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by

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FOREWORD

Aeronomic problems of molecular oxygen photodissociation - IV. "The various parameters for the Herzberg continuum" will be published in Planetary Space Science, volume 36, 1988.

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Aeronomic problems of molecular oxygen photodissociation - IV. "The various parameters for the Herzberg continuum", sera publié dans Planetary Space Science, volume 36, 1988.

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AERONOMIC PROBLEMS OF MOLECULAR OXYGEN PHOTODISSOCIATION - IV. THE VARIOUS PARAMETERS FOR THE HERZBERG CONTINUUM

by

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Abstract

Stratospheric conditions of direct photodissociation of molecular oxygen by solar radiation in the 202-242 nm wavelength range have been determined after introduction of the more recent aeronomic parameters : solar irradiances of SUSIM from Spacelab 2, O_2 absorption cross sections, molecular scattering cross sections and O_3 absorption cross sections. The O_2 photodissociation frequency has a maximum of 5.8×10^{-10} s^{-1}, becomes about 5.3×10^{-10} s^{-1} at the stratopause and reaches an isophotolytic level at 5×10^{-12} s^{-1} for any variation in the adopted O_2 absorption cross section. The accuracy of the O_3 absorption cross section should be better than $\pm$ 2.5 % particularly in the 202 - 220 nm wavelength range to reduce the errors in the O_2 photodissociation rates at low stratospheric levels to less than $\pm$ 10%.

Résumé

Les conditions stratosphériques de la photodissociation directe de l'oxygène moléculaire par la radiation solaire dans le domaine de longueur d'onde de 202-242 nm ont été déterminées en utilisant les paramètres aéronomiques plus récents : irradiances solaires de SUSIM de Spacelab 2, sections efficaces d'absorption de O_2, sections efficaces de la diffusion moléculaire et sections efficaces d'absorption de O_3. La fréquence de photodissociation de O_2 débute par le maximum correspondant à 5.8×10^{-10} s^{-1}, est de l'ordre de 5.3×10^{-10} s^{-1} à la stratopause et atteint une valeur isophotolytique à 5×10^{-12} s^{-1} pour toute variation imposée à la section efficace d'absorption de O_2 adoptée. Le degré de précision de la section efficace d'absorption de O_3 devrait être supérieur à $\pm$ 2.5%, en particulier dans le domaine de longueurs d'onde 202 à 220 nm, afin de réduire à moins de $\pm$ 10% les erreurs des fréquences de photodissociation de O_2 dans la stratosphère inférieure.

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Samenvatting

De stratosferische toestand van de rechtstreekse fotodissociatie van moleculaire zuurstof door de zonnestraling in het golflengtegebied van 202 - 242 nm werden bepaald na invoering van de recentere aëronomische parameters : zonnestralingssterkte van SUSIM afkomstig van Spacelab 2, werkzame absorptiedoorsneden van O_2, werkzame doorsneden voor moleculaire verstrooiing en werkzame absorptiedoorsneden van O_3. De fotodissociatiefrequentie van O_2 heeft een maximum bij 5.8×10^{-10} s^{-1}, bedraagt ongeveer 5.3×10^{-10} s^{-1} aan de stratopauze en bereikt een isofotolytisch niveau bij 5×10^{-12} s^{-1} voor elke variatie van de gebruikte werkzame absorptiedoorsnede van O_2. De nauwkeurigheid van de werkzame absorptiedoorsnede van O_3 zou beter moeten zijn dan $\pm$ 2.5%, in het bijzonder in het golflengtegebied van 202 - 220 nm, teneinde de fouten in de fotodissociatiefrequenties van O_2 in de lage stratosfeer tot minder dan $\pm$ 10% te herleiden.

Zusammenfassung

Die stratosphärische Verhältnisse der direkten Photodissoziation des molekularen Sauerstoffes durch die Sonnenstrahlung in dem Wellenlängengebiet 202 - 242 nm wurden nach Einführung der neuesten aeronomischen Parametern : Sonnenstrahlungsdichten nach SUSIM von Spacelab 2, effektive O_2 Absorptionsquerschnitten, effektive Querschnitten der molekularen Diffusion und effektive O_3 Absorptionsquerschnitten bestimmt. Die O_2 Photodissoziationsfrequenz beginnt mit einem Maximalwert gleich ungefähr 5.8×10^{-10} s^{-1}, wird 5.3×10^{-10} s^{-1} an der Stratopause und erreicht in der mittleren Stratosphäre ein isophotolytisches Niveau von 5×10^{-12} s^{-1} unabhängig von der gebrauchten effektiven O_2 Absorptionsquerschnitten. Die Messgenauigkeit der effektiven O_3 Absorptionsquerschnitten söllte besser sein als $\pm$ 2.5%, besonders in dem Wellenlängengebiet 202 - 220 nm, um die Fehler der Photodissoziationsrate in der unteren Stratosphäre unterhalb $\pm$ 10% zu reduzieren.

1. INTRODUCTION

In a recent paper (Nicolet and Kennes, 1987), we have made an analysis of the aeronomic conditions related to oxygen photodissociation in the region of the Herzberg continuum. This study was based on various parameters available in 1986 : solar spectral irradiances, molecular oxygen absorption cross sections, molecular scattering absorption cross sections and ozone absorption cross sections. The observational and experimental data available at the present time require another analysis. The purpose of this paper is, therefore, to determine the photodissociation of molecular oxygen in the spectral region of the Herzberg continuum with the introduction of the latest aeronomic parameters.

2. DATA BASE DESCRIPTION

Spectral irradiances in the 240 - 200 nm region have been discussed in a recent paper (Nicolet and Kennes, 1988). The spectral irradiances adopted here are deduced from the SUSIM data (Solar Ultraviolet Spectral Irradiance Monitor) obtained in Spacelab 2 with a 0.15 nm bandpass (personal communication, Van Hoosier et al., to be published 1988). They correspond to the most recent data (see Nicolet and Kennes, 1988) with a systematic difference ranging from - 10% to + 10% and random errors of about $\pm$ 10%. The adopted irradiances are given in Table I in intervals of 500 cm^{-1}. The atmospheric scattering cross sections σ_{MS} are determined by the formula obtained by Nicolet (1984), from a re-evaluation of the air scattering cross section by Bates (1984),

$$\sigma_{MS} = 4.02 \times 10^{-18} \, (\nu/10^4)^{4 + x} \qquad (1)$$

where

$$x = 9.426\, \nu + 3.89 \times 10^3/\nu - 0.3228 \qquad (2)$$

and ν in cm^{-1}.

TABLE 1.- Solar spectral irradiances for $\Delta\nu = 500\ cm^{-1}$ and corresponding attenuation cross-sections in the spectral region of the Herzberg continuum of O_2.

Spectral Interval (cm^{-1})	Photons * Number ($cm^{-2}s^{-1}$)	O_2 Cross section (cm^2)	(O_2) ** Scattering (cm^2)	Molecular Scattering (cm^2)	O_3 *** Cross section (cm^2)
41250 - 41500	1.67×10^{13}	1.03×10^{-24}	0.72×10^{-24}	1.50×10^{-25}	8.60×10^{-18}
41500 - 42000	1.40	1.23	0.74	1.54	8.09
42000 - 42500	1.60	1.54	0.78	1.63	6.98
42500 - 43000	1.33	1.88	0.83	1.72	5.91
43000 - 43500	1.55	2.27	0.87	1.82	4.92
43500 - 44000	1.38	2.69	0.92	1.92	4.03
44000 - 44500	1.29	3.15	0.97	2.02	3.23
44500 - 45000	1.59	3.63	1.02	2.13	2.56
45000 - 45500	1.20	4.12	1.07	2.24	2.00
45500 - 46000	1.11×10^{13}	4.62	1.13	2.36	1.55
46000 - 46500	8.63×10^{12}	5.12	1.19	2.49	1.19×10^{-18}
46500 - 47000	8.96	5.60	1.26	2.62	9.11×10^{-19}
47000 - 47500	7.73	6.04	1.32	2.75	6.99
47500 - 48000	4.84	6.44	1.39	2.90	5.43
48000 - 48500	2.88	6.79	1.46	3.05	4.35
48500 - 49000	2.41	7.08	1.54	3.20	3.64
49000 - 49500	1.92×10^{12}	7.30×10^{-24}	1.61×10^{-24}	3.36×10^{-25}	3.26×10^{-19}

(*) Solar irradiances at the top of the Earth's atmosphere. See text.

(**) Molecular scattering corresponding to formula . See text.

(***) Ozone absorption. See text.

In order to make a direct comparison with the O_2 absorption cross sections, the atmospheric scattering cross section may be converted for use with the toal number of O_2 molecules, i.e.

$$\sigma_{MS}(O_2)_{EQU} = [n(M)/n(O_2)]\ \sigma_{MS}(M) = 4.8 \times \sigma_{MS} \qquad (3)$$

where n(M) and $n(O_2)$ are the atmospheric total and molecular oxygen number densities (cm^{-3}), respectively. The numerical values for invervals of 500 cm^{-1} are also given in Table 1 and may be compared with the O_2 absorption cross sections.

The O_3 cross sections used in this calculation were taken from the measurements made by Molina and Molina (1986), and the adopted values for intervals of 500 cm^{-1} are also given in Table I.

Finally, the adopted absorption cross sections for O_2 were deduced from the following formula, which will be discussed later,

$$\sigma_{HER}(O_2) = 7.5 \times 10^{-24} \exp\{-50\ [\ln(\nu/5 \times 10^4)^2]\} \qquad (4)$$

and the numerical values are also shown in Table I. However, the spectral range of the Herzberg continuum will be limited here from 41250 cm^{-1} to 49500 cm^{-1}, since the 500 cm^{-1} interval 50000 - 49500 cm^{-1} corresponds also to the predissociated 1 - 0 band of the Schumann-Runge system. Its additional photodissociation cannot be neglected and is included in the O_2 predissociated region 57000 - 49500 cm^{-1}.

THE HERZBERG CONTINUUM

In our preceeding analysis (Nicolet and Kennes, 1986) we discussed the experimental and theoretical results obtained between 1984 and 1986 : the laboratory determinations of Johnston et al. (1984), of Cheung et al. (1986) and Jenouvrier et al. (1986), the theoretical determinations of Saxon and Slanger (1986). The stratospheric determinations of Herman and Mentall (192) were also considered. At the present time, we can add the

the results deduced from stratospheric observations by Anderson and Hall (1986 and 1988 unpublished) based on different O_3 absorption cross sections (Inn and Tannaka, 1959 or Molina and Molina, 1986). Unpublished laboratory determinations by the Harvard-Smithsonian group and the Reims group (private communication) may be also considered.

All the various observational, experimental and theoretical data are illustrated in Fig. 1. It is clear that the O_2 absorption cross section varies with an accuracy better than $\pm$ 10% from about 1 x 10^{-24} cm^2 at the threshold near 41250 cm^{-1} to about 7.5 x 10^{-24} cm^2 near 49500 cm^{-1} if all the data are included. It should be noticed (Anderson and Hall, private communication) that an analysis based on stratospheric irradiances obtained at 40 km and on different O_3 absorption cross sections (Inn and Tanaka or Molina and Molina) may lead to different interpretations. The observations marked Bedford (1986) or (1987) in Fig. 1 show the possible differences related to the adoption of two different O_3 cross sections in the stratospheric determination of the O_2 absorption cross section.

Thus, the various available sets of Herzberg continuum cross sections derived from various observational, experimental and theoretical determinations lead us to adopt formula (4) to determine the required numerical values in the whole spectral range 41000 - 55000 cm^{-1}.

O_2 PHOTODISSOCIATION RATES

The O_2 photodissociation frequency at the top of the Earth's atmosphere for the spectral range 49500 - 41250 cm^{-1} is 5.8 x 10^{-10} s^{-1} when the aeronomic parameters given in Table 1 are adopted. The atmospheric absorption is negligible above the mesopause, and

$$J_{HER}(O_2)\ 85\ km = 5.8 \times 10^{-10}\ s^{-1} \qquad (6)$$

If we adopt the standard model as described in Table 2 by Nicolet and Kennes (1986) it can be seen that the atmospheric absorption by O_2

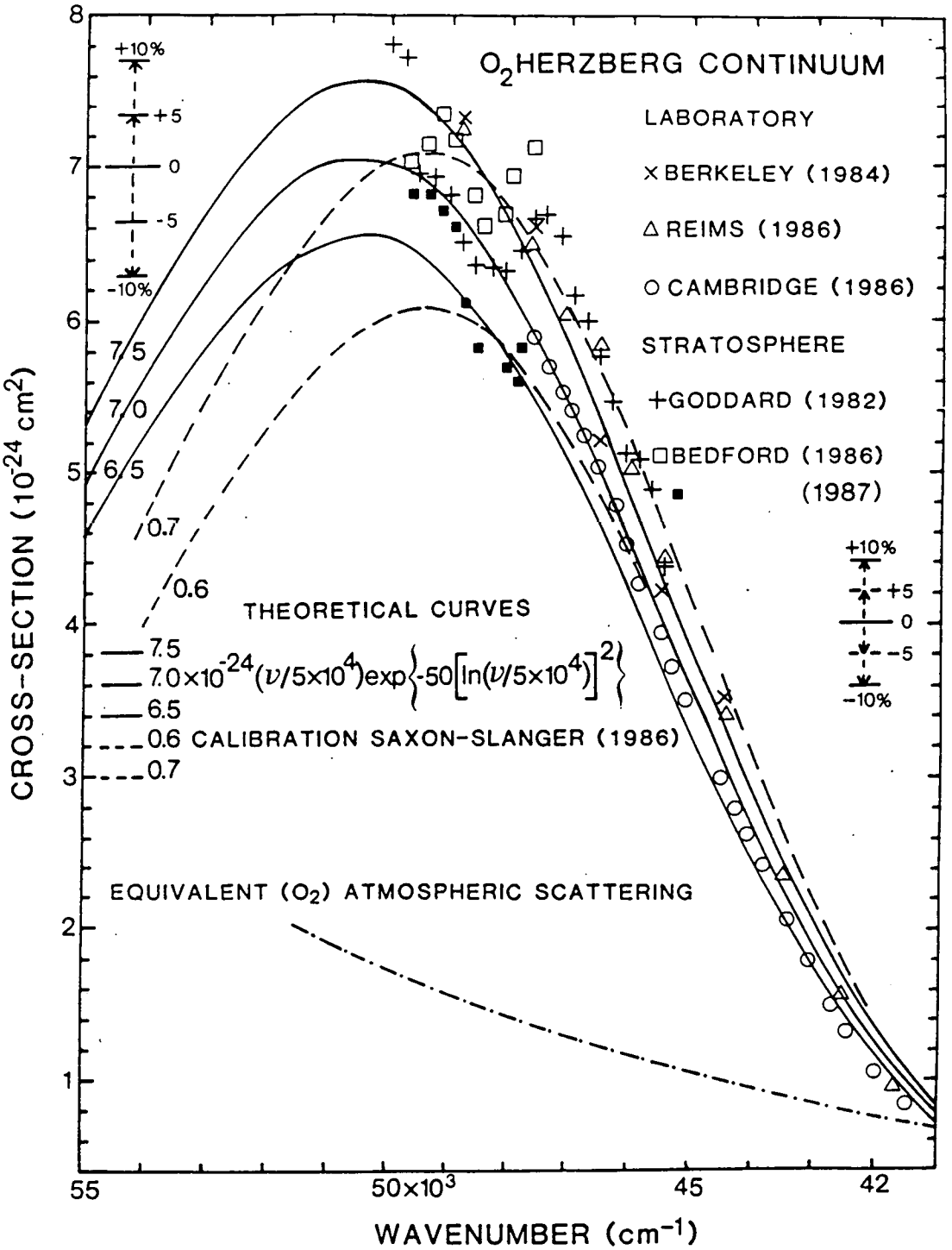

Fig. 1.- Absorption cross sections (cm^2) of the Herzberg continuum : Observational and experimental data, and theoretical results; see text, and Nicolet and Kennes (1986) for all references.

and O_3 begins only below 70 km and must be taken into account above the stratopause between 50 km and 60 km. For an overhead sun, the O_2 photodissociation frequency $J_{HER}(O_2) = 5.7 \times 10^{-10}$ s^{-1} without ozone absorption at 50 km and decreases only to 5.3×10^{-10} s^{-1} when the ozone effect is included.

There is an isophotolytic level in the photodissociation frequency $J_{HER}(O_2)$, i.e. a constant value for $J(O_2)$ even when the adopted cross sections of O_2 are different (Nicolet and Kennes, 1986). We have determined the aeronomic conditions (Fig. 2) for various solar zenith angles (sec χ = 1 to 4) for differences in the O_2 cross sections of $\pm$ 5% and $\pm$ 10%, respectively. Various values indicating the possible differences between 35 km and 20 km show clearly that the isophotolytic level corresponds to an O_2 photodissociation frequency

$$J_{HER}(O_2) = 5 \times 10^{-12} \ s^{-1} \qquad (7)$$

a value of the order of 10 times less than the maximum value (6). Figures 3, 4 and 5 illustrate the details of the differences (%) in the abscissa scale of $J_{HER}(O_2)$ with the variations of $\pm$ 5% and $\pm$ 10% in the O_2 cross sections for 3 solar zenith angles sec χ = 1,2 and 4, respectively. The slope of the curves changes from positive to negative (or vice versa), at the isophotolytic level, $J_{HER}(O_2) = 5 \times 10^{-12}$ s^{-1}. The differences in $J(O_2)$ become greater than the differences in the cross sections when $J(O_2)$ reaches about 10^{-13} s^{-1}, a value which corresponds in fact to a small photodissociation rate as indicated in Table 2, i.e. to a dissociation rate of less than 5×10^4 O_2 molecules cm^{-3} s^{-1}, practically a negligible number at low levels, in the lower stratosphere where the transport processes are more important.

Table 2 shows also that at 55 km the O_2 photodissociation rate is 1.30×10^6 molecules cm^{-3} s^{-1} ($\pm$ 5%), an almost constant rate between sec χ = 1 (overhead sun) to sec χ = 4. This corresponds to an atomic oxygen production in 10^4 seconds of about 2.5×10^{10}, i.e. a value similar to the observed O_3 number density at this altitude.

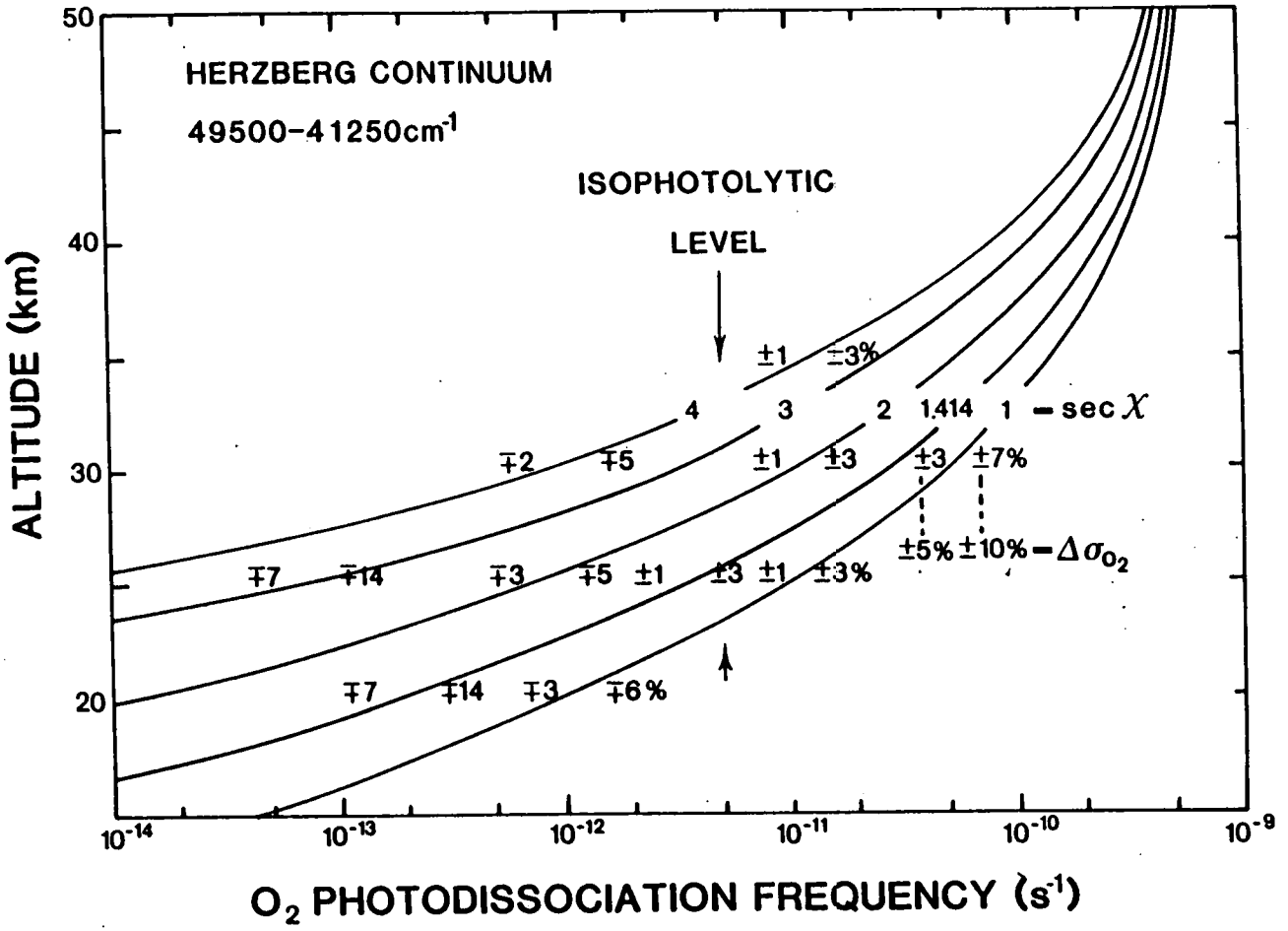

Fig. 2.- Stratospheric photodissociation frequency (s^{-1}) of O_2 for the 49500 - 41250 cm^{-1} interval.
Photodissociation frequencies deduced for atmospheric model conditions at solar zenith angles χ corresponding to sec χ = 1, 1.414, 2, 3, and 4, respectively. Effects on $J(O_2)$ of differences of $\pm$ 5% or $\pm$ 10% in the O_2 cross sections indicated at various altitudes. Isophotolytic levels at $J(O_2) = 5 \times 10^{-12}$ s^{-1} shown.

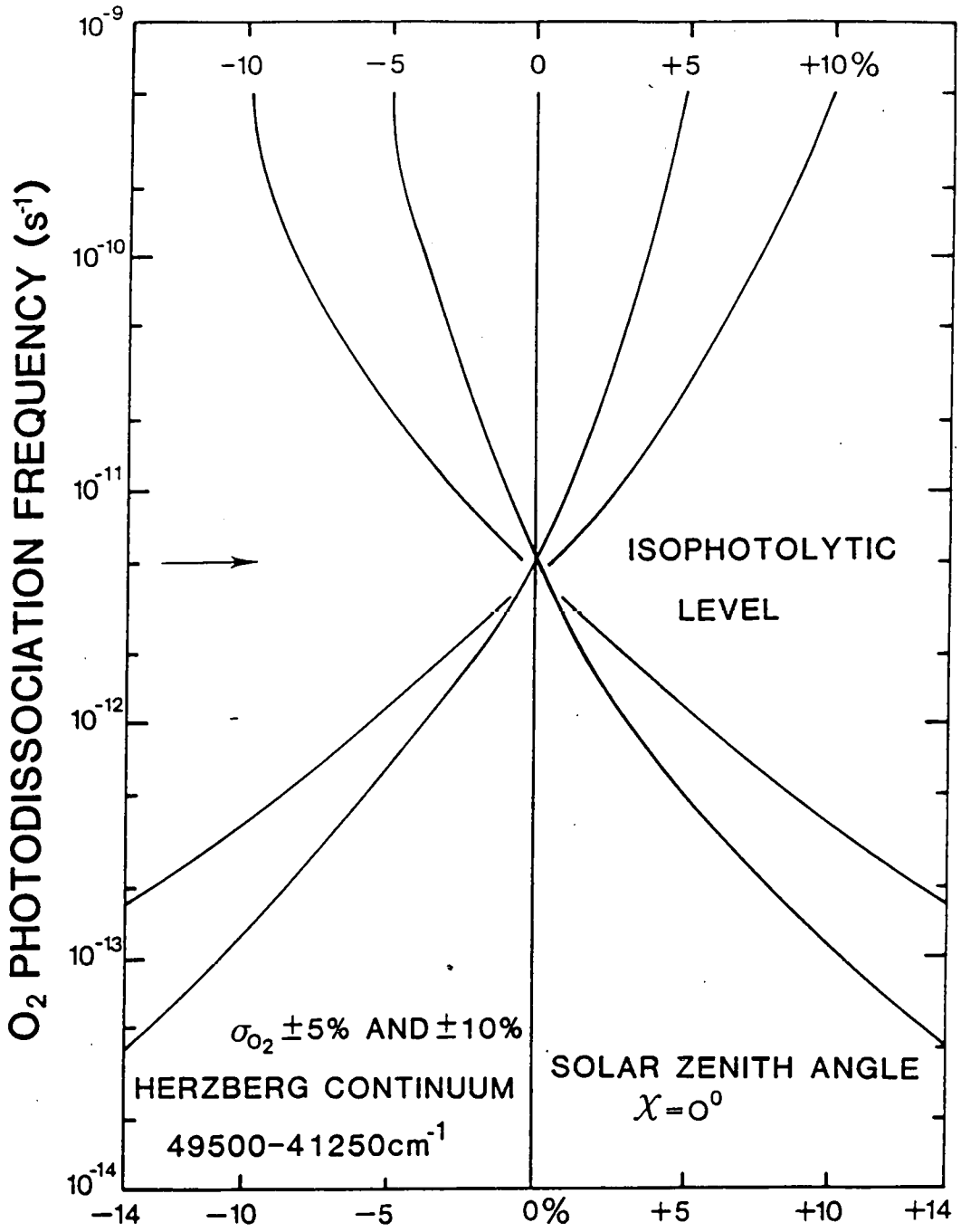

Fig. 3.- Stratospheric variations of the photodissociation frequency for differences in the O_2 absorption cross sections. Sec χ = 1. From small optical depths at $J(O_2) = 5 \times 10^{-10}$ s^{-1} with identical differences - 10%, - 5%, + 5% and + 10% in O_2 photodissociation frequencies and absorptions cross sections, variations to + 10%, + 5%, - 5% and - 10% near $J(O_2) = 10^{-13}$ s^{-1} through an isophotolytic level at $J(O_2) = 5 \times 10^{-12}$ s^{-1} with all differences = 0%.

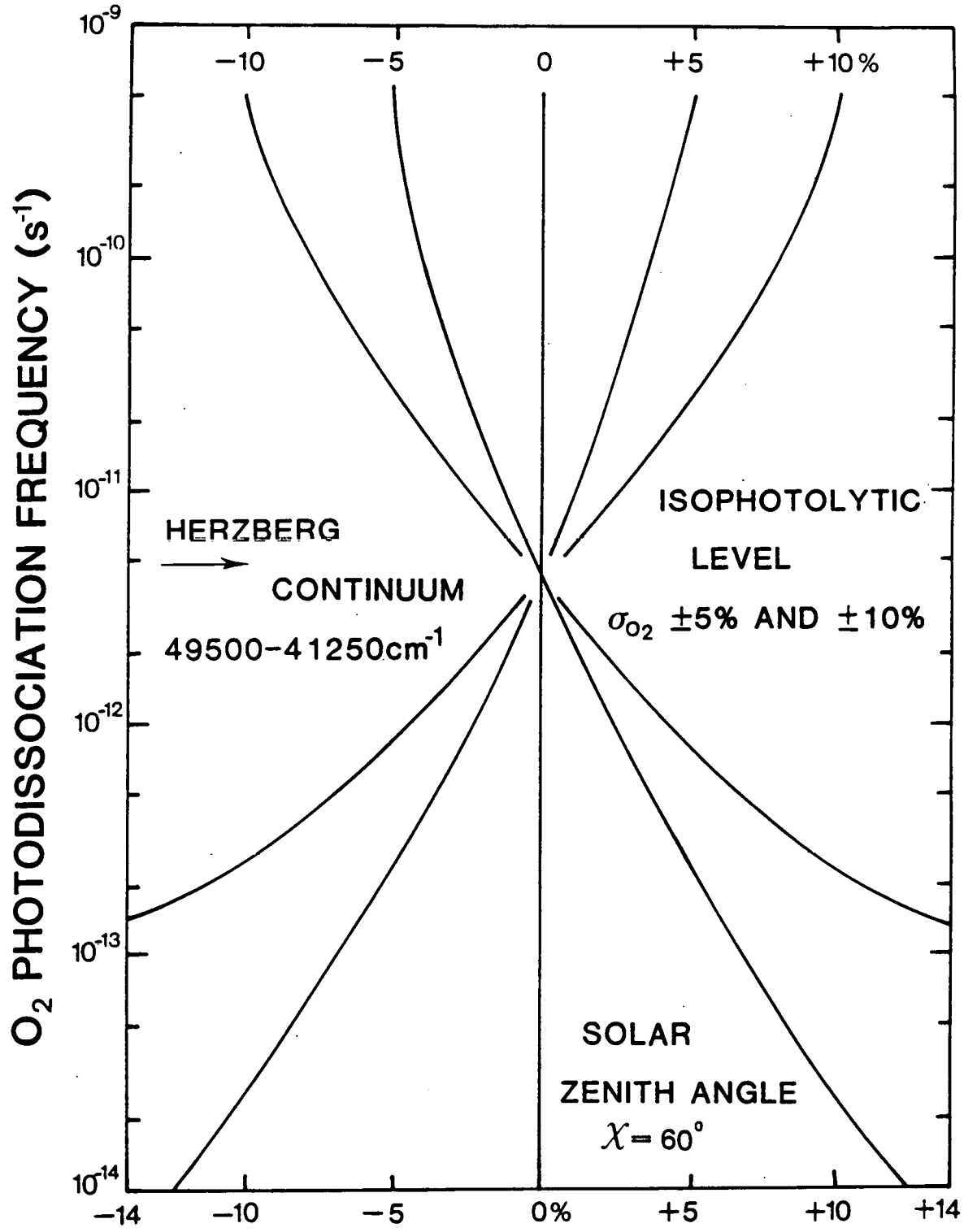

Fig. 4.- Stratospheric variations of the photodissociation frequency for differences in the O_2 absorption cross sections. Sec χ = 2. As for fig. 3.

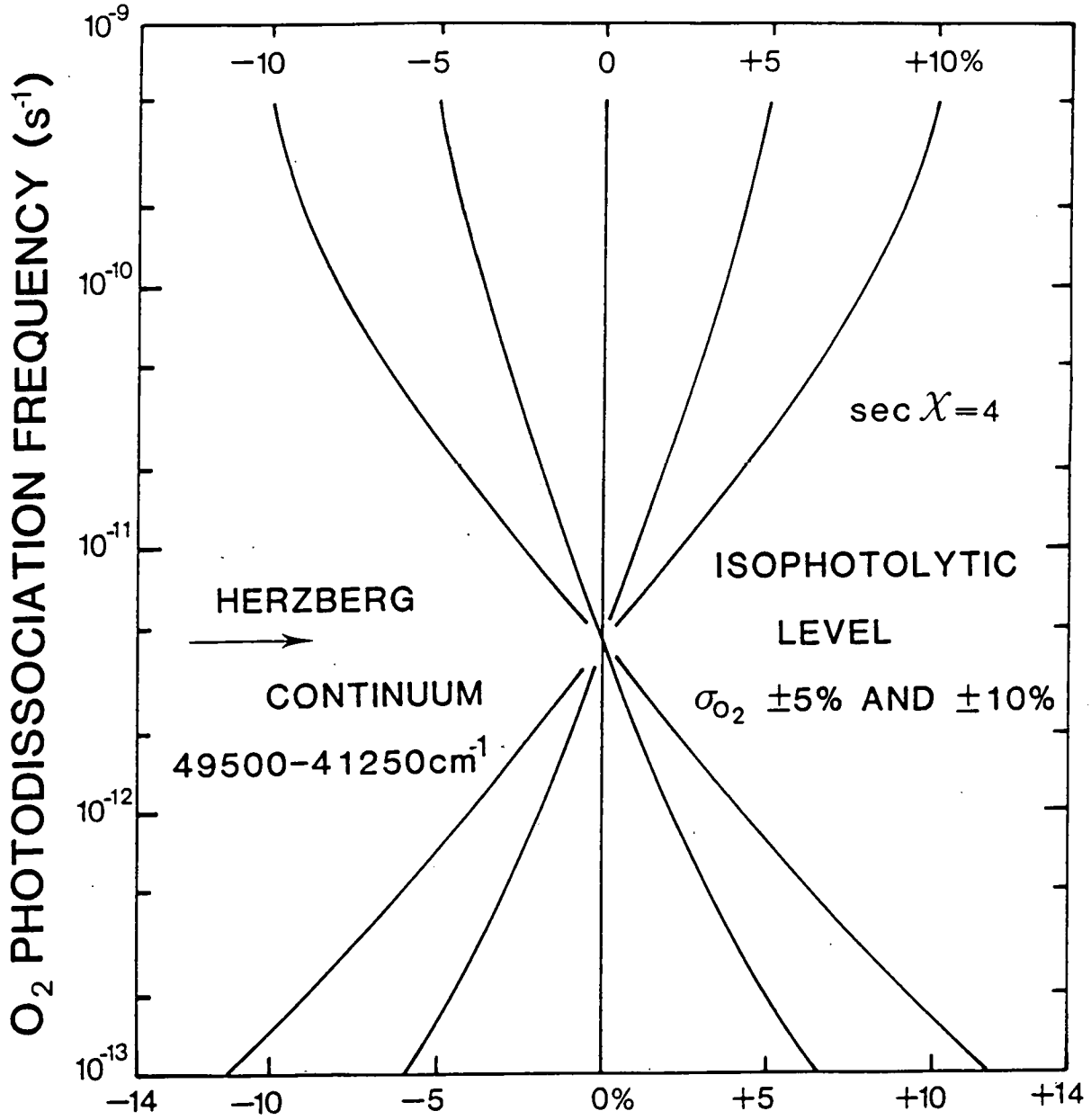

Fig. 5.- Stratospheric variations of the photodissociation frequency for differences in the O_2 absorption cross sections Sec χ = 4. As for Fig. 3 and 4.

TABLE 2.- O_2 photodissociation frequency (s^{-1}) and photodissociation rates ($cm^{-3}\ s^{-1}$) in the 41250 - 49500 cm^{-1} region of the Herzberg Continuum.

Altitude (km)	Photodissociation frequency and rates	sec χ = 1	1.414	2	3	4
60	$J(O_2)$	5.71×10^{-10}	5.68×10^{-10}	5.63×10^{-10}	5.56×10^{-10}	5.48×10^{-10}
	$n(O_2) \cdot J(O_2)$	7.59×10^{5}	7.55×10^{5}	7.49×10^{5}	7.39×10^{5}	7.29×10^{5}
55	"	5.58×10^{-10}	5.50×10^{-10}	5.39×10^{-10}	5.20×10^{-10}	5.02×10^{-10}
		1.36×10^{6}	1.34×10^{6}	1.31×10^{6}	1.27×10^{6}	1.23×10^{6}
50	"	5.25×10^{-10}	5.05×10^{-10}	4.79×10^{-10}	4.37×10^{-10}	4.01×10^{-10}
		2.35×10^{6}	2.26×10^{6}	2.14×10^{6}	1.96×10^{6}	1.79×10^{6}
45	"	4.45×10^{-10}	4.03×10^{-10}	3.53×10^{-10}	2.86×10^{-10}	2.36×10^{-10}
		3.81×10^{6}	3.45×10^{6}	3.02×10^{6}	2.45×10^{6}	2.02×10^{6}
40	"	2.97×10^{-10}	2.39×10^{-10}	1.82×10^{-10}	1.21×10^{-10}	8.39×10^{-11}
		5.17×10^{6}	4.16×10^{6}	3.16×10^{6}	2.10×10^{6}	1.46×10^{6}
35	"	1.42×10^{-10}	9.59×10^{-11}	5.87×10^{-11}	2.79×10^{-11}	1.42×10^{-11}
		5.22×10^{6}	3.50×10^{6}	2.16×10^{6}	1.03×10^{6}	5.23×10^{5}
30	"	4.99×10^{-11}	2.58×10^{-11}	1.10×10^{-11}	2.93×10^{-12}	8.43×10^{-13}
		4.00×10^{6}	2.07×10^{6}	8.85×10^{5}	2.34×10^{5}	6.76×10^{4}
25	"	1.05×10^{-11}	3.39×10^{-12}	7.58×10^{-13}	6.80×10^{-14}	6.70×10^{-15}
		1.83×10^{6}	5.90×10^{5}	1.32×10^{5}	1.18×10^{4}	1.17×10^{3}
20	"	1.06×10^{-12}	1.52×10^{-13}	1.10×10^{-14}	1.43×10^{-16}	2.03×10^{-18}
		4.09×10^{5}	5.00×10^{4}	4.23×10^{3}	5.54×10^{1}	7.85×10^{-1}
15	"	3.93×10^{-14}	1.52×10^{-15}	1.69×10^{-17}	8.91×10^{-21}	5.08×10^{-24}
		3.34×10^{4}	1.29×10^{3}	1.43×10^{1}	7.55×10^{-3}	4.31×10^{-6}

An illustration of the total photodissociation rates of O_2 from 55 km to 20 km is given in Fig. 6 after the introduction of the effect of the spectral region of the Schumann-Runge bands (see a subsequent paper). This figure shows that the O_2 photodissociation rate is near 2×10^6 molecules cm^{-3} s^{-1} corresponding to an oxygen production of 4×10^{10} atoms in 10^4 seconds at 55 km.Their association with O_2 molecules would lead to an equivalent production of O_3 molecules. Thus, the photochemical equilibrium conditions should be studied with particular attention between 50 and 60 km and the ozone concentrations should be established with great accuracy at atmospheric levels in the neighbourhood of the stratopause, particularly in the tropical regions.

THE ACCURACY OF THE O_3 ABSORPTION CROSS SECTION

The O_2 photodissociation frequency in the stratosphere depends strongly on the accuracy of the O_3 cross section in the 242 - 202 nm region. The results of an effect of differences of $\pm$ 2.5% and $\pm$ 5% in the O_3 cross sections are illustrated in Fig. 7. It is clear (Table 3) that the effect of such differences in the upper stratosphere is very small but increases rapidly from 35 km to the lower stratosphere. Numerical values given in Table 3 show that for a variation $\pm$ 5% in the O_3 absorption cross section yield a variation of $\pm$ 10% when $J(O_2)$ is of the order of 10^{-11} s^{-1} above the isophotolytic level (5×10^{-12} s^{-1}). When $J(O_2)$ is about 10^{-12} s^{-1} and 10^{-13} s^{-1} the differences increase up to 15% and to more than 20%, respectively. Thus, it seems that the accuracy of the O_3 cross sections should be better than $\pm$ 2.5% for a correct determination of $J(O_2)$ in the lower stratosphere. A comparison between the absorption cross sections of Inn and Tanaka (1959) given at 1 nm intervals between 200.2 nm and 228.2 nm and those of Molina and Molina (1986) given at 0.5 nm intervals is depicted in Fig. 8 and 9. From these two figures it can be concluded that there is a systematic difference beginning near 202 nm to at least 220 nm where there is (220.2 nm) a discontinuity in the curve deduced from the experimental results of Inn and Tanaka (1959). On the other hand, if the part of the spectrum corresponding to the effective O_2 photodissociation rate in the lower

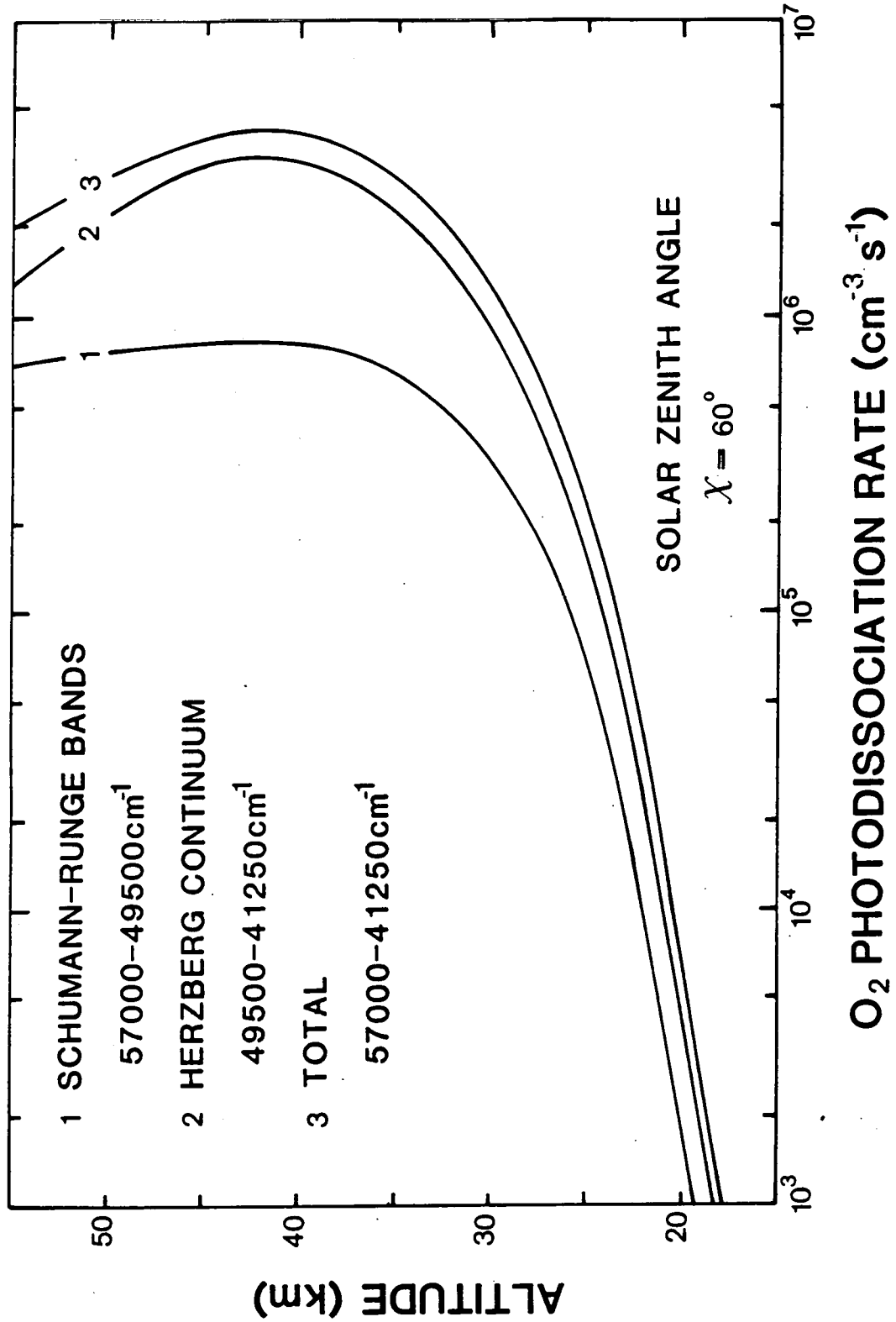

Fig. 6 - Stratospheric photodissociation rates (cm^{-3} s^{-1}) of O_2 at 60° solar zenith angle.
Total photodissociation rates corresponding to the Herzberg continuum and Schumann-Runge bands.

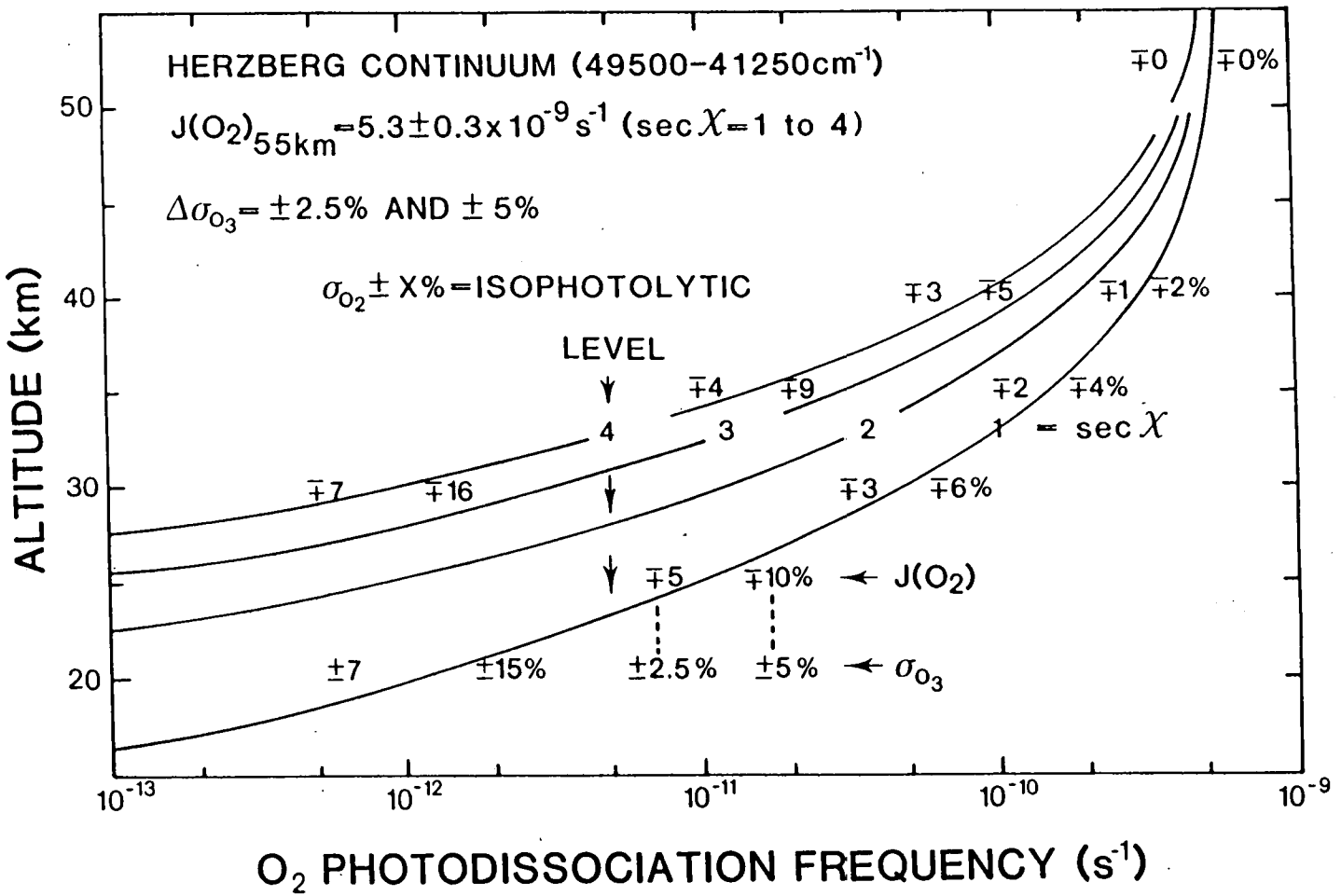

Fig. 7.- Stratospheric photodissociation frequency (s^{-1}) of O_2 and associated differences in O_3 cross sections.
From small optical depths (55 km), where variations in $J(O_2)$ = $\mp$ 0% for differences of - 5%, - 2,5%, + 2,5% and 5% in O_3 cross sections to important variations of more than $\pm$ 10% of $J(O_2)$ in lower stratosphere. See also table 3.

TABLE 3.- Stratospheric effect of the O_2 photodissociation frequency of differences of $\pm$ 2.5% and $\pm$ 5% in the absolute absorption cross section of O_3

Altitude (km)	Sec χ = 1		Sec χ = 2		Sec χ = 3		Sec χ = 4	
	$\pm$ 2.5%	$\pm$ 5%	$\pm$ 2.5 %	$\pm$ 5%	$\pm$ 2.5%	$\pm$ 5%	$\pm$ 2.5%	$\pm$ 5%
50	$\pm$ 0%	$\pm$ 0%	$\pm$ 0%	$\pm$ 1%	$\pm$ 0 %	$\pm$ 1%	$\pm$ 1%	$\pm$ 1%
45	$\pm$ 0	$\pm$ 0	$\pm$ 1	$\pm$ 2	$\pm$ 1	$\pm$ 2	$\pm$ 2	$\pm$ 3
40	$\pm$ 1	$\pm$ 2	$\pm$ 2	$\pm$ 3	$\pm$ 2	$\pm$ 4	$\pm$ 3	$\pm$ 5
35	$\pm$ 2	$\pm$ 4	$\pm$ 3	$\pm$ 6	$\pm$ 4	$\pm$ 8	$\pm$ 4	$\pm$ 9
30	$\pm$ 3	$\pm$ 6	$\pm$ 5	$\pm$ 10(*)	$\pm$ 6	$\pm$ 13(*)	$\pm$ 7	$\pm$ 10(*)
25	$\pm$ 6	$\pm$ 10(*)	$\pm$ 8	$\pm$ 16(**)	$\pm$ 11	$\pm$ 23	$\pm$ 14	$\pm$ 30
20	$\pm$ 7	$\pm$ 15(**)	$\pm$ 12	$\pm$ 26				
15	$\pm$ 9	$\pm$ 18						

(*)$J(O_2) = 1 \times 10^{-11}$ (*)$J(O_2) = 1 \times 10^{-11}$ (*)$J(C_2) = 3 \times 10^{-12}$ (*)$J(O_2) = 8 \times 10^{-13}$

(**) $= 1 \times 10^{-12}$ (**) $= 8 \times 10^{-13}$

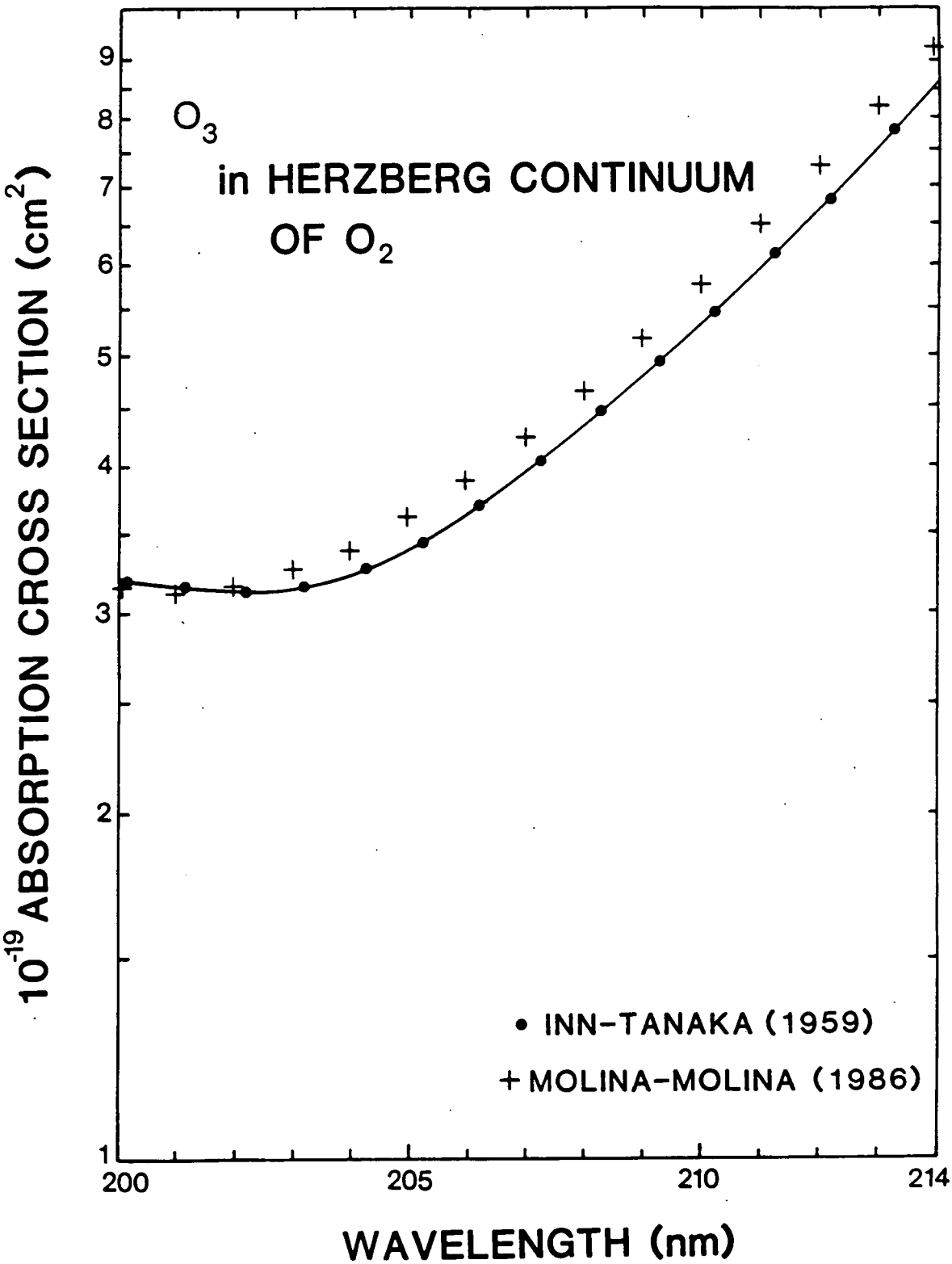

Fig. 8.- O_3 absorption spectrum between 200 and 214 nm.

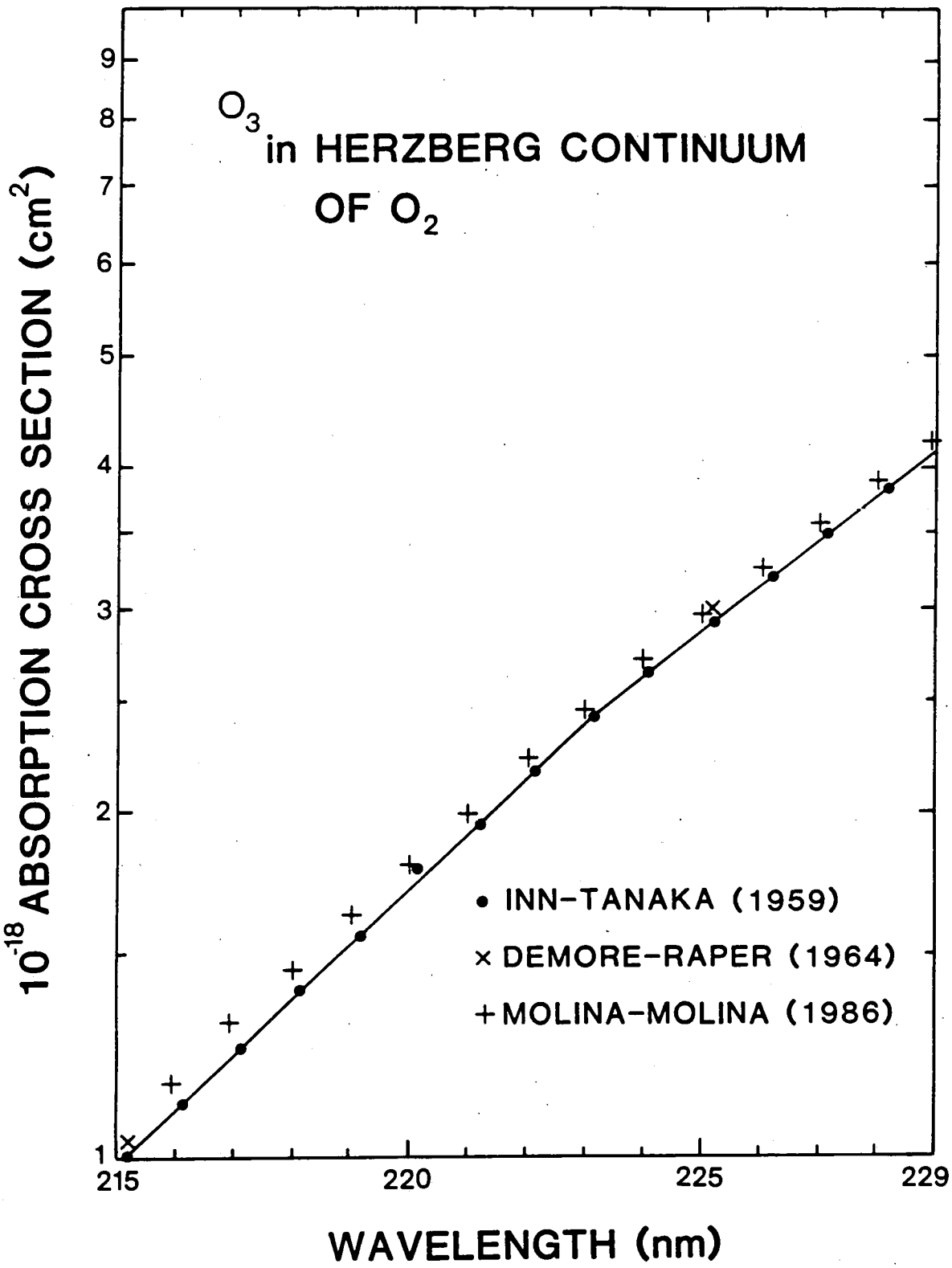

Fig. 9.- O_3 absorption spectrum between 215 and 229 nm.

stratosphere, where the absolute value of the O_3 absorption cross section plays a leading role, is considered (Table 4), it must be concluded that it is associated with the spectral interval where there is maximum difference between the O_3 cross sections of Molina and Molina and of Inn and Tanaka. The differences are reflected by the O_2 absorption cross sections reproduced in Fig. 1 as Bedford (1986) and (1987) from the analysis of Anderson and Hall. Table 4 shows that the wavelength interval which plays a major role in the photodissociation at and below 35 km, belongs to the spectral range between 220 and 202 nm. A comparison between the numerical results given in Table 3 and 4 shows that the O_2 photodissociation frequency cannot be less than 10^{-13} s^{-1} to be certain that, for a difference of 2.5% in the O_3 cross section, the error in the photodissociation rate will not be more than 10%. The atmospheric optical depth (see Table 4) must be less than 7, i.e. an atmospheric transmittance not less than 10^{-3} in which the role of the ozone absorption (column 6 in Table 4) is always more than 50%. Thus, particular attention should be given to the determination of the absolute accuracy of the absorption cross sections of O_2 and O_3 in the 202 - 222 nm region.

CONCLUDING REMARKS

The absorption in the 202 - 242 nm wavelength range by O_2 in the Herzberg continuum is the direct dominant source of odd oxygen in the stratosphere and is at the same time a source of the atmospheric opacity in the stratosphere. However, the O_3 absorption contributes greatly to the diminution of the atmospheric transmittance particularly at low stratospheric levels. Particular attention should be given first to specific spectral regions playing the most important role in the O_2 and O_3 absorption processes in order to increase the accuracy of aeronomic parameters in the stratosphere.

TABLE 4.- Spectral intervals corresponding to the effective photodissociation frequency (at least 90% of the total) of O_2 in the Herzberg continuum and the corresponding role of O_3 on the atmospheric transmittance.

Solar zenith Angle	Altitude (km)	Interval (cm^{-1})	Interval (nm)	Optical Depths	O_3 Role (%)	$J(O_2)$ (s^{-1})
Sec χ =1	35	45000 - 49500	222 - 202	< 2	50 to 90	1.4×10^{-10}
	30	46000 -	217.5 -	< 2.5	50 to 85	5.0×10^{-11}
	25	46500 -	215 -	< 4	50 to 80	1.0×10^{-11}
	20	46500 -	215 -	< 7	50 to 70	1.1×10^{-12}
Sec χ =1.414	35	45500 - 49500	220 - 202	< 2	50 to 90	9.6×10^{-11}
	30	46500 -	215 -	< 3	50 to 80	2.6×10^{-11}
	25	47000 -	212.5 -	< 5	50 to 75	3.4×10^{-12}
	20	47500 -	212.5 -	< 7	50 to 60	1.5×10^{-13}
Sec χ =2	35	46000 - 49500	217.5 - 202	< 2	50 to 80	5.9×10^{-11}
	30	46500 -	215 -	< 4	50 to 80	1.1×10^{-11}
	25	47000 -	212.5 -	< 7	50 to 75	7.6×10^{-13}
	20	47500 -	210 -	< 10	50 to 60	1.1×10^{-14}
Sec χ =3	35	46500 - 49500	215 - 202	< 3	50 to 80	2.8×10^{-11}
	30	47000 -	212.5 -	< 5	50 to 75	2.9×10^{-12}
	25	47500 -	210 -	< 9	50 to 70	6.8×10^{-14}
	20	48000 -	208 -	> 12	45 to 55	1.4×10^{-16}
Sec χ =4	35	46500 - 49500	215 - 202	< 4	50 to 80	1.4×10^{-11}
	30	47000 -	212.5 -	< 7	50 to 75	8.4×10^{-13}
	25	48000 -	208 -	< 10	50 to 60	6.7×10^{-15}
	20	48000 -	208 -	> 16	45 to 55	2.0×10^{-18}

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