 1600Å, for which an f-value of 0.0211 was measured. [36] The f-value suggests a fairly allowable transition. For the weaker continuum in the range 1600 to 2100Å, an f-value of 0.0015 [36] suggests a forbidden transition.

c. Spectral Region Below 1000Å [104]

Walker and Weissler [104] found the region from 675 to 950Å to be mostly independent of pressure. They found an ionization onset to occur at about 965Å. Superimposed on the continua between 150 and 1000Å are numerous narrow, sharp bands at shorter wavelengths, which become broader toward longer wavelengths. Metzger and Cook [103] indicate that at least two distinct continua are present below 1000Å.



Comments - Figures

The region between 1890Å and 2400Å has been measured by Thompson *et al*.[37]

Figure 29. Spectral ranges of data obtained with line and continuum light sources: Nitrous oxide (Figures 30 and 31 and Tables 37-39).

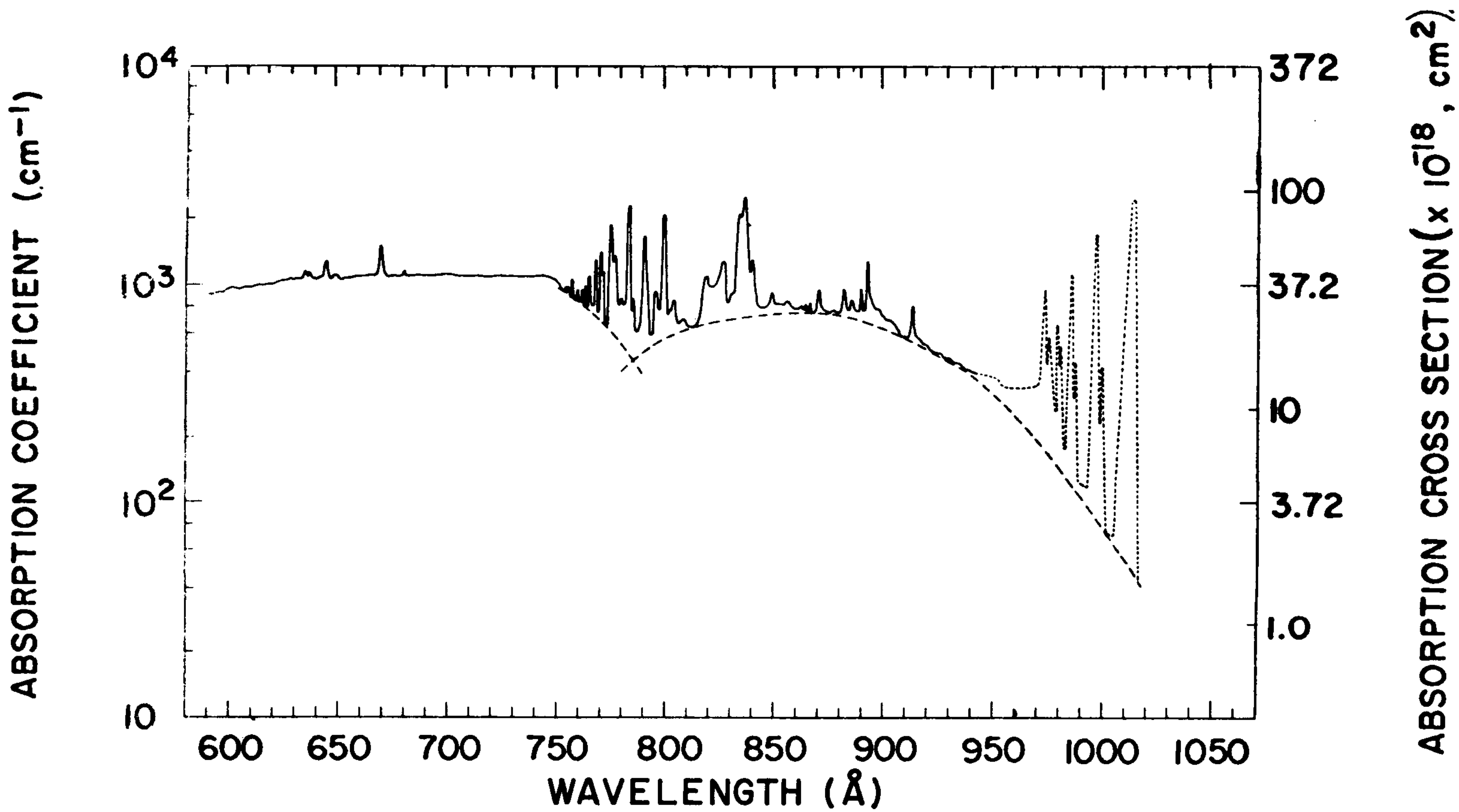


Figure 30. Absorption coefficients and cross sections of N_2O.
λ = 600Å to λ = 960Å
Method: Photoelectric detection
Ref: P. Metzger and G. Cook, Technical Report No. ATN-63(9218)-7, Aerospace Corp. (1963)

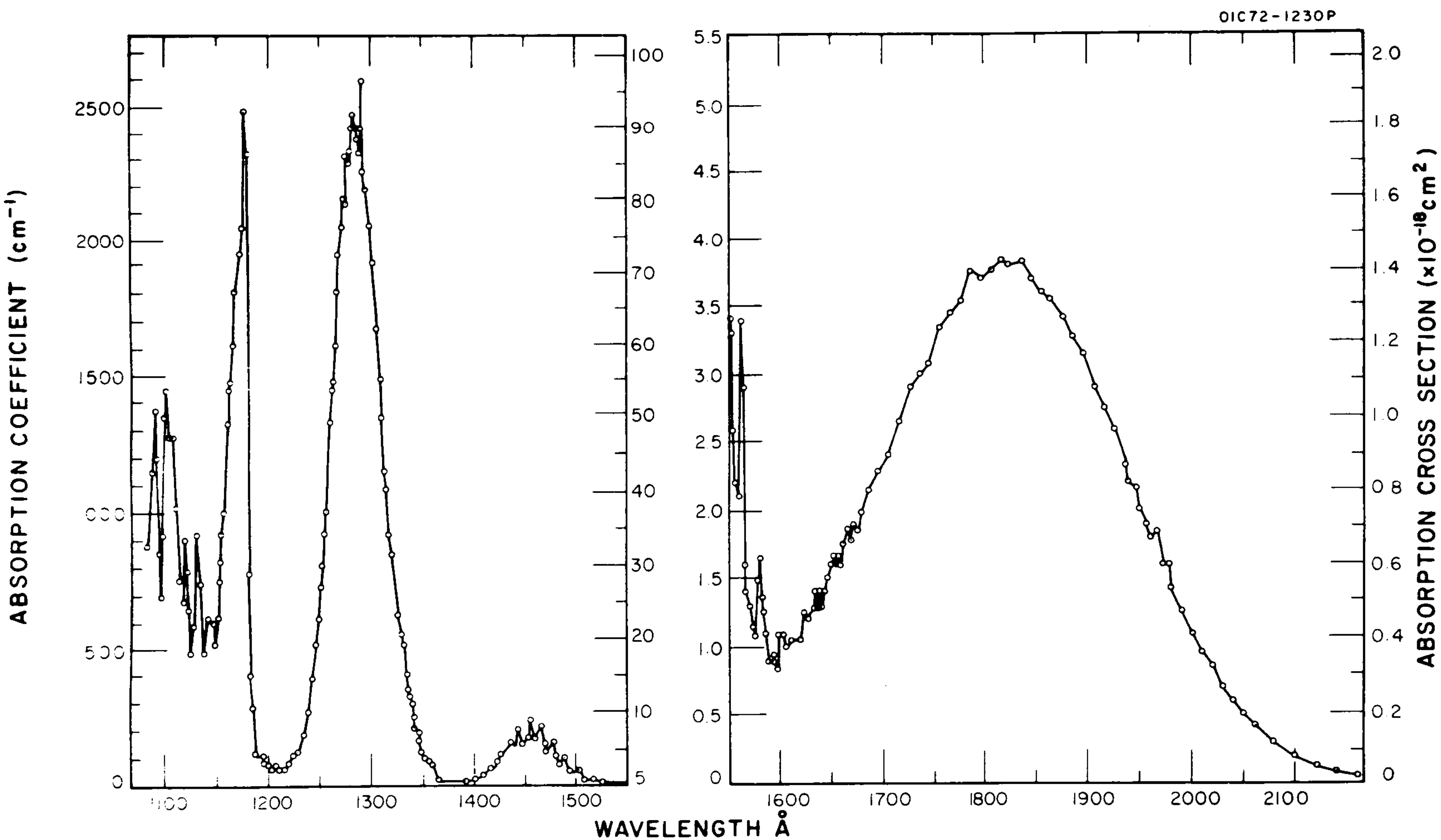


Figure 31. Absorption coefficients and cross sections of N_2O.
λ = 1080Å to λ = 2160Å
Method: Photoelectric detection
Ref: K. Watanabe et al., AFCRC Tech. Rpt. No. 53-23, Geophys. Res. Paper No. 21 (1953).
Experimental error: 5-10%

TABLE 37

ABSORPTION COEFFICIENTS OF N_2O

λ = 163Å to λ = 981Å

Method: Photographic Detection

Ref: J. Romand, Laboratories de Bellevue, France, Private Communication (1962)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
163	200	212	760	307	1000
164	250	214	820	308	780
165	220	215	740	309	1020
166	430	222	780	310	870
168	510	230.5	820	312	1100
169	450	231	920	320	760
170	530	232	820	321	930
171	430	233	860	324	1000
172	370	235	780	325	780
173	520	236.5	840	328	880
177.8	600	238.6	900	330	760
180	620	240	770	333	1240
182	600	240.5	740	335	900
186.5	560	243.3	990	340.5	820
188.5	600	246	840	342	900
189.5	680	247	890	344	1120
191.7	660	248	660	346	870
192.2	710	253	600	346.5	795
193	620	262	330	352	1110
194.8	660	263.8	340	359	870
195.5	630	265	470	361	930
196	730	273	690	366	1120
197	750	277	810	370	930
200	720	280	820	372	810
201	660	284.5	680	373	1240
202	670	289	800	377	960
203	720	290	1000	389	1070
204	700	293	1020	395	1180
205	720	296	1050	401	820
207	800	300	1080	402	1050

TABLE 37 (continued)

ABSORPTION COEFFICIENTS OF N_2O

λ = 163Å to λ = 981Å

Method: Photographic Detection

Ref: J. Romand, Laboratories de Bellevue, France, Private Communication (1962)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
403	1120	527	1020	707	840
408	1060	532	830	720	820
411	1140	538	550	759	1000
416	1100	547	700	788	>>
419.5	720	553	830	810	1130
427	1000	555	800	871	1180
446	830	570	720	890	1040
468	740	602	1040	901	790
505	720	629	870	912	1100
508.5	510	636	730	965	670
513	450	652	840	981	610
526	480	692	1080		

TABLE 38

ABSORPTION COEFFICIENTS OF N_2O

λ = 1080Å to λ = 2160Å

Method: Photoelectric Detection

Ref: K. Watanabe et al., AFCRC Tech. Rep. No. 53-23, Geophys. Res. Paper No. 21 (1953).

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1082	880	1172	1950	1265	1610
1087	1150	1175	2050	1269	1810
1089.5	1370	1177.5	2490	1271	1950
1091.5	1200	1179	2320	1273	2050
1093.5	850	1180	770	1274	2160
1095.5	690	1182	400	1275	2100
1097	920	1185	280	1276.5	2320
1098	1350	1189	126	1278	2280
1100.5	1450	1190	112	1279.5	2330
1104.5	1270	1192	104	1282	2430
1107	1270	1196	84	1283	2470
1109	1020	1198	83	1285.5	2430
1112	750	1201	72	1287	2370
1115.5	680	1202.5	67	1288	2330
1118	900	1205	65	1290	2390
1120	790	1209	74	1292	2590
1122	560	1211	70	1293	2260
1124	490	1215.6	66	1297	2190
1126.5	590	1218	68	1299.5	2060
1130	930	1222	84	1302	1920
1132	740	1233	87	1307	1670
1135.5	490	1225.5	112	1311	1490
1141	620	1229.5	133	1312	1340
1145	600	1234.5	188	1315	1160
1148	520	1239	272	1317	1080
1151	610	1242.5	390	1319	920
1152.5	730	1246.5	520	1323	850
1153.5	810	1249	610	1327	630
1155.5	930	1251.5	730	1331	560

TABLE 38 (continued)

ABSORPTION COEFFICIENTS OF N_2O

λ = 1080Å to λ = 2160Å

Method: Photoelectric Detection

Ref: K. Watanabe *et al.*, AFCRC Tech. Rep. No. 53-23, Geophys. Res. Paper No. 21 (1953).

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
1155.5	930	1251.5	730	1331	560
1157	1000	1253	810	1332	520
1161	1330	1255	930	1335.5	410
1162	1450	1256.5	1000	1337	350
1163	1470	1261	1330	1338	330
1166	1610	1263	1450	1340	300
1168.5	1810	1264	1470	1342	260
1343.5	220	1433	152	1512	26
1345	198	1434	162	1515	25
1347	175	1436	156	1516	27
1350	130	1439.5	145	1518	25
1353	103	1441	141	1521	15.7
1354.5	88	1443.5	209	1523	11.8
1357	74	1446	205	1525	10.3
1361	53	1448	152	1526	11.1
1363	47	1450.5	147	1528.5	13.4
1367	32	1452	177	1532	10.6
1370.5	27.1	1455	242	1534	9.7
1374	22.3	1458	169	1535	8.5
1376	21.2	1460.5	137	1536	7.6
1380	19.5	1463.5	153	1537.5	5.9
1382.5	18.7	1466	224	1539	5.3
1385.5	19	1468	148	1539.5	4.8
1387	19.5	1470	115	1540	4.6
1390.5	20.5	1474	124	1541.5	4.6
1394	21.3	1476.5	164	1543	5.6
1396	24.5	1480	102	1545	7
1398.5	28	1481	87	1546	6.2
1402	30	1484	72	1547	5.1

TABLE 38 (Continued)

ABSORPTION COEFFICIENTS OF N_2O

λ = 1080Å to λ = 2160Å

Method: Photoelectric Detection

Ref: K. Watanabe *et al.*, AFCRC Tech. Rep. No. 53-23, Geophys. Res. Paper No. 21 (1953).

k in Reciprocal Centimeters

λ	k
1549	4.2
1550.5	3.4
1552	3.3
1553.5	2.6
1557	2.2
1559	2.1
1563	3.4
1564	2.9
1567.5	1.60
1568.5	1.38
1570	1.32
1572	1.27
1574	1.11

TABLE 39

ABSORPTION COEFFICIENTS OF N_2O FOR SOME PROMINENT RYDBERG BANDS

$\lambda = 754Å$ to $\lambda = 836Å$

Method: Photoelectric Detection

Ref: P. Metzger and G. Cook, Technical Report No. ATN-63 (9218) - 7, Aerospace Corporation, (1963)

k in Reciprocal Centimeters

n	Series III		Series IV		Series V	
	λ	k	λ	k	λ	k
3	835.8	2500	848.0	930	-	-
4	798.3	2100	803.1	850	-	-
5	782.4	2300	785.0	880	-	-
6	774.4	1880	775.7	1350	-	-
7	769.4	1410	770.5	1140	-	-
8	766.3	1300	767.0	-	759.0	950
9	764.2	1090	-	-	756.8	1050
10	-	-	-	-	755.4	980
11	-	-	-	-	754.2	970

10. Nitrogen Dioxide

a. Historical Survey [15]

There appears to have been few investigations of the vacuum ultraviolet absorption characteristics of NO_2. The absorption spectrum has been studied by Price and Simpson [110] and by Mori [111, 112]. The only data included in this study were reported by Watanabe et al. [15] who made absorption cross section measurements in the region from 1050 to 2700Å and Hall and Blacet [113] who studied the region from 2400 to 5000Å.

b. Ultraviolet Spectral Region [15]

Several strong diffuse bands in the region from 1080 to 1200Å were found to fit a Rydberg series whose convergence limit of 11.62 eV was interpreted as the second ionization potential. From 1300 to 1600Å there are many sharp bands superimposed on a rather strong continuum. Rydberg series bands converging to the first ionization potential, 9.76 eV are expected in this area but have escaped detection. There appears to be at least three dissociation continua here with dividing lines at about 1320 and 1500Å. The region from 1600 to 2000Å is dominated by continuous absorption with a number of relatively weak bands appearing. Although the k-values throughout the entire range were found to be generally independent of pressure, a distinct pressure effect was detected from 1850 to 2400Å, where a continuum is apparent. Watanabe et al. [15] inferred that this continuum was due to the varying concentration of N_2O_4 in the NO_2 sample used. At about 2450Å, where the wings of two continua overlap, it is probable that the spectrum is complicated by predissociation.

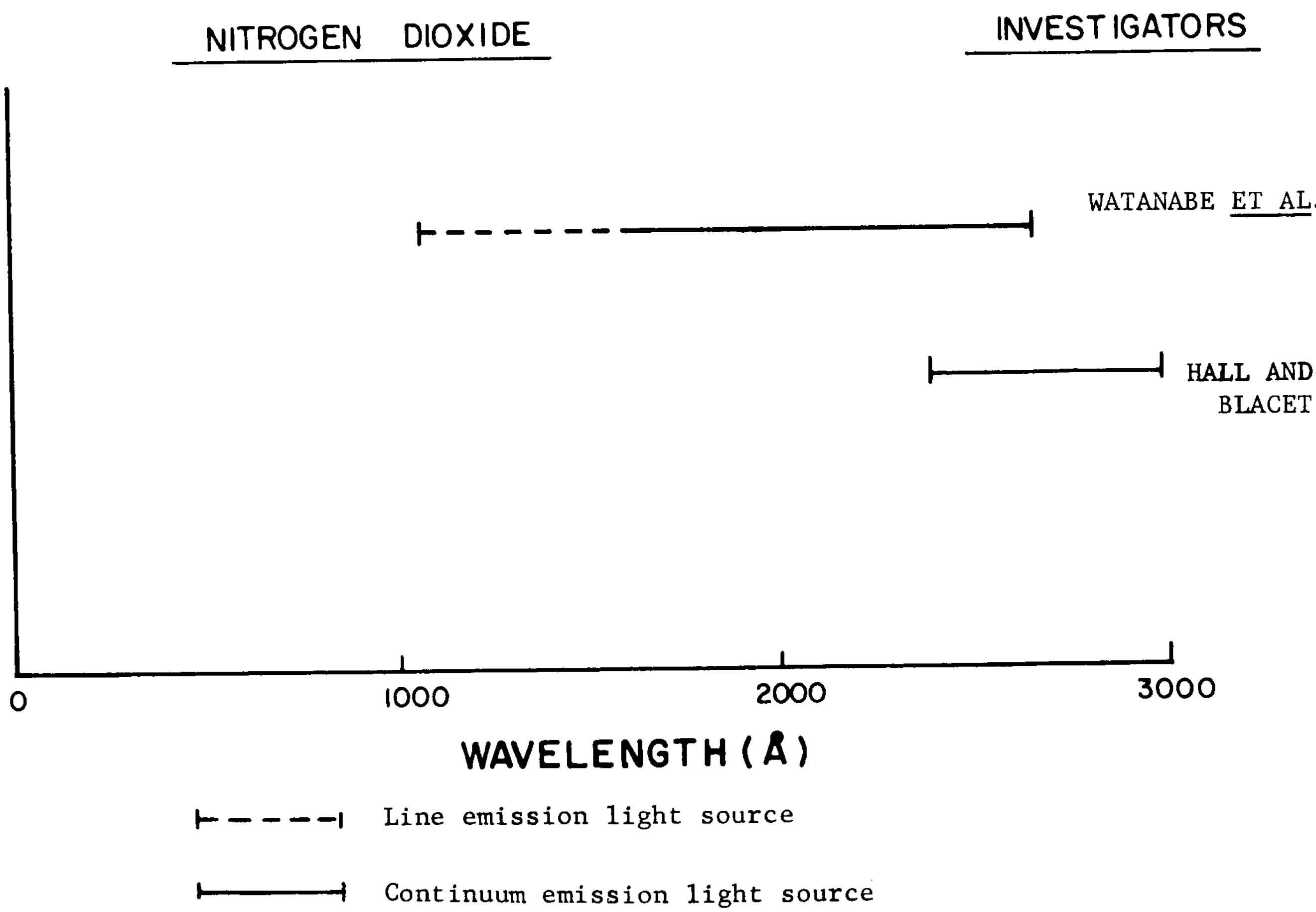


Figure 32. Spectral ranges of data obtained with line and continuum light sources: Nitrogen dioxide (Figures 33-35 and Table 40).

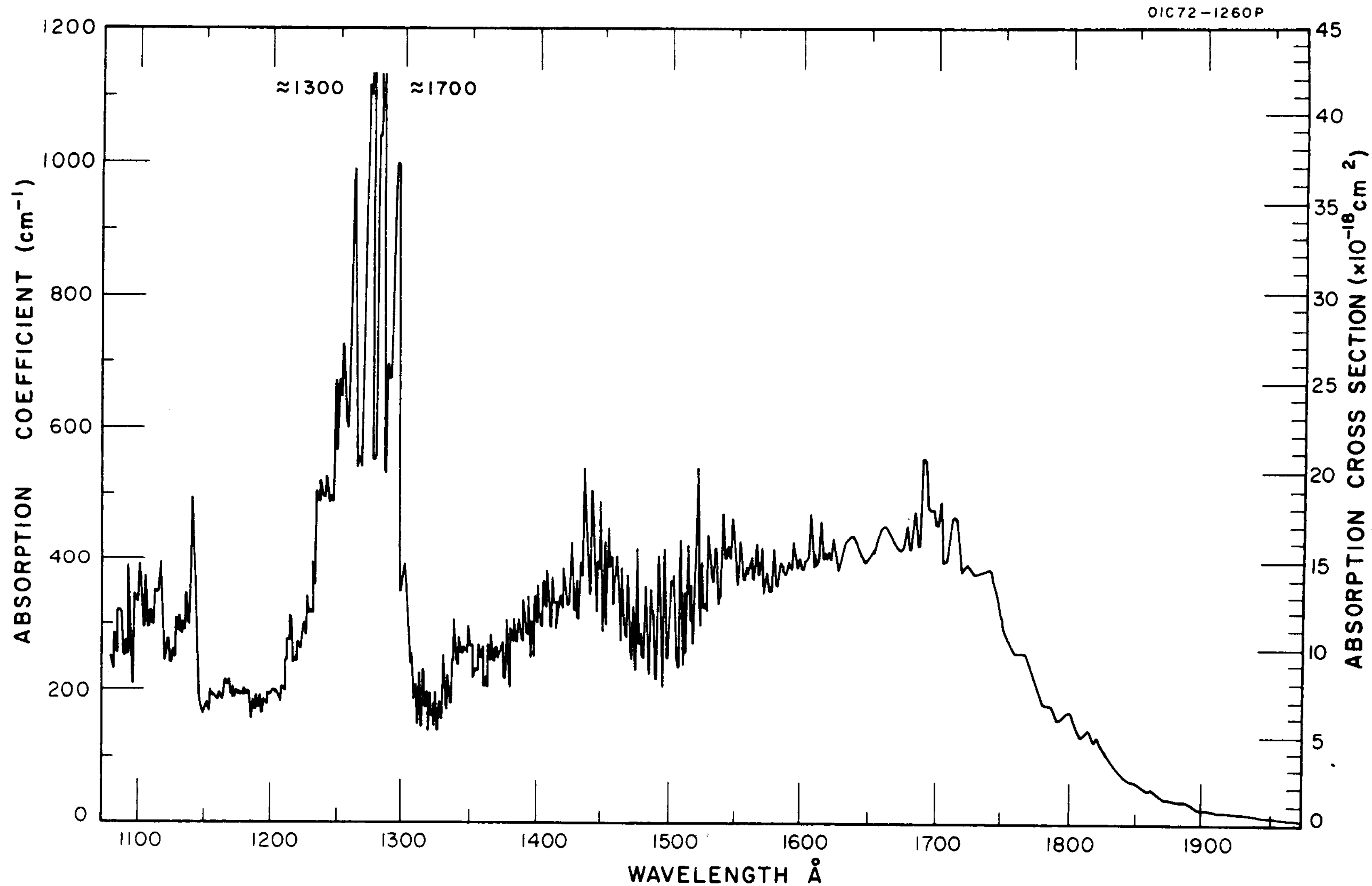


Figure 33. Absorption coefficients and cross sections of NO_2.
λ = 1080Å to λ = 1975Å
Method: Photoelectric detection
Ref: K. Watanabe, et al., Hawaii Inst. of Geophys. Contr. No. 11 Dec. (1958)
Experimental error: 10-20%

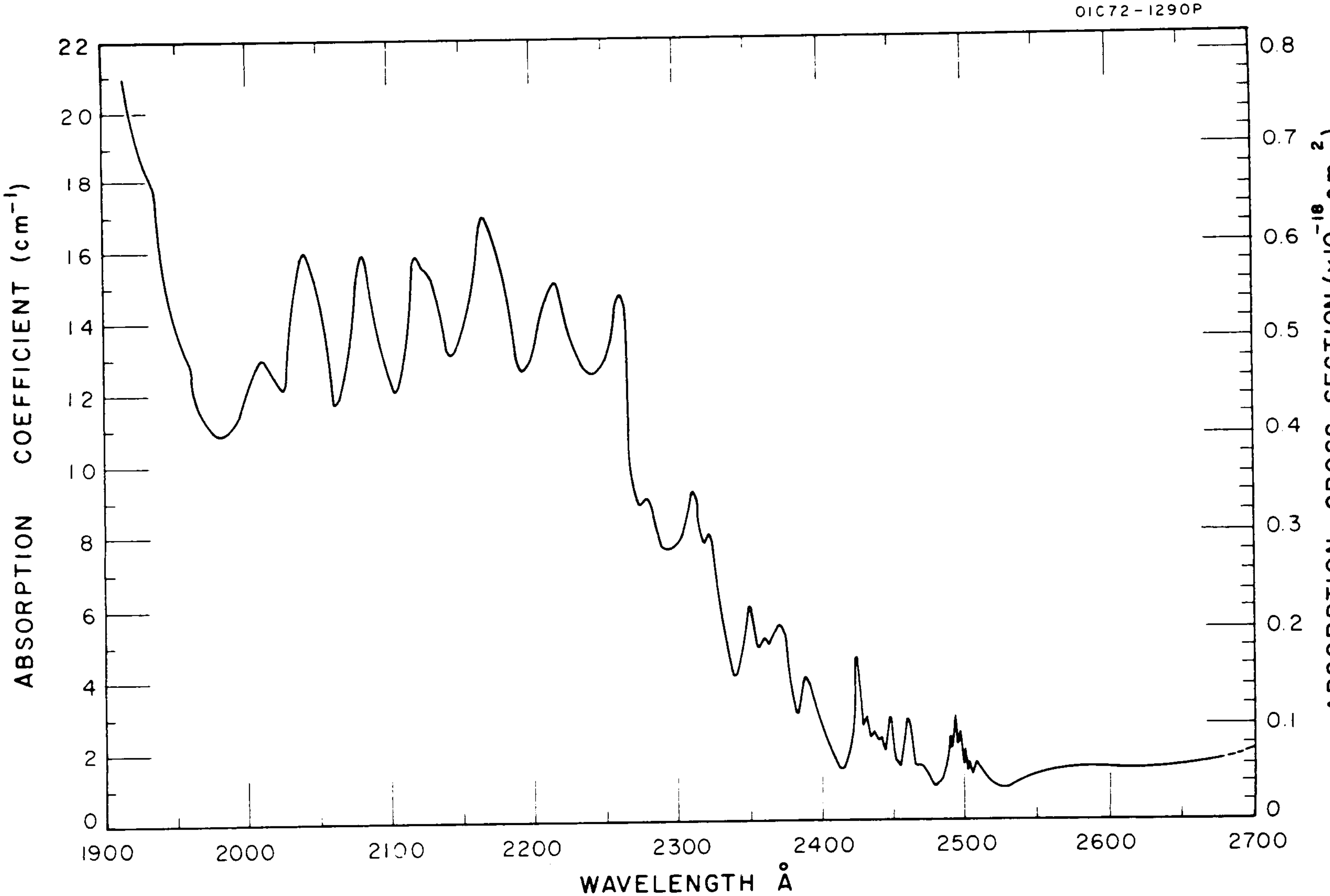


Figure 34. Absorption coefficients and cross sections of NO_2.
λ = 1920Å to λ = 2700Å
Method: Photoelectric detection
Ref: K. Watanabe, et al., Hawaii Inst. of Geophys. Contr. No. 11 Dec. (1958)
Experimental error: 30%

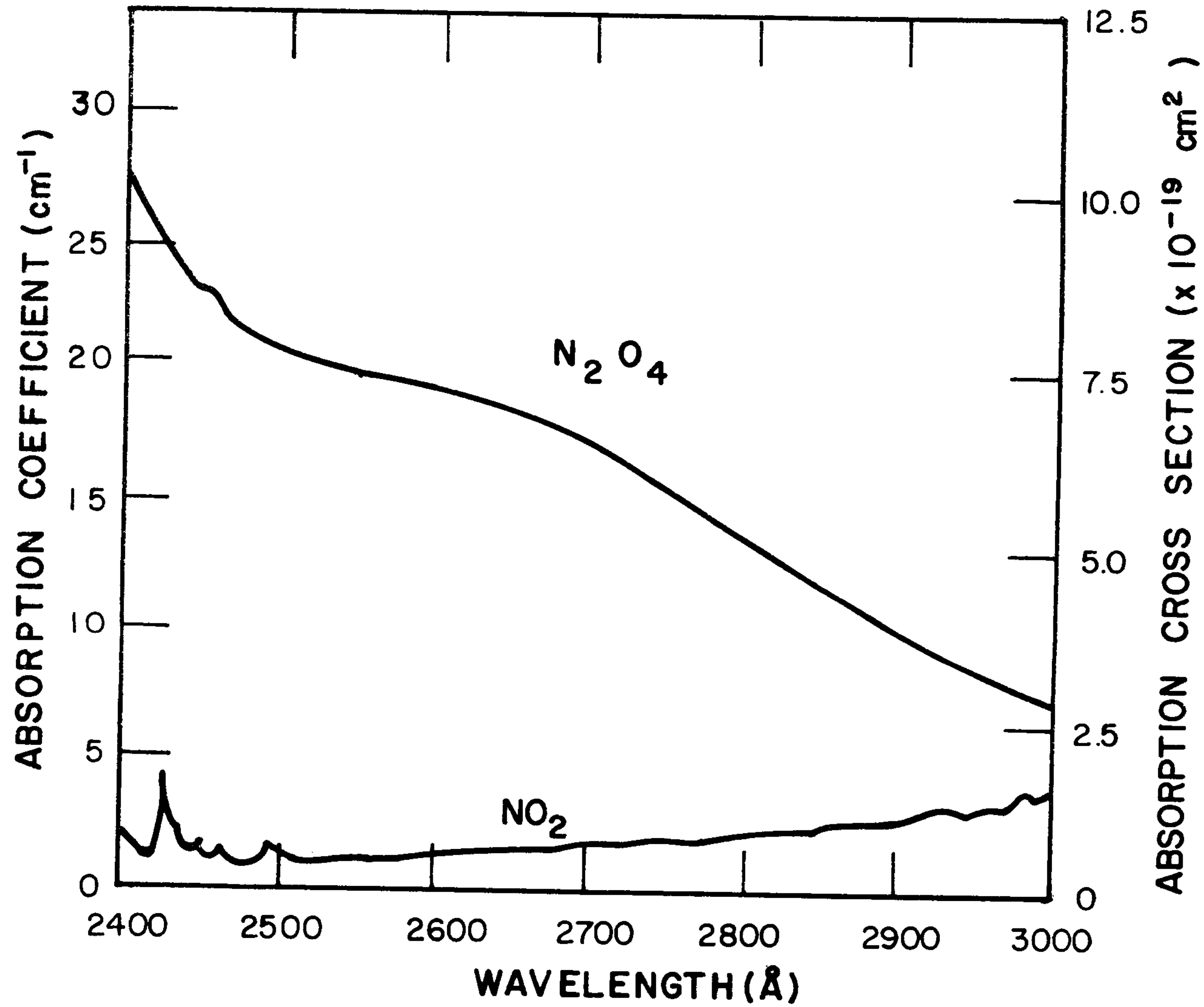


Figure 35. Absorption coefficients and cross sections of NO_2 and N_2O_4. λ = 2400Å to λ = 3000Å
Method: Photoelectric detection
Ref: T. Hall and F. Blacet, J. Chem. Phys. 20, 1745 (1952)

TABLE 40

ABSORPTION COEFFICIENTS OF NO_2

λ = 2400Å to λ = 3000Å

Method: Photoelectric Detection

Ref: T. Hall and F. Blacet, J. Chem. Phys., 20, 1745 (1952)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
2400	2.62	2600	1.31	2850	2.36
2450	1.75	2650	1.53	2900	2.62
2500	0.87	2700	1.75	2950	3.06
2550	1.09	2750	1.92	3000	3.50
		2800	1.48		

11. Ammonia

a. Historical Survey [16, 36]

The absorption spectrum of NH_3 in the vacuum ultraviolet was thoroughly studied by Duncan [114, 115]. He confirmed the earlier observations of Leifson [67] and Dixon [116] in the longer wavelength region and extended their investigation down to 850Å as well as analyzing the resonance bands which appeared above 1150Å. Absorption cross sections in the region from 1700 to 2200Å have been published by Tannenbaum et al. [117]. Watanabe et al. [36] reported k-values between 1060 and 2200Å, and Sun and Weissler [118] reported cross sections for the region from 374 to 1306Å. The absorption coefficients of ammonia have been measured at wavelengths as long as 2330Å recently by Thompson et al. [37] where the value at the latter wavelength is 10^{-4} cm^{-1}. Metzger and Cook [85] have obtained refined absorption coefficient values for the 600 - 1000Å region.

b. Ultraviolet Spectral Region [16, 36, 118]

The structure of the absorption contour suggests the existence of two ionization continua: a stronger one which peaks at about 730Å, and a weaker one which peaks at about 1130Å. These two maxima correspond to the ionization limits of the outer electrons of NH_3. Sun and Weissler [118] report a total f-value of 5.9 for this region. The region above 1300Å was included in the study made by Watanabe et al. [36]. For the continuum between 1200 and 1550Å, they estimated an f-value of 0.02; and for the continuum between 1600Å to 2200Å, they calculated an f-value of 0.030.

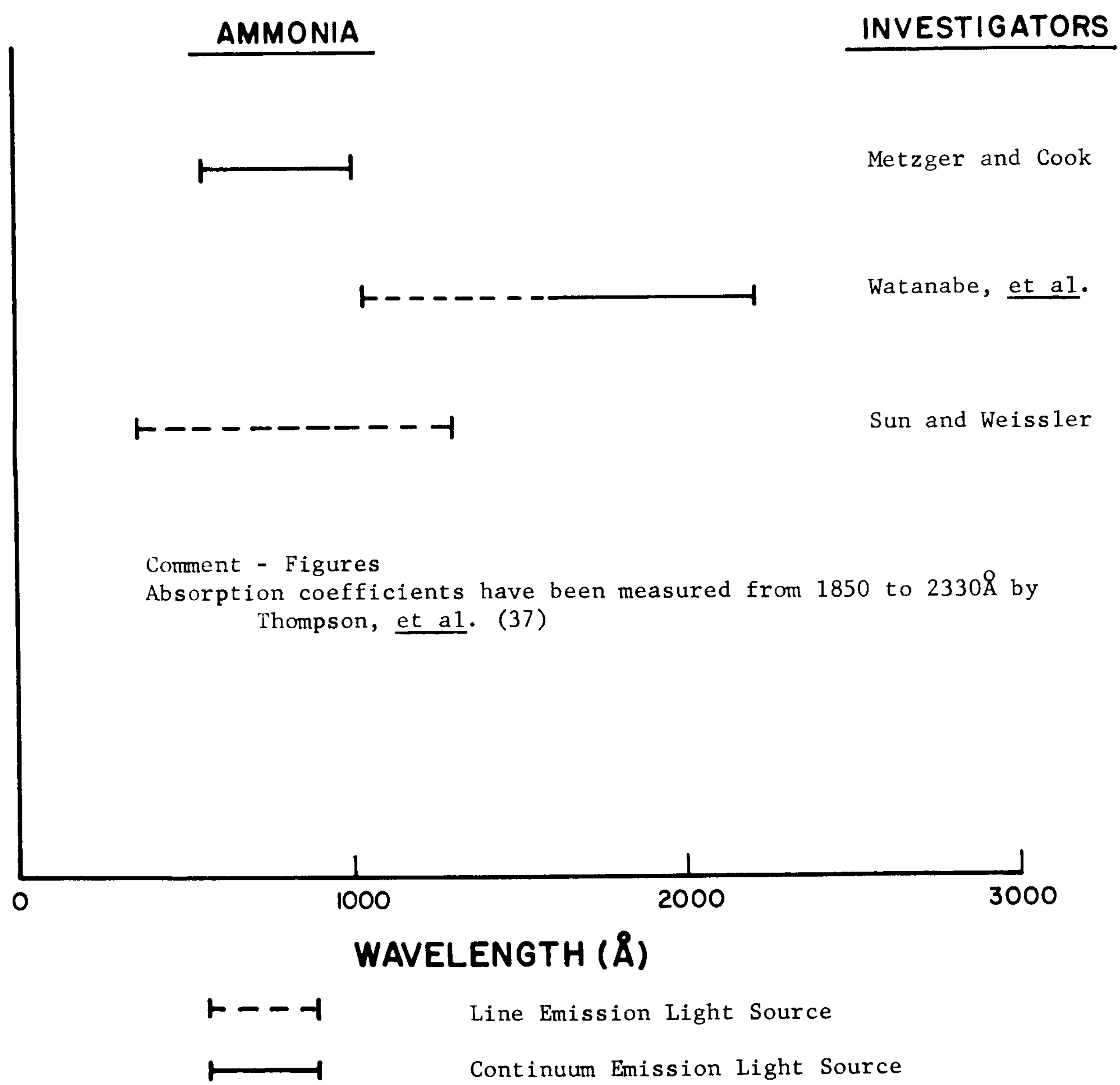


Figure 36. Spectral ranges of data obtained with line and continuum light sources: Ammonia (Figures 37 and 38 and Table 41).

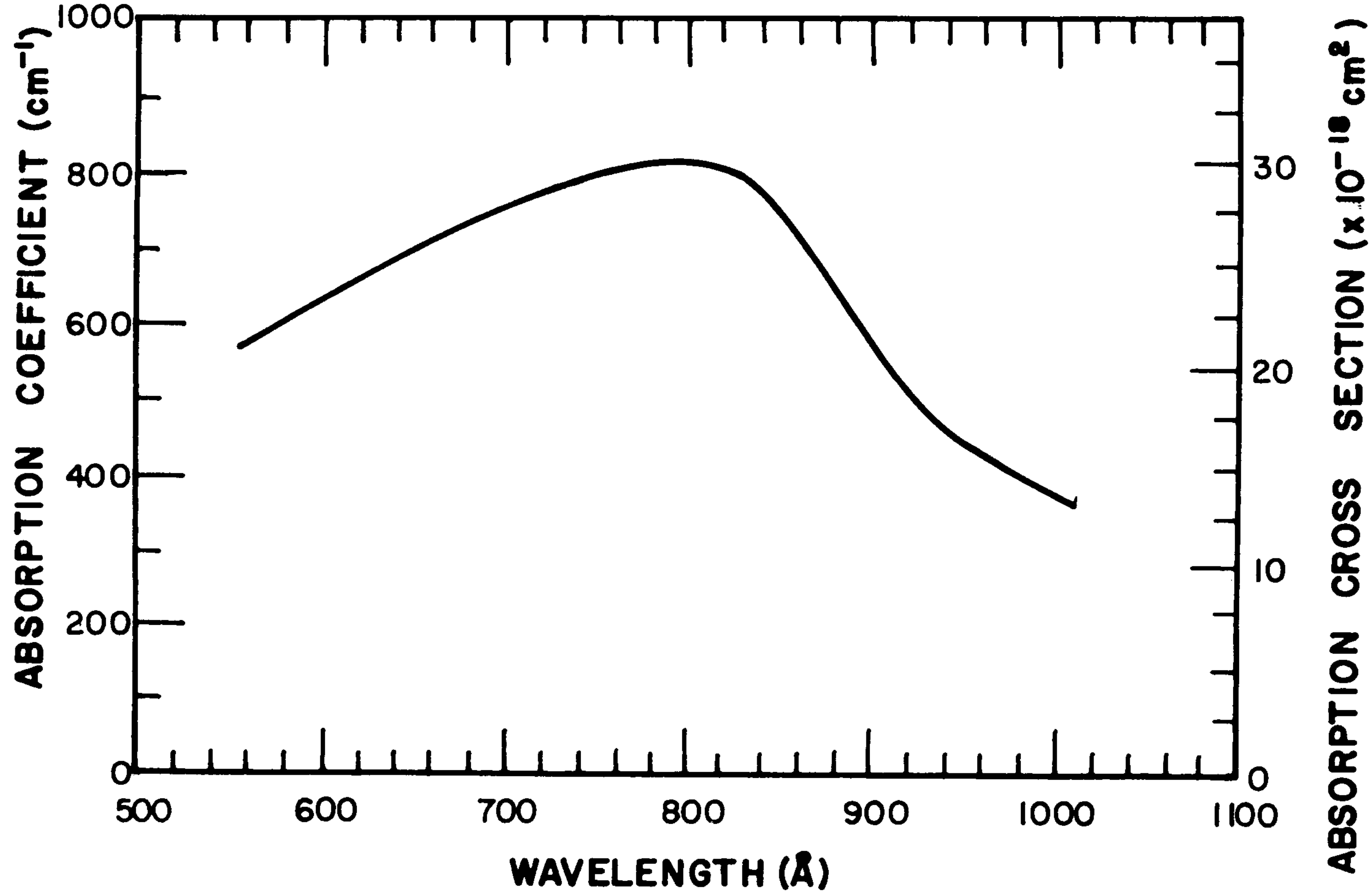


Figure 37. Absorption coefficients and cross sections of NH_3.
λ = 560Å to λ = 1000Å
Method: Photoelectric detection
Ref: P. Metzger and G. Cook, J. Chem. Phys. 41, 642 (1964)
Experimental error: ±10%

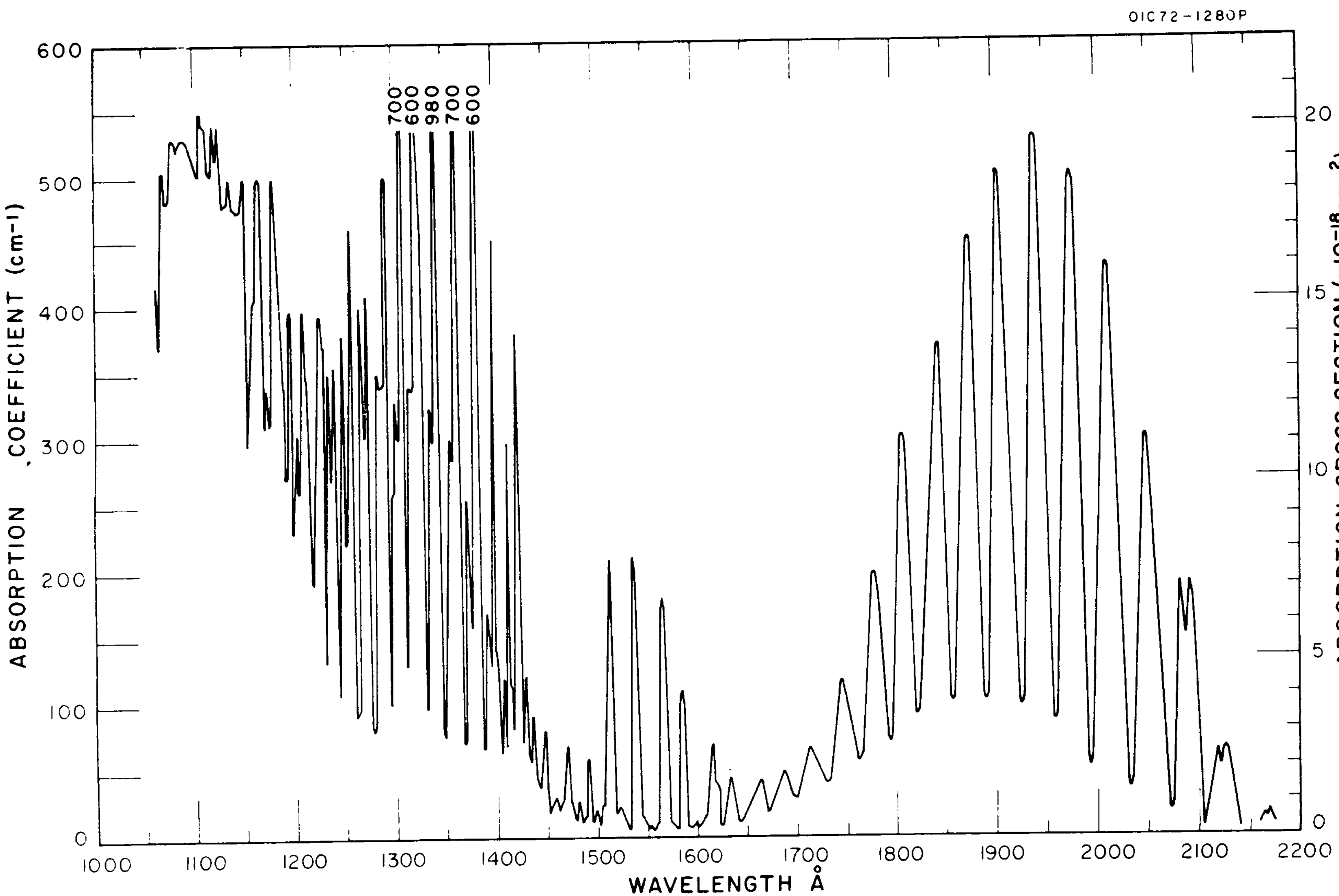


Figure 38. Absorption coefficients and cross secti ... of NH_3.
λ = 1060Å to λ = 2200Å
Method: Photoelectric detection
Ref: K. Watanabe, et al., AFCRC Tech. Rep. No. 53-23, Geo. Res. Paper No. 21 (1953)
Peak values are approximate

TABLE 41

ABSORPTION COEFFICIENTS OF NH_3

$\lambda = 374Å$ to $\lambda = 1306Å$

Method: Photographic Detection

Ref: H. Sun and G. L. Weissler, J. Chem. Phys. 23, 1160 (1955)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
374.1	538	685.5	833	883.2	860
374.3	457	685.8	833	887.4	941
503.7	780	686.3	780	915.9	564
511.5	645	702.3	887	916.0	538
538.3	753	702.9	941	916.7	564
539.2	753	703.9	941	922.5	618
539.4	699	718.5	914	923.0	618
539.9	833	723.4	914	923.2	618
555.1	726	725.5	860	923.5	699
580.4	753	730.9	914	924.3	645
581.0	780	740.2	941	977.0	645
582.2	780	746.8	833	979.8	672
599.6	726	747.0	887	988.8	618
604.2	833	763.3	968	989.8	511
616.3	860	764.5	968	991.5	538
617.1	833	765.1	887	1036.0	511
635.2	941	771.5	887	1037.0	538
637.3	914	771.9	887	1084.0	511
641.4	726	772.4	914	1084.6	538
641.8	833	773.0	914	1134.4	591
643.3	753	776.0	887	1135.0	618
644.1	833	796.7	887	1183.0	484
644.6	833	832.8	860	1184.5	457
644.8	806	833.3	833	1199.5	210
645.2	753	833.7	860	1200.2	210
660.3	753	835.1	806	1200.7	210
661.9	806	835.3	860	1243.3	97
664.6	806	840.0	941	1275.1	151
666.0	860	843.8	914	1276.2	121
670.9	833	850.6	941	1302.2	403
671.9	833	871.1	806	1304.9	220
672.0	860	875.5	780	1306.0	726
673.0	860	878.7	699		
685.0	887	879.6	726		

12. Methane

a. Historical Survey [16,36]

Leifson [67], Rose [119], and Duncan and Howe [120] were the earlier investigators of the vacuum ultraviolet absorption spectrum of CH_4. Absorption coefficients were measured from 1370 to 1455Å by Wilkinson and Johnston [71]. Later, Moe and Duncan [121] and Watanabe et al. [36] reported measurements down to 1050Å. Ditchburn [122] as well as Sun and Weissler [117] published values for the region between 1300 and 400Å. Using an independent method, Wainfan et al. [21] determined the cross sections between 960 and 470Å. With improved light sources, Metzger and Cook [85] refined the data from 600 to 1000Å and Rustgi [96] improved the data between 600 and 170Å.

b. Ultraviolet Spectral Region [3,118]

As expected from the symmetrical structure of the CH_4 molecule, the absorption is continuous with superimposed band structure appearing only in a few regions. Only below 800Å can absorption be wholly accounted for by photoionization. Sun and Weissler [118] reported a total f-value of 6.1 pertaining to transitions of 2p electrons. They further reported that the first ionization potential occurs at about 960Å. The oscillator strength as measured by Rustgi [96] is f = 7.6 which is higher than Dalgarno's theoretical estimate of f = 6.3 [123]. Rustgi's integration was cut-off at 200Å, whereas Dalgarno integrated down to 500Å only. Nevertheless, correcting for this wavelength difference, Rustgi found an oscillator strength of 4.6 between 1440 and 500Å. Metzger and Cook [85] found the first ionization potential to occur at 13.12 eV in agreement with Watanabe **et al.** [124].

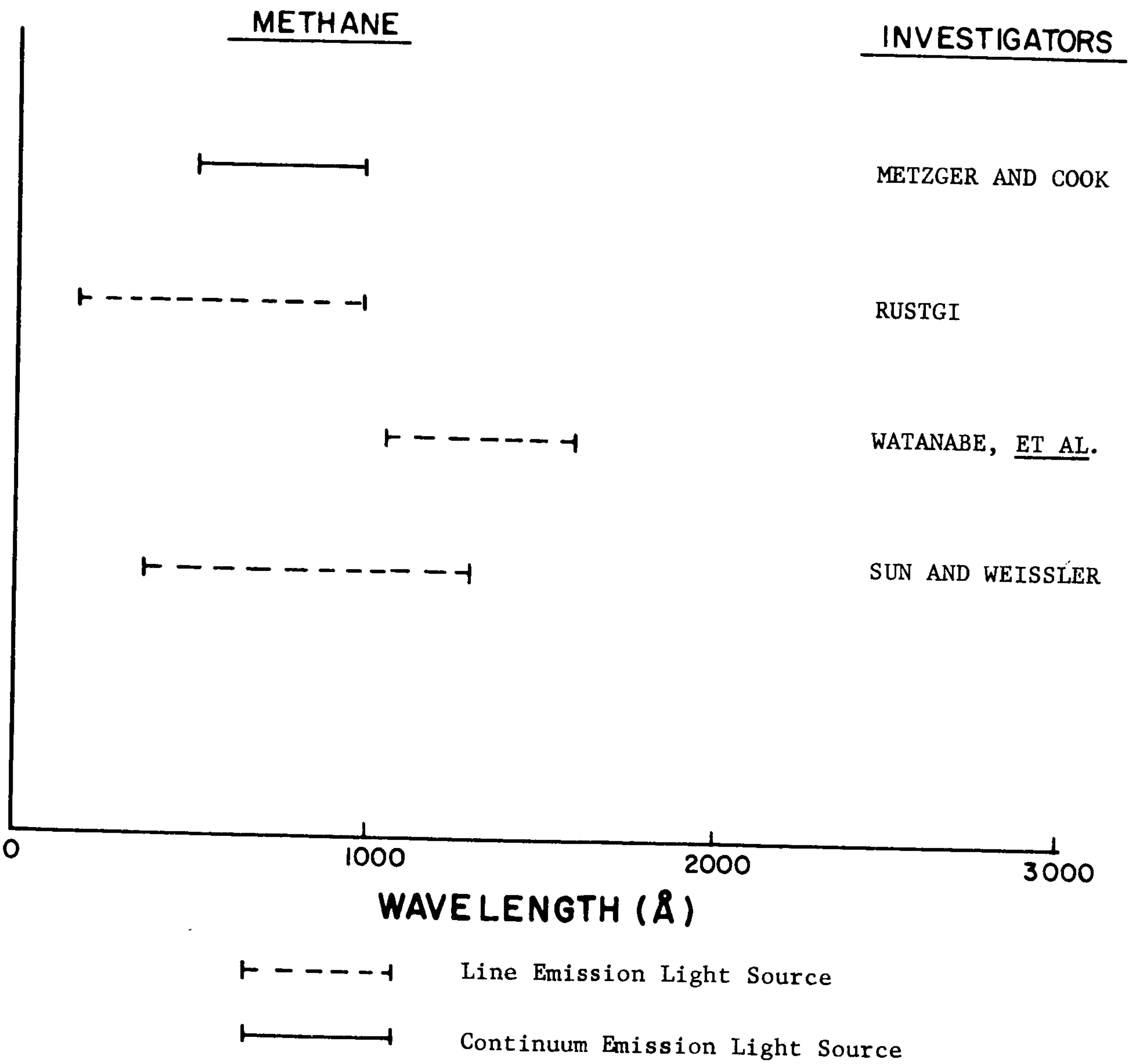


Figure 39. Spectral ranges of data obtained with line and continuum light sources: Methane (Figures 40-42 and Table 42).

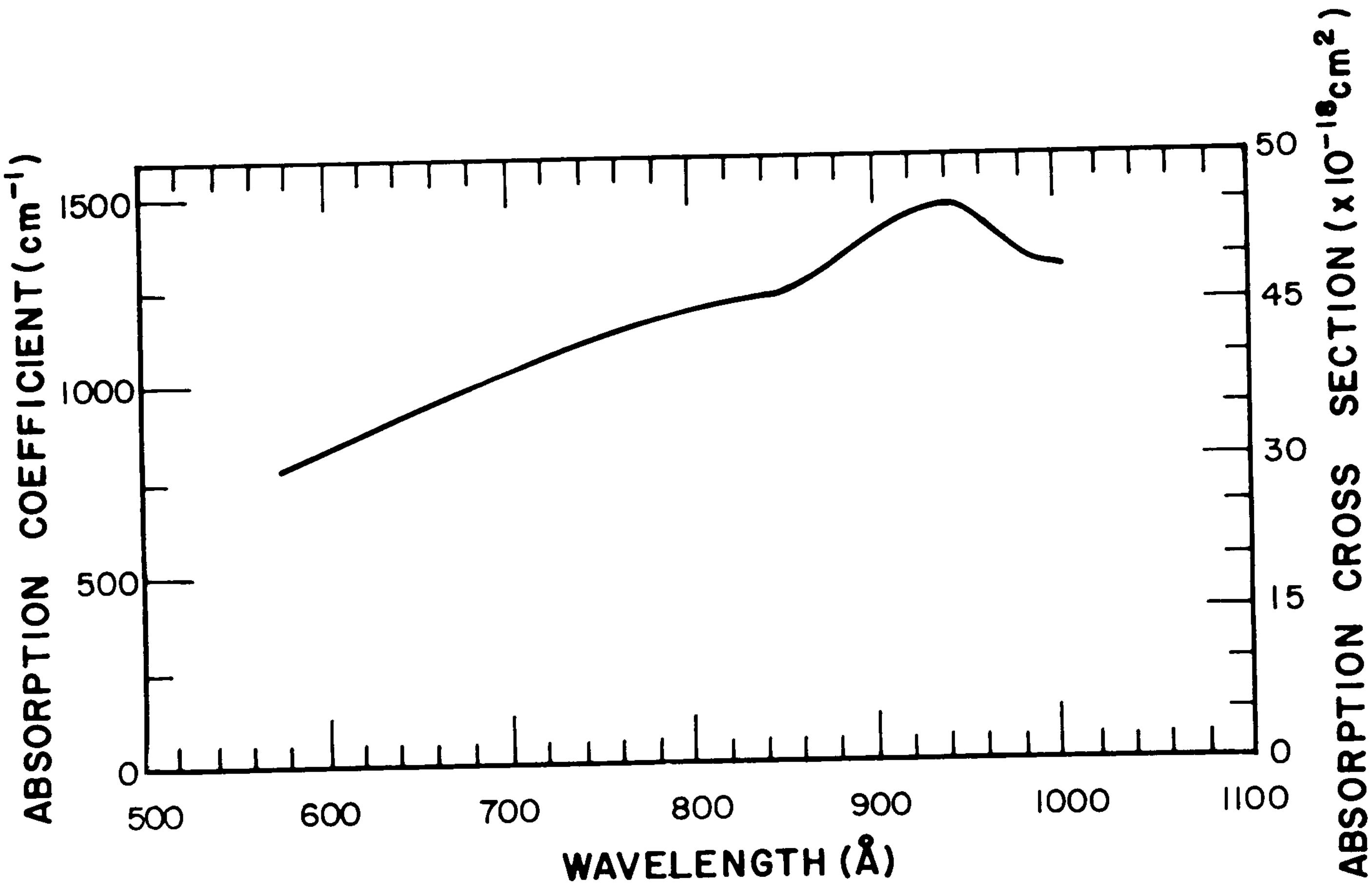


Figure 40. Absorption coefficients and cross sections of CH_4.
λ = 580Å to λ = 1000Å
Method: Photoelectric detection
Ref: P. Metzger and G. Cook, J. Chem. Phys. 41, 642 (1964
Experimental error: ±10%

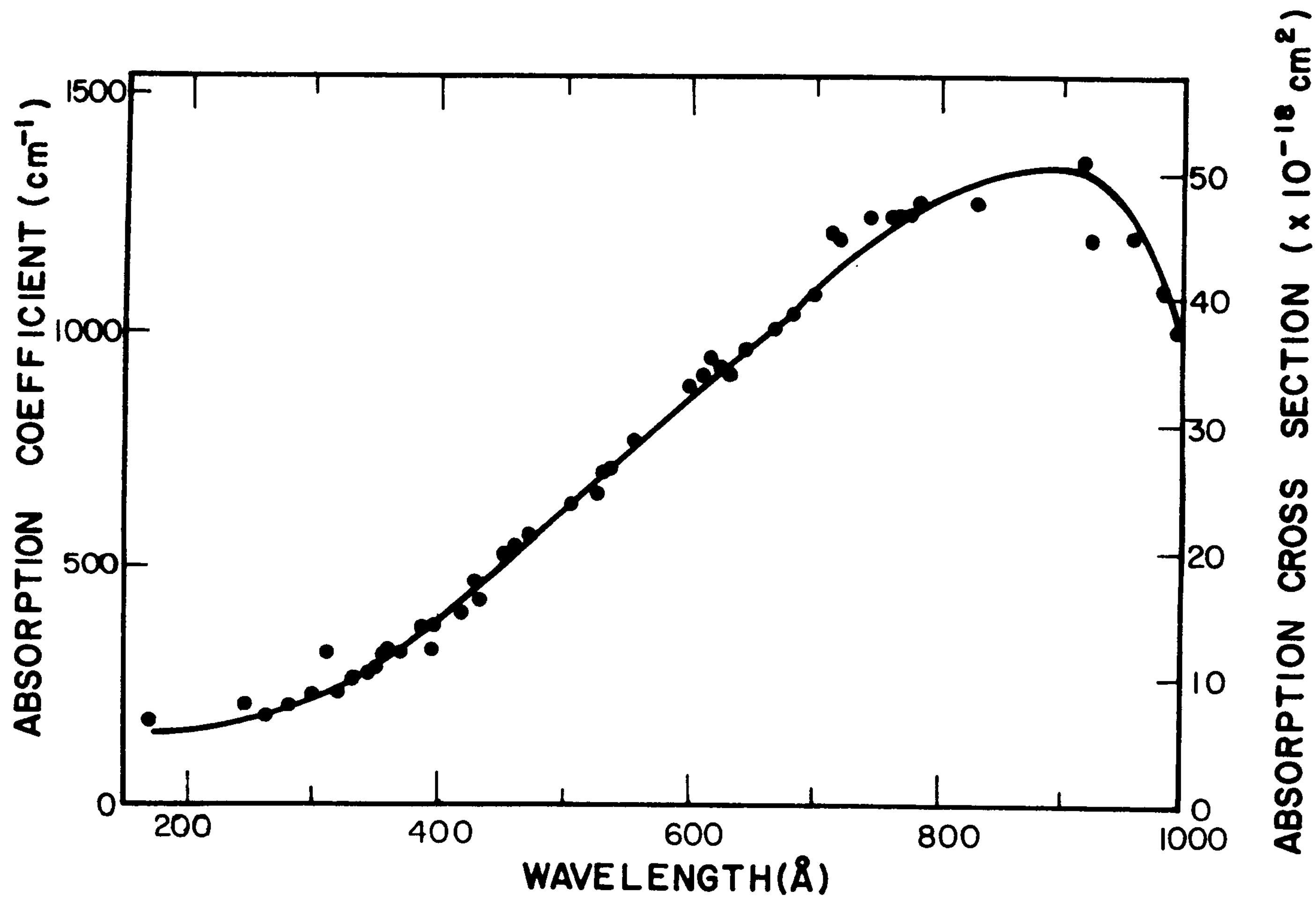


Figure 41. Absorption coefficients and cross sections of CH_4.
λ = 170Å to λ = 1000Å
Method: Photoelectric detection
Ref: O. Rustgi, J. Opt. Soc. of Am. 54, 464 (1964

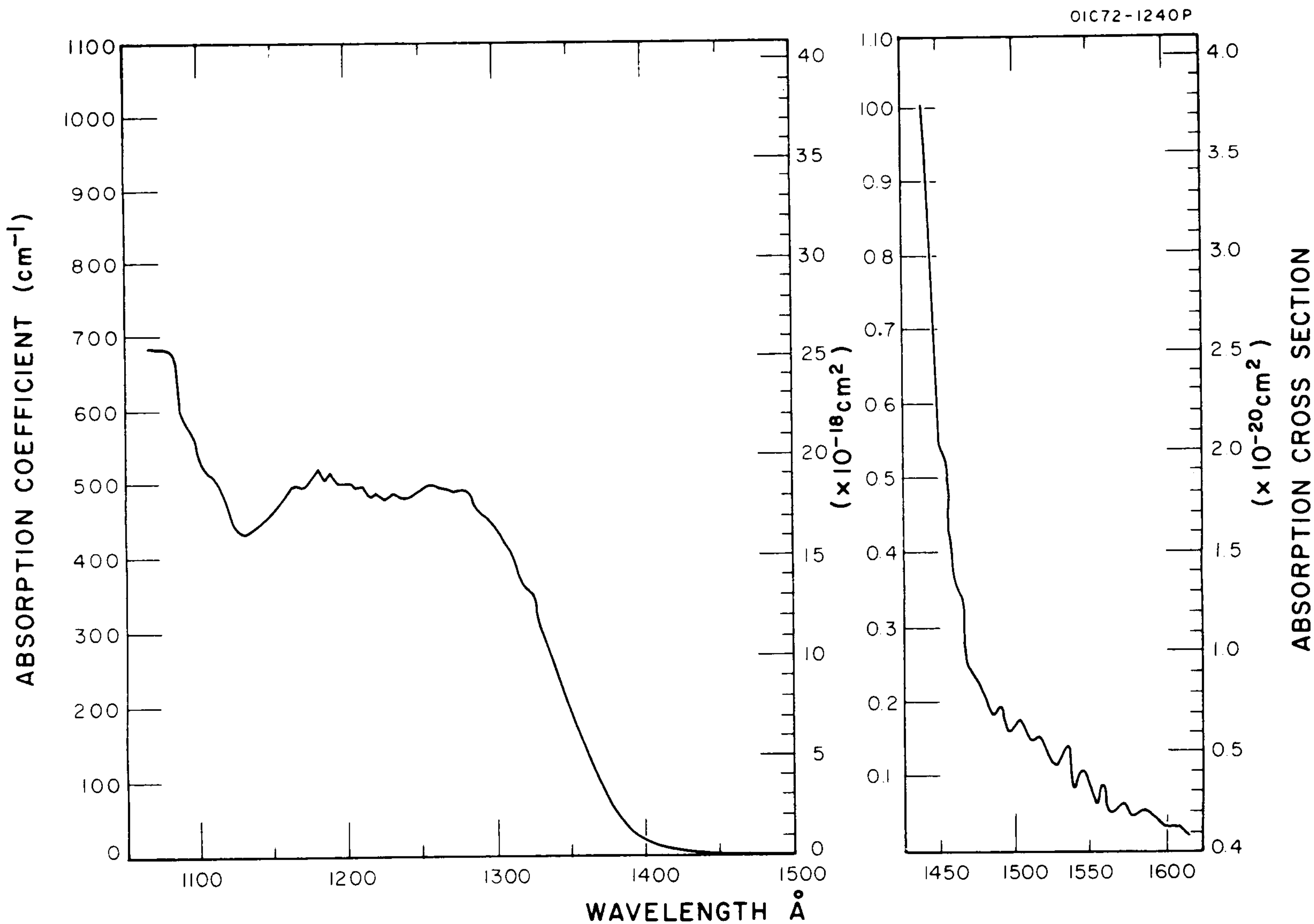


Figure 42. Absorption coefficients and cross sections of CH_4.
λ = 1065Å to λ = 1610Å
Method: Photoelectric detection
Ref: K. Watanabe, et al., AFCRC Tech. Rep. No. 53-23
Geophys. Res. Paper No. 21 (1953)

TABLE 42

ABSORPTION COEFFICIENTS OF CH_4

λ = 374Å to λ = 1306Å

Method: Photographic Detection

Ref: H. Sun and G. L. Weissler, J. Chem. Phys. 23, 1160 (1955)

k in Reciprocal Centimeters

λ	k	λ	k	λ	k
374.3	376	772.4	1022	977.0	1183
507.7	672	772.9	1156	979.8	1102
508.2	618	775.9	1048	989.8	1022
537.8	645	776.7	1129	991.5	780
538.3	618	796.7	1129	1036.3	833
580.4	672	833.3	1156	1037.0	833
581.0	672	833.7	1236	1065.9	833
582.2	672	834.6	1290	1071.8	860
599.6	833	835.1	1129	1084.6	726
600.6	833	840.0	1102	1085.5	780
616.3	833	850.6	1156	1134.4	511
617.1	914	851.6	1183	1135.0	511
629.2	968	864.7	1129	1152.1	511
629.4	941	871.1	1129	1175.5	618
644.1	968	875.8	1209	1176.4	672
644.6	726	879.6	1102	1183.0	618
644.8	860	883.2	1048	1184.5	538
645.2	780	887.4	1022	1199.5	511
660.3	887	916.0	1236	1200.2	538
685.0	860	916.7	1317	1200.7	511
686.3	968	923.2	1236	1206.9	484
745.8	1048	924.3	1129	1215.7	430
747.0	941	932.0	1290	1217.6	511
763.3	968	951.9	1505	1243.3	484
764.5	968	954.8	1505	1275.1	430
765.1	1075	955.5	1505	1302.2	376
771.5	1048	958.5	1613	1304.9	376
771.9	1156	961.5	1505	1306.0	376

13. Hydrogen Sulfide

a. Historical Survey

The only data published on the absorption cross sections of H_2S in the vacuum ultraviolet region is by Watanabe and Jursa [82]. The investigation of the absorption spectrum has been made by Price [78], Bloch et al. [125] and Walsh [126]. The convergence limit of the Rydberg series identified by Price [78] was 10.472 $\pm$ 0.005 eV. Watanabe and Jursa [82] observed the threshold of ionization at 1185Å or 10.46 eV. This is in good agreement with the limit as obtained by Price [78].

b. Spectral Region (1600 - 2100Å)

The spectrum in this region as observed by Watanabe and Jursa [82] consists of a broad continuum with almost no discrete structure. This continuum apparently extends beyond the data of Watanabe and Jursa and may be evident up to 2700Å as can be seen by the data of Goodeve and Stein [127] who measured extinction coefficients of H_2S beyond 2000Å. Watanabe found four very diffuse bands superimposed on this continuum at about 1875, 1917, and 2005Å. His data supports Mulliken's interpretation [128] that the continuum is due to predissociation.

c. Spectral Region (1060 - 1600Å)

In this region Price arranged most of the prominent bands into four Rydberg series converging to the first ionization potential at 10.472 $\pm$ 0.005 eV. The data of Watanabe and Jursa [82] is compatible with the photographic data as observed by Price [78]. Nevertheless the values reported down to 1200Å by Watanabe and Jursa [82], are semi-quantitative since the strong bands showed a considerable amount of pressure dependence. There appears to be a second continuum with the onset just under 1700Å, extending into the extreme ultraviolet region. For this region absorption bands occur down to 1200Å; however, below this, the absorption is essentially continuous. Some diffuse bands are evident between 1060 to 1200Å suggesting the presence of discrete states of the H_2S molecule in the region above the first ionization potential.

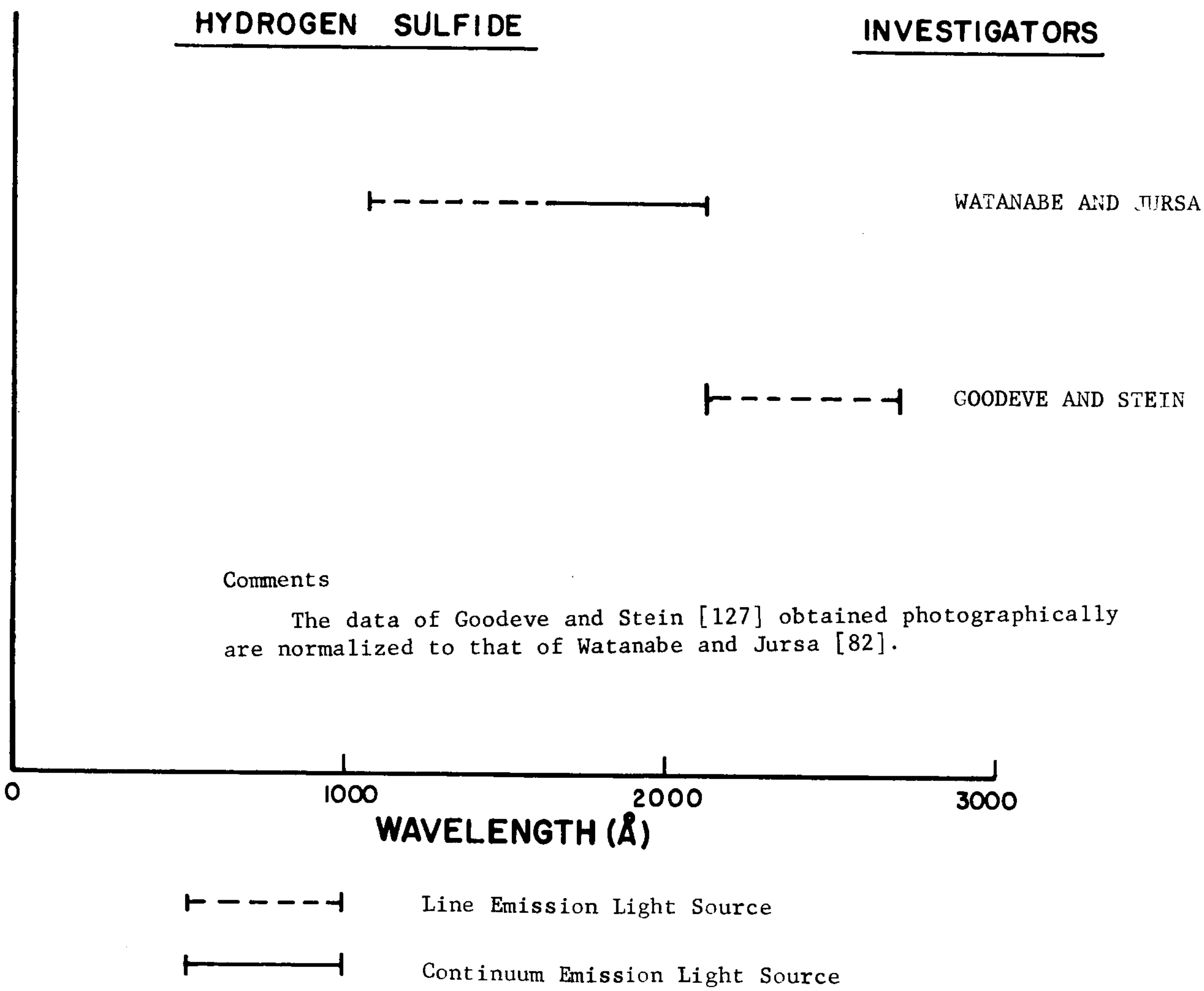


Figure 43. Spectral ranges of data obtained with line and continuum light sources: Hydrogen Sulfide (Figures 44-47).

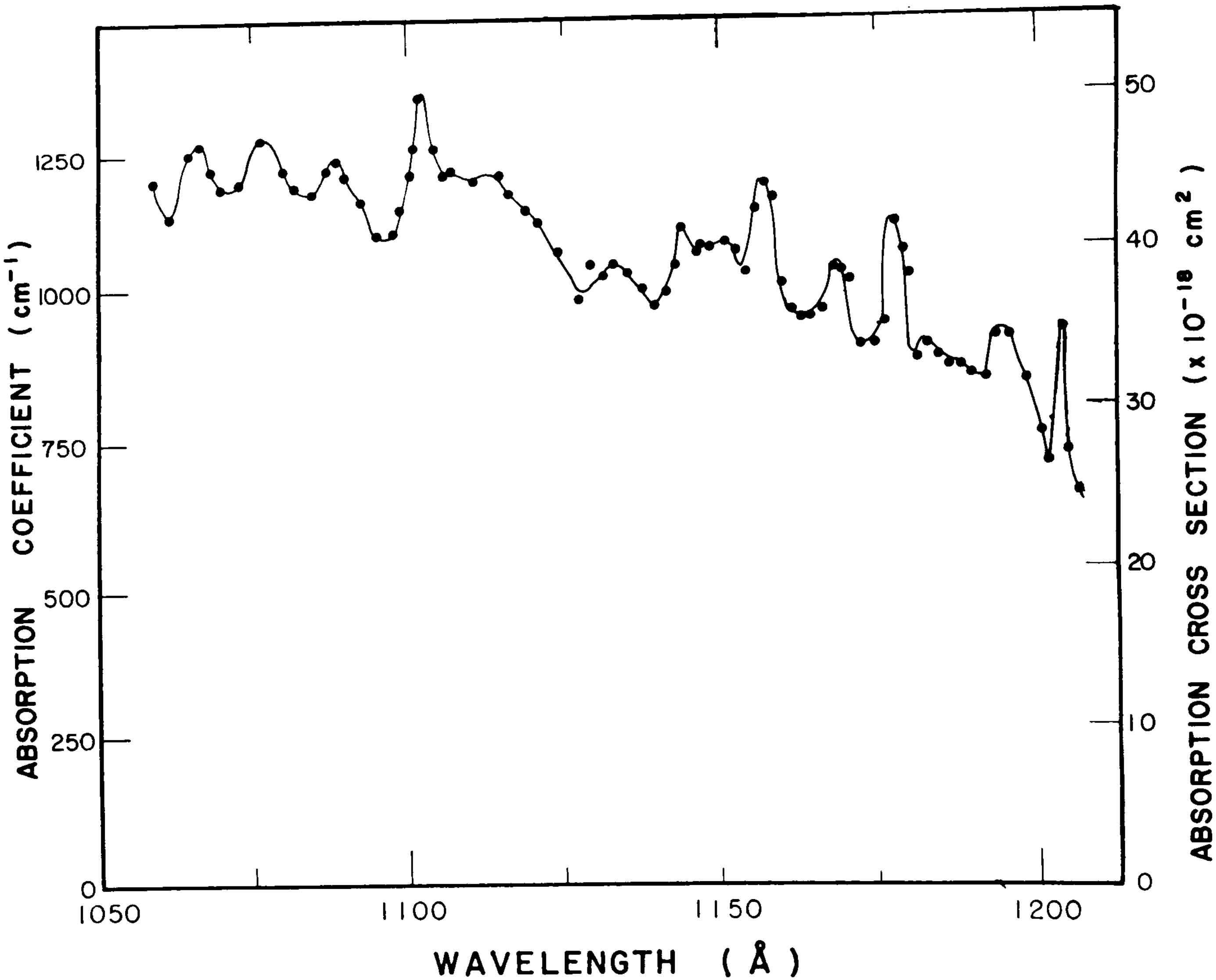


Figure 44. Absorption coefficients and cross sections of H_2S.
λ = 1060Å to λ = 1210Å
Method: Photoelectric detection
Ref: K. Watanabe and R. Jursa, J. Chem. Phys. 41, 1650 (1964)

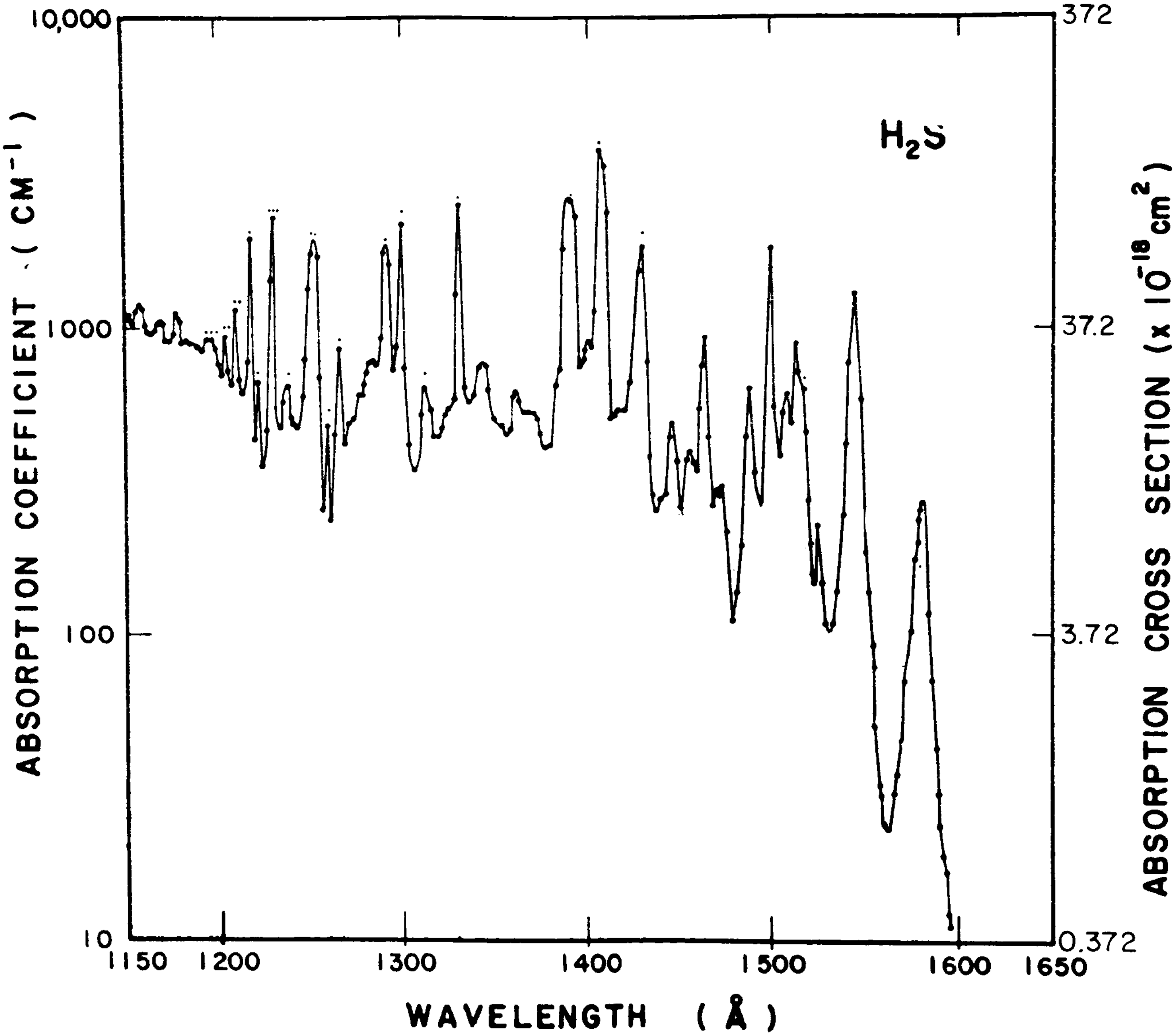


Figure 45. Absorption coefficients and cross sections of H_2S.
λ = 1150A to λ = 1600Å
Method: Photoelectric detection
Ref: K. Watanabe and R. Jursa, J. Chem. Phys. 41, 1650 (1964)
Experimental error: Maxima of and minima between bands, semi-quantitative. All other values 10-20%

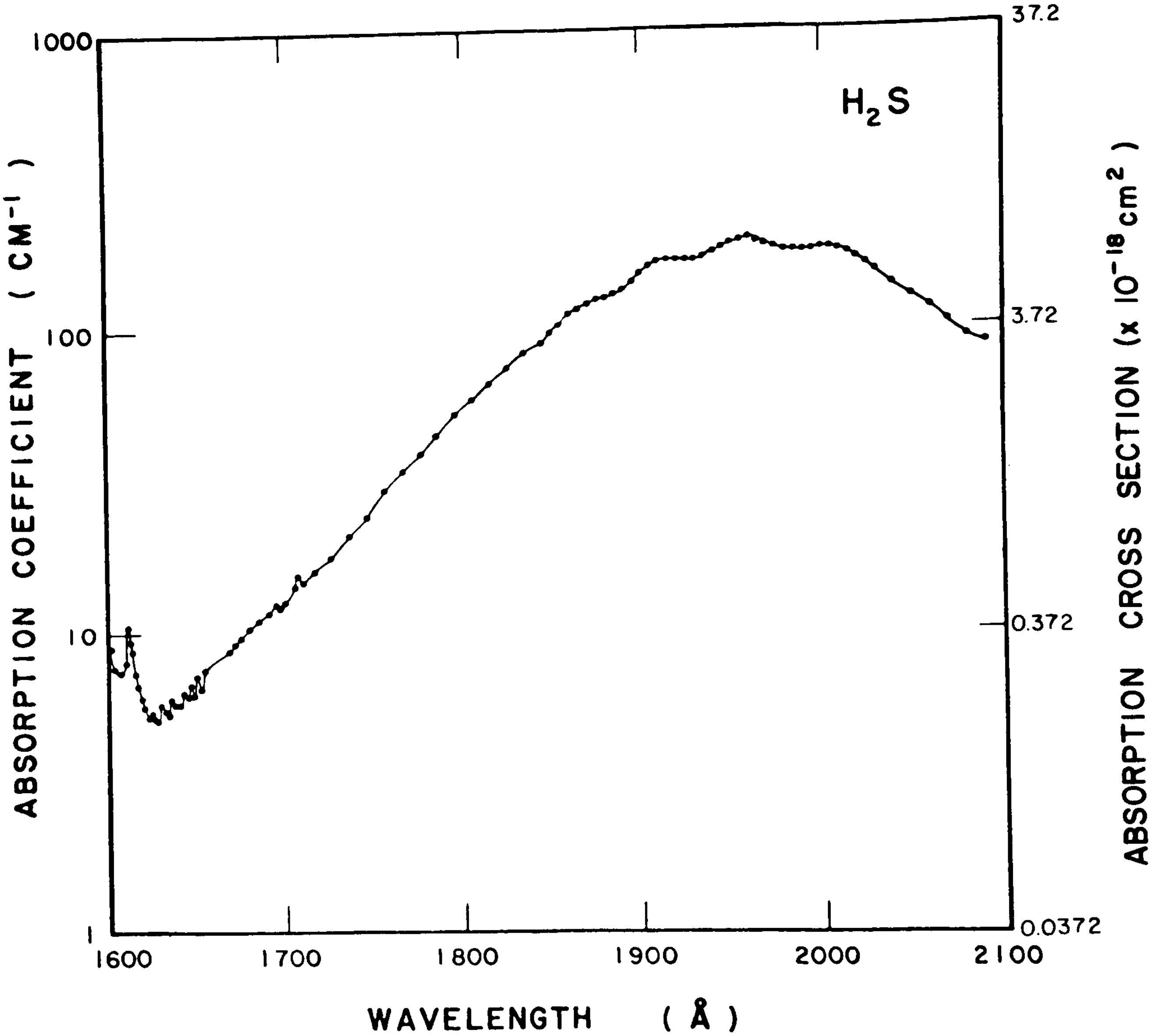


Figure 46. Absorption coefficients and cross sections of H_2S.
λ = 1600Å to λ = 2100Å
Method: Photoelectric detection
Ref: K. Watanabe and R. Jursa, J. Chem. Phys. 41, 1650 (1964)
Experimental error: 10%

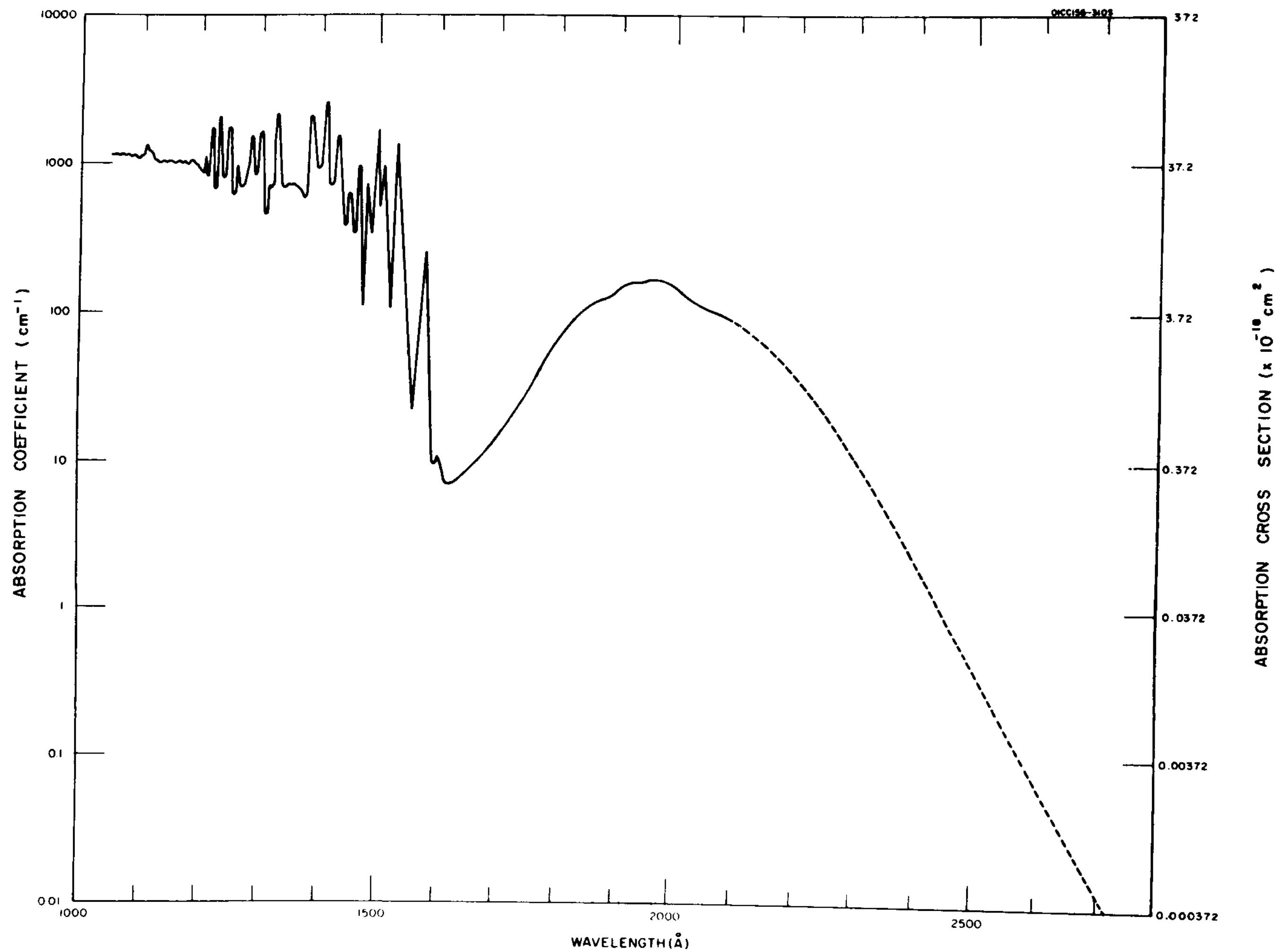


Figure 47. Absorption coefficients and cross sections of H_2S.
λ = 1050Å to λ = 2100Å
Method: Photoelectric detection
Ref: K. Watanabe and R. Jursa, J. Chem. Phys. 41, 1650 (1964)
λ = 2100Å to λ = 2720Å
Method: Photographic detection
Ref: C. Goodeve and N. Stein, Trans. Faraday Soc. 27, 393 (1931)

14. Sulfur Dioxide

a. Historical Survey

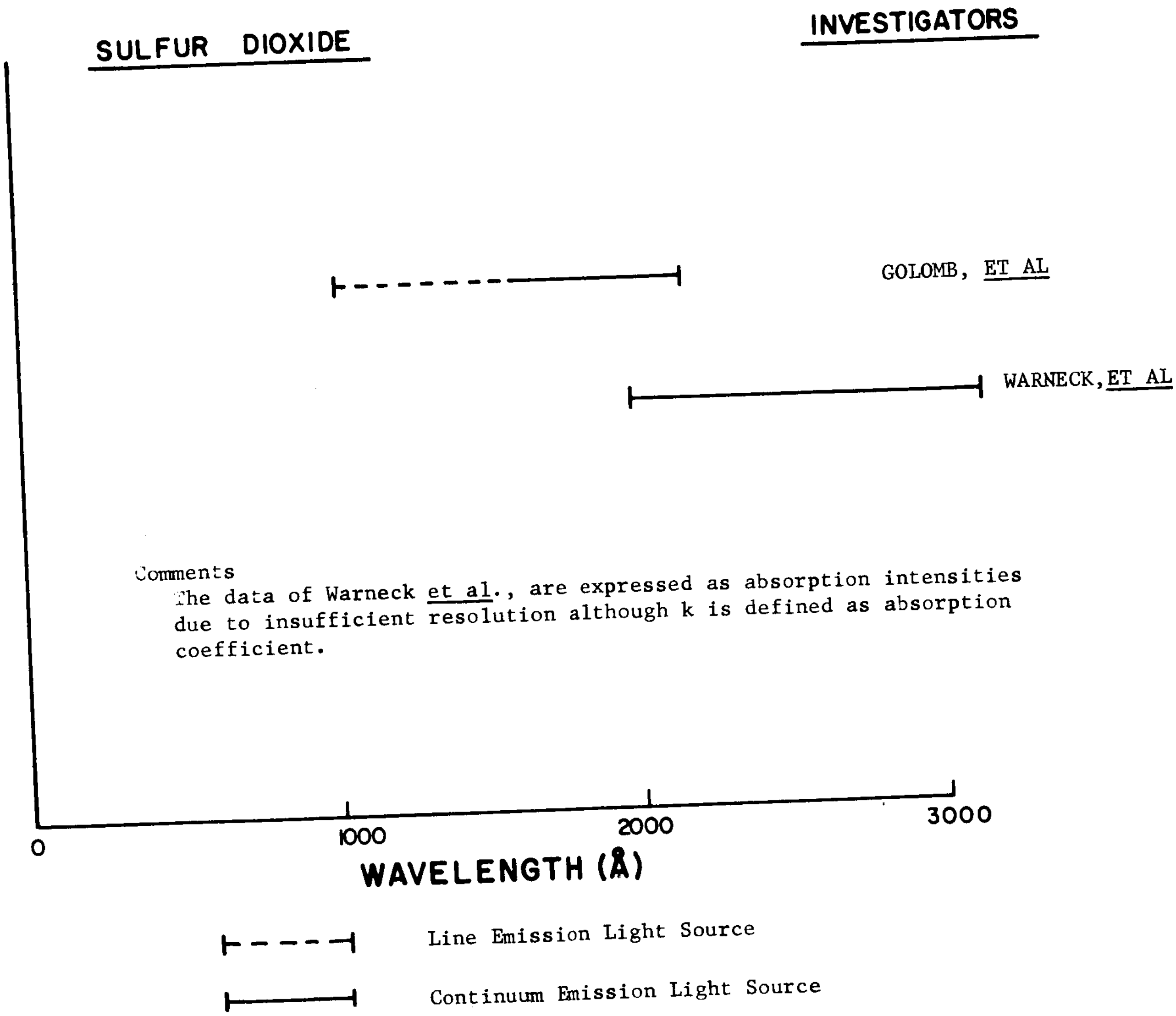
The complex absorption spectrum of sulfur dioxide in the near and vacuum ultraviolet spectral region has been repeatedly studied with the aim of classifying band systems and making vibrational analyses. Specifically in the wavelength range above 2000Å, this has been nearly satisfactorily achieved by Duchesne and Rosen [129] and by Metropolis [130] while theoretical implications have been discussed by Mulliken [131] and Walsh [126]. However, quantitative absorption coefficients for the 1050 - 2100Å spectral region as studied by Golomb et al. [132] appears to be the only available data. Measurements of SO_2 absorption intensities have been made by Warneck et al. [133]. These data are reported as absorption coefficients; but must be considered as apparent since a lower resolution 2~3Å was used when the data were compared with those of Golomb et al. [132].

b. Spectral Region 1050 to 2100Å

Below 1350Å, the absorption spectrum has been recognized by Price and Simpson [134] to belong to the resonance bands approaching the first ionization potential; this spectrum is interpreted in terms of a Rydberg series converging upon the ionization potential of 12.34 eV as obtained by the photoionization method by Watanabe [135]. The band system in the 1800 - 2400Å region has been observed by several investigators, (see for example Duchesne and Rosen [129]). It was interpreted by Mulliken [131] and more recently by Walsh [126] as a system belonging to two or more transitions. A system in the 1500 - 1600Å was detected by Price and Simpson [134], although only the bands at 1573, 1558 and 1529Å were recorded. Above 1300Å, a continuum is evidenced between the 1300 - 1700Å wavelength region. The experimental long wavelength onset of this continuum could be reliably estimated to lie at 1680Å: the maximum occurs at 1485Å. The superposition of intense bands on the short wavelength slope of the continuum makes the obtained f-values somewhat ambiguous. The largest possible f-value is $f = 0.0473$, while the assumption of a symmetric continuum gives $f = 0.035$. A second true absorption continuum from 1700 - 2300Å was demonstrated by Warneck et al. [133] with an upper limit absorption coefficient of 28 cm^{-1} at 1849Å. The maximum of the continuum lies at 1915Å. Conventional computation give an f-number of 0.0294; however, this is probably too high because of the insufficient spectral resolution employed. Since with increasing pressure the 1849Å apparent absorption coefficient decreases from $k = 75$ to $k = 28$ cm^{-1}, the corrected value is reduced to $f = 0.011$.

c. Spectral Region 2100 to 3150Å

The spectrum above 2400Å obtained by Warneck et al. [133] gives the appearance of a continuum that is really due to the restricted spectral



Comments
The data of Warneck et al., are expressed as absorption intensities due to insufficient resolution although k is defined as absorption coefficient.

Figure 48. Spectral ranges of data obtained with line and continuum light sources: Sulfur Dioxide (Figures 49-54).

resolution (2Å) and to a considerable overlapping of the involved bands. This view is compatible with existent spectroscopic data of Kornfeld and Weegmann [136] and specific absorption experiments performed by Warneck *et al*. [133]. The absorption spectrum has also been measured from 1900 to 3300Å by Thompson *et al*. [37] however, the instrumental resolution is unknown. Nevertheless, good agreement between all three experimenters has been observed.

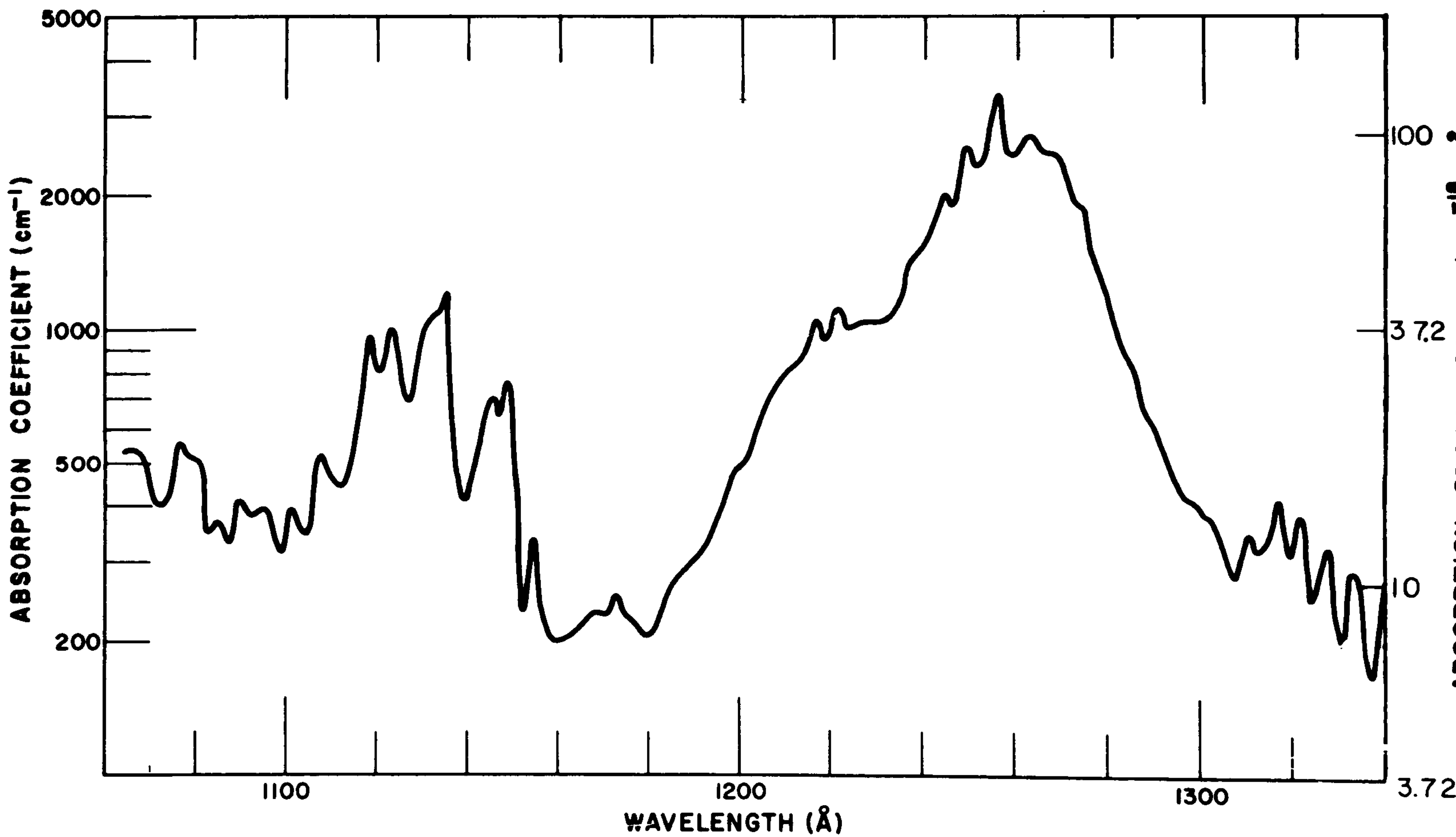


Figure 49. Absorption coefficients and cross sections of SO_2.
λ = 1065Å to λ = 1340Å
Method: Photoelectric detection
Ref: D. Golomb, et al., J. Chem. Phys. 36, 958 (1962)

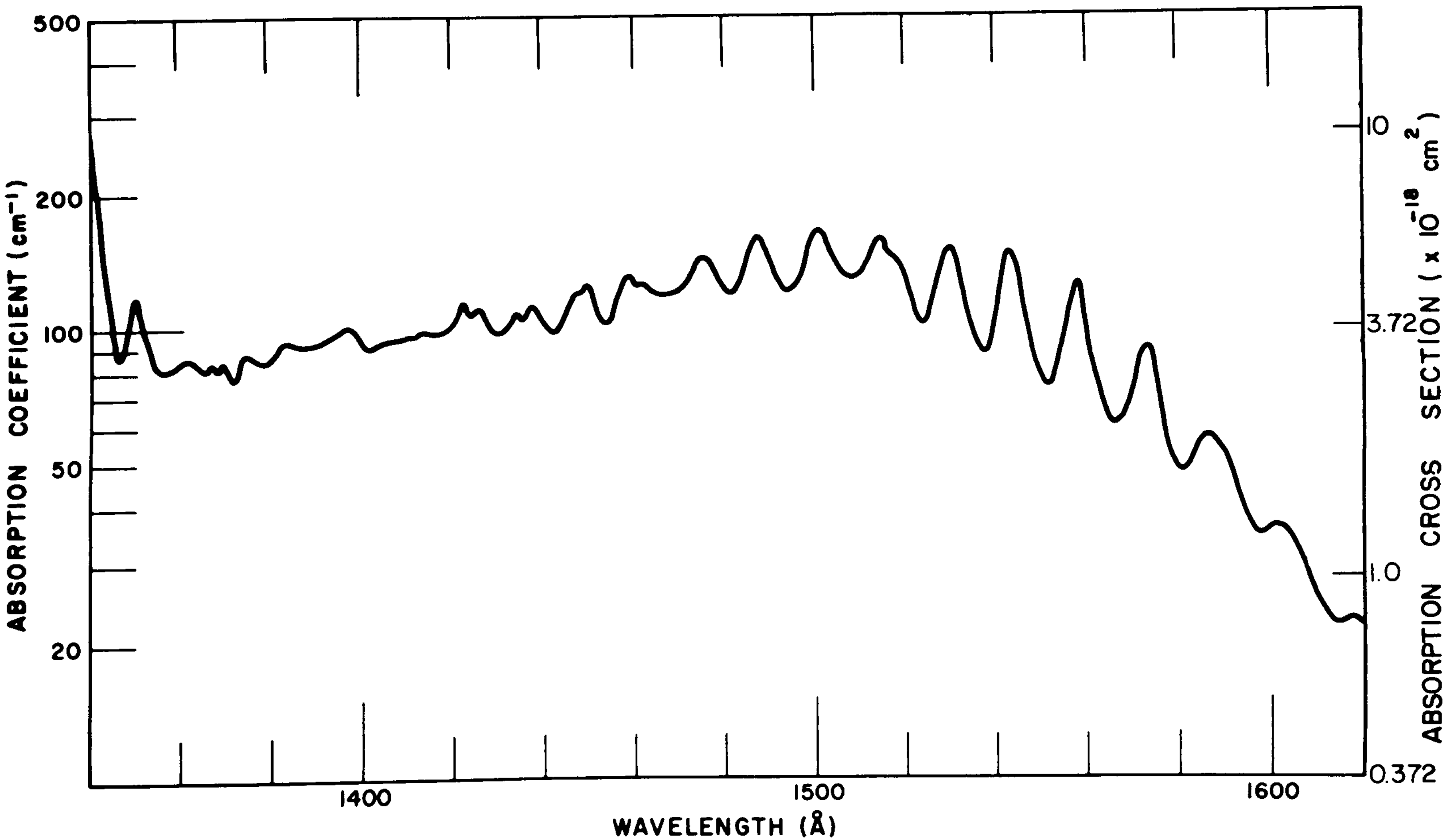


Figure 50. Absorption coefficients and cross sections of SO_2.
λ = 1340Å to λ = 1620Å
Method: Photoelectric detection
Ref: D. Golomb, et al., J. Chem. Phys. 36, 958 (1962)
Experimental error: 10%

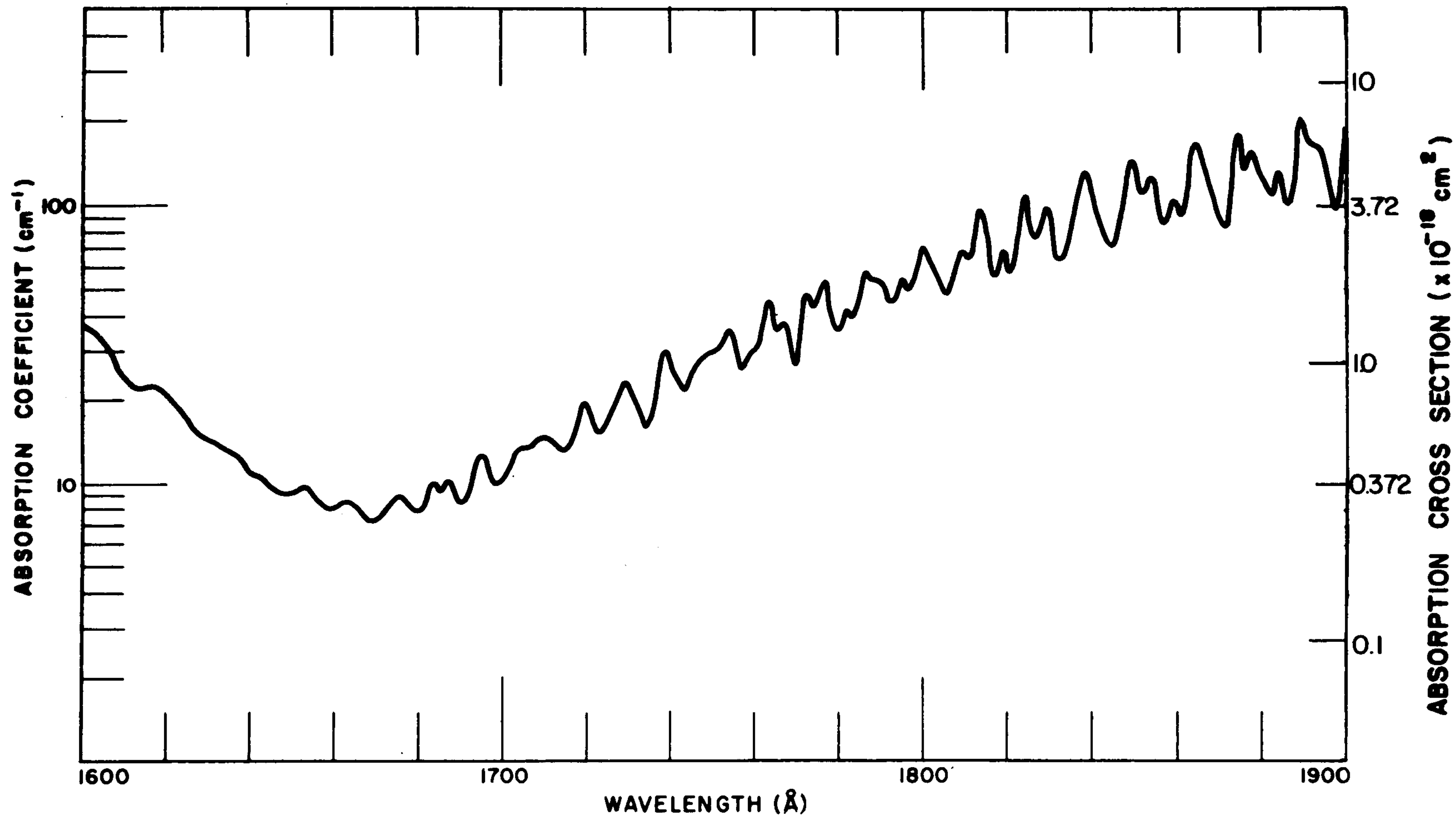


Figure 51. Absorption coefficients and cross sections of SO_2.
λ = 1600Å to λ = 1900Å
Method: Photoelectric detection
Ref: D. Golomb, et al., J. Chem. Phys. 36, 958 (1962)
Experimental error: 10%

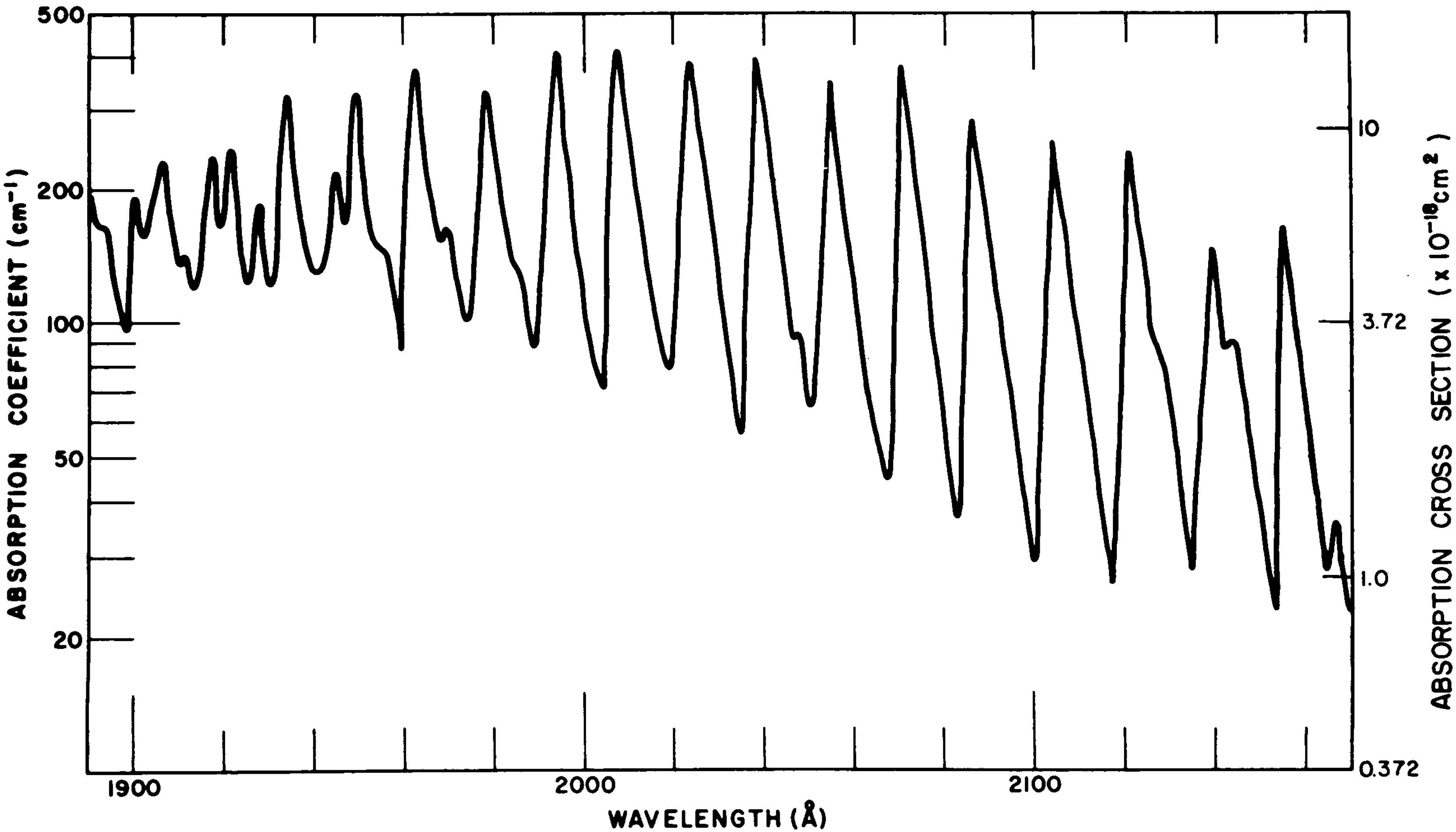


Figure 52. Absorption coefficients and cross sections of SO_2.
λ = 1890Å to λ = 2170Å
Method: Photoelectric detection
Ref: D. Golomb, et al., J. Chem. Phys. 36, 958 (1962)
Experimental error: 10%

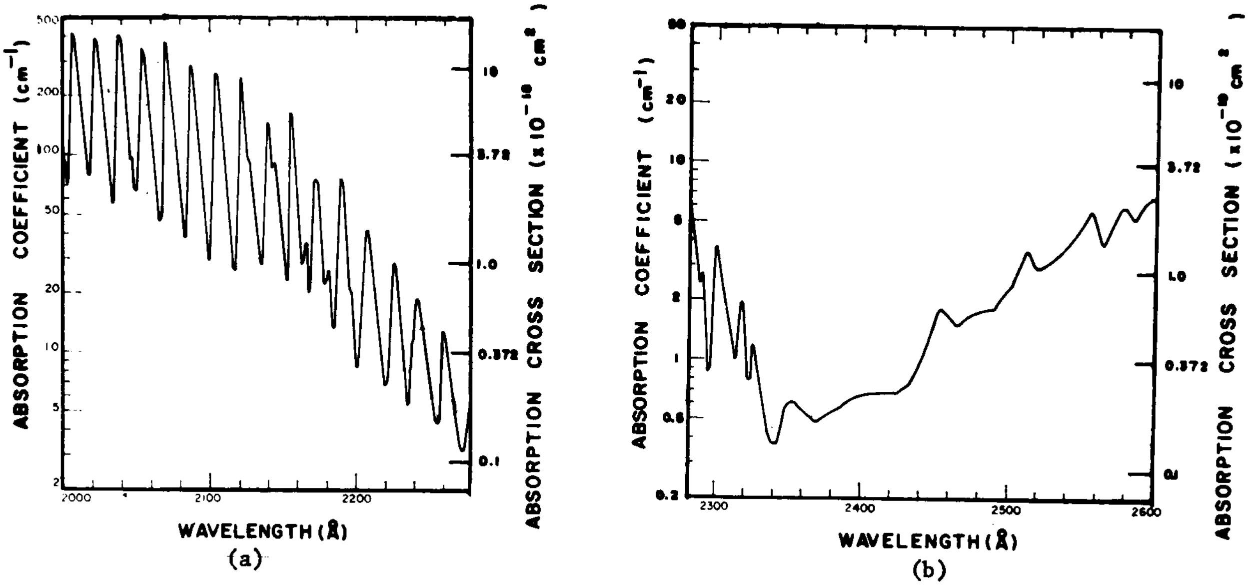


Figure 53. Absorption coefficients and cross sections of SO_2.
λ = 2000Å to λ = 2600Å
Method: Photoelectric detection
Ref: Warneck, et al., J. Chem. Phys. 40, 1132 (1964)

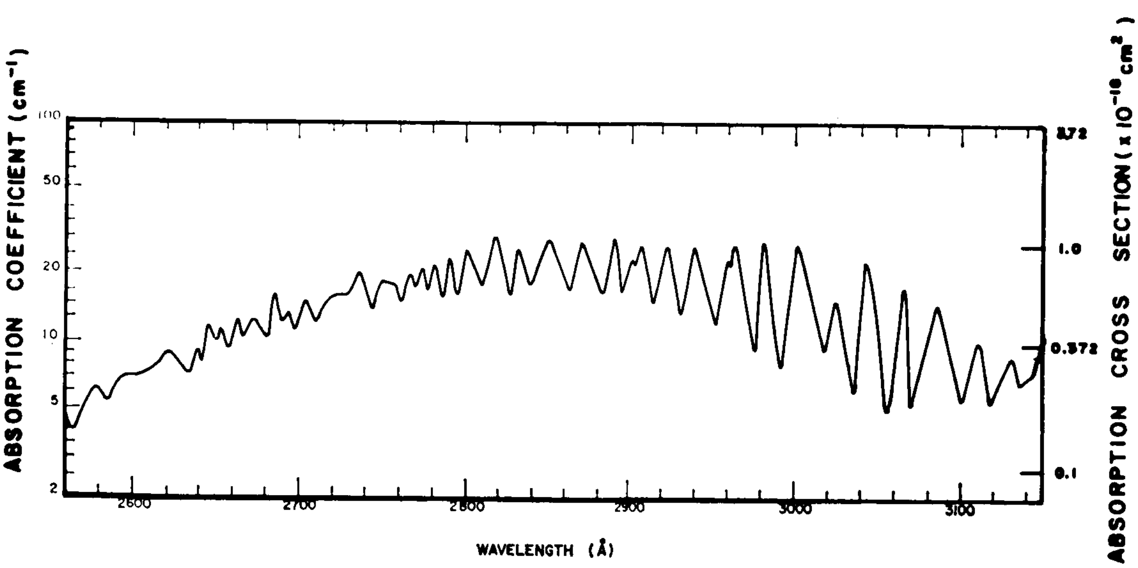


Figure 54. Absorption coefficients and cross sections of SO_2.
λ = 2560Å to λ = 3150Å
Method: Photoelectric detection
Ref: Warneck, et al., J. Chem. Phys. 40, 1132 (1964)

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