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TRANSITION PROBABILITIES AND FRANCK-CONDON FACTORS FOR THE SECOND NEGATIVE BAND SYSTEM OF O_2^+

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Abstract. Transition probabilities for the second negative band system of O_2^+ are computed using the dipole transition moment presented by Wetmore et al. [1984]. Vibrational levels $v'' = 0 - 54$ of the $X^2\Pi_g$ ground state and $v' = 0 - 33$ of the excited $A^2\Pi_u$ state are included. Franck-Condon factors for ionization-excitation of O_2 $(X^3\Sigma_g^-; v = 0 - 25)$ to $O_2^+(A^2\Pi_u; v' = 0 - 33)$ are also presented.

1. Introduction

The second negative band system of O_2^+ arises from the transition $A^2\Pi_u(v') \rightarrow X^2\Pi_g(v'')$. The excited electronic state $A^2\Pi_u$ can be populated by photoionization and electron impact ionization of O_2 and by fluorescent scattering of radiation by $O_2^+(X^2\Pi_g)$ in planetary and cometary atmospheres. The latter process is a source of excitation of high vibrational levels $(v > 5 - 7)$ of ground state O_2^+ in the atmospheres of the terrestrial planets [Fox, 1985, 1986]. Recently, James et al. [1988] and Schappe et al. [1988] have investigated the production of the second negative band system by electron impact on O_2. They have presented cross sections for production of specific bands within the system and for the system as a whole. Analysis of the emission spectrum requires Franck-Condon factors for the excitation-ionization of ground state O_2 to produce $O_2^+(A^2\Pi_u)$ and radiative transition probabilities for individual bands of the second negative system. Since transition probabilities were not available, both James et al. and Schappe et al. used Franck-Condon factors to compute the ratios of band intensities, a practice which is valid only if the transition moment is constant with internuclear distance. In addition, in computing the Franck-Condon factors, James et al. used a Morse potential, which is less accurate for high vibrational levels than a Rydberg-Klein-Rees (RKR) potential.

Several years ago, in connection with studies of the vibrational distribution of O_2^+ in the dayside ionospheres of the terrestrial planets [Fox, 1985; 1986], we computed transition probabilities of the second negative band system, using the ab initio dipole transition moment of Wetmore et al. [1984]. Wetmore et al. [1984] presented absorption oscillator strengths for the bands involving the first eight vibrational levels of the ground and excited states, and lifetimes of the $O_2^+(A^2\Pi_u)$ state for $v' = 0 - 33$. The computed lifetimes agreed very well with the available measured values [Jeunehomme, 1966; Erman and Larsson, 1977; Fink and Welge, 1968]. We present here transition probabilities for vibrational levels $v'' = 0$ to 54 of the ground state $O_2^+(X^2\Pi_g)$ and $v' = 0$ to 33 of $O_2^+(A^2\Pi_u)$. We also present Franck-Condon factors for ionization-excitation of $O_2(X^3\Sigma_g^-; v = 0 - 25)$ to produce $O_2^+(A^2\Pi_u; v' = 0 - 33)$, a wider range of vibrational quantum numbers than previously available [Nicholls, 1965; Krupenie, 1972]. Many vibrational quanta are potentially important, because the equilibrium internuclear distance of the $O_2^+(A^2\Pi_u)$ potential curve is very different from those of the $O_2(X^3\Sigma_g^-)$ and $O_2^+(X^2\Pi_g)$ states. Hence a wide range of vibrational levels of the A state are populated in ionization or fluorescent scattering; the excited states then decay to an even wider range of vibrational levels of the ground state.

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2. Calculations and Results

We have constructed vibrational wave functions for the $O_2^+(X^2\Pi_g)$, $O_2^+(A^2\Pi_u)$ and $O_2(X^3\Sigma_g^-)$ states by numerical integration of the radial equation of nuclear motion [cf. Wetmore et al. 1984]. Our potential curves for O_2^+ were adopted from the RKR values of Krupenie [1972] extended to larger internuclear distances using the asymptotic polarization term $-\frac{1}{2}\alpha R^{-4}$, where $\alpha = 5.28a_0^3$ is the polarizability of atomic oxygen. The potential curves for the ground state of O_2 were taken from Allison et al. [1982]. The Franck-Condon factors for ionization-excitation of $O_2(X^3\Sigma_g^-; v = 0 - 25)$ to $O_2^+(A^2\Pi_u; v'' = 0 - 33)$ are presented in Tables $1a - 1c$. Our values for ionization-excitation from $O_2(X^3\Sigma_g^-; v = 0)$ agree well with those presented by James et al. [1988].

Transition probabilities and band origins of the second negative system are given in Tables $2a - 2e$ for $O_2^+(A^2\Pi_u, v' = 0 - 33)$ and $O_2^+(X^2\Pi_g, v'' = 0 - 54)$. Vibrational levels of the X state with $v'' \geq 30$ lie above the lowest vibrational level of the A state, so some of the high vibrational levels of the X state decay radiatively to vibrational levels of the A state. The "reverse" $X \rightarrow A$

TABLE 1a. Franck-Condon Factors for Ionization of $O_2(X^3\Sigma_g^-; v'' = 0-10)$ to $O_2^+(A^2\Pi_u; v')$

	v''										
v'	0	1	2	3	4	5	6	7	8	9	10
0	3.058(−3)	2.087(−2)	6.692(−2)	1.344(−1)	1.900(−1)	2.016(−1)	1.674(−1)	1.117(−1)	6.107(−2)	2.778(−2)	1.062(−2)
1	1.291(−2)	6.225(−2)	1.258(−1)	1.295(−1)	5.880(−2)	1.670(−3)	2.929(−2)	1.064(−1)	1.541(−1)	1.420(−1)	9.572(−2)
2	2.994(−2)	9.849(−2)	1.108(−1)	3.397(−2)	3.490(−3)	6.622(−2)	9.167(−2)	3.378(−2)	6.845(−4)	5.173(−2)	1.228(−1)
3	5.071(−2)	1.084(−1)	5.246(−2)	6.114(−4)	5.785(−2)	6.538(−2)	5.169(−3)	2.669(−2)	8.182(−2)	5.235(−2)	1.651(−3)
4	7.032(−2)	9.103(−2)	8.519(−3)	3.121(−2)	6.362(−2)	5.861(−3)	2.837(−2)	6.533(−2)	1.432(−2)	1.325(−2)	7.128(−2)
5	8.489(−2)	5.968(−2)	1.400(−3)	5.759(−2)	2.210(−2)	1.215(−2)	5.691(−2)	1.122(−2)	1.865(−2)	6.072(−2)	1.702(−2)
6	9.260(−2)	2.923(−2)	1.864(−2)	5.033(−2)	6.671(−5)	4.365(−2)	2.341(−2)	8.473(−3)	5.152(−2)	1.097(−2)	1.737(−2)
7	9.356(−2)	8.749(−3)	3.863(−2)	2.484(−2)	1.225(−2)	4.216(−2)	3.341(−5)	3.978(−2)	1.927(−2)	9.868(−3)	4.793(−2)
8	8.904(−2)	4.194(−4)	4.806(−2)	4.809(−3)	3.237(−2)	1.728(−2)	1.423(−2)	3.508(−2)	3.231(−4)	3.957(−2)	1.282(−2)
9	8.075(−2)	1.844(−3)	4.485(−2)	3.029(−4)	3.859(−2)	9.443(−4)	3.283(−2)	9.288(−3)	1.959(−2)	2.697(−2)	2.758(−3)
10	7.022(−2)	8.815(−3)	3.356(−2)	7.765(−3)	2.935(−2)	3.803(−3)	3.154(−2)	2.259(−4)	3.303(−2)	2.801(−3)	2.581(−2)
11	5.888(−2)	1.723(−2)	2.036(−2)	1.851(−2)	1.473(−2)	1.579(−2)	1.655(−2)	1.059(−2)	2.267(−2)	3.792(−3)	2.979(−2)
12	4.824(−2)	2.441(−2)	9.733(−3)	2.610(−2)	3.990(−3)	2.455(−2)	3.691(−3)	2.224(−2)	6.376(−3)	1.806(−2)	1.290(−2)
13	3.894(−2)	2.926(−2)	3.170(−3)	2.850(−2)	6.031(−5)	2.554(−2)	3.644(−5)	2.430(−2)	3.757(−6)	2.427(−2)	7.691(−4)
14	3.103(−2)	3.155(−2)	3.465(−4)	2.643(−2)	1.494(−3)	2.052(−2)	3.618(−3)	1.800(−2)	3.894(−3)	1.859(−2)	2.514(−3)
15	2.461(−2)	3.180(−2)	1.677(−4)	2.188(−2)	5.441(−3)	1.338(−2)	9.482(−3)	9.455(−3)	1.094(−2)	8.826(−3)	1.052(−2)
16	1.944(−2)	3.051(−2)	1.453(−3)	1.654(−2)	9.533(−3)	7.007(−3)	1.396(−2)	3.089(−3)	1.549(−2)	1.968(−3)	1.596(−2)
17	1.537(−2)	2.830(−2)	3.283(−3)	1.160(−2)	1.251(−2)	2.721(−3)	1.574(−2)	2.672(−4)	1.601(−2)	2.729(−6)	1.604(−2)
18	1.217(−2)	2.562(−2)	5.068(−3)	7.586(−3)	1.399(−2)	5.658(−4)	1.512(−2)	2.776(−4)	1.356(−2)	1.490(−3)	1.241(−2)
19	9.660(−3)	2.275(−2)	6.496(−3)	4.622(−3)	1.415(−2)	8.599(−9)	1.302(−2)	1.770(−3)	9.876(−3)	4.200(−3)	7.732(−3)
20	7.697(−3)	1.993(−2)	7.456(−3)	2.605(−3)	1.337(−2)	3.647(−4)	1.035(−2)	3.602(−3)	6.321(−3)	6.556(−3)	3.849(−3)
21	6.158(−3)	1.727(−2)	7.953(−3)	1.333(−3)	1.203(−2)	1.118(−3)	7.729(−3)	5.103(−3)	3.556(−3)	7.896(−3)	1.400(−3)
22	4.941(−3)	1.484(−2)	8.043(−3)	5.954(−4)	1.045(−2)	1.903(−3)	5.490(−3)	6.012(−3)	1.716(−3)	8.196(−3)	2.590(−4)
23	3.973(−3)	1.263(−2)	7.808(−3)	2.125(−4)	8.835(−3)	2.527(−3)	3.739(−3)	6.327(−3)	6.649(−4)	7.727(−3)	1.219(−6)
24	3.198(−3)	1.067(−2)	7.333(−3)	4.675(−5)	7.317(−3)	2.916(−3)	2.457(−3)	6.174(−3)	1.694(−4)	6.820(−3)	1.991(−4)
25	2.572(−3)	8.944(−3)	6.696(−3)	8.700(−7)	5.962(−3)	3.070(−3)	1.567(−3)	5.705(−3)	9.462(−6)	5.743(−3)	5.420(−4)
26	2.064(−3)	7.424(−3)	5.961(−3)	1.147(−5)	4.793(−3)	3.024(−3)	9.738(−4)	5.058(−3)	1.831(−5)	4.672(−3)	8.512(−4)
27	1.648(−3)	6.096(−3)	5.180(−3)	4.056(−5)	3.806(−3)	2.827(−3)	5.925(−4)	4.337(−3)	8.813(−5)	3.702(−3)	1.049(−3)
28	1.305(−3)	4.942(−3)	4.395(−3)	6.791(−5)	2.987(−3)	2.530(−3)	3.549(−4)	3.615(−3)	1.592(−4)	2.875(−3)	1.122(−3)
29	1.023(−3)	3.946(−3)	3.640(−3)	8.500(−5)	2.316(−3)	2.179(−3)	2.105(−4)	2.938(−3)	2.056(−4)	2.195(−3)	1.090(−3)
30	7.917(−4)	3.099(−3)	2.941(−3)	9.030(−5)	1.771(−3)	1.812(−3)	1.245(−4)	2.331(−3)	2.216(−4)	1.652(−3)	9.854(−4)
31	6.033(−4)	2.389(−3)	2.318(−3)	8.597(−5)	1.336(−3)	1.458(−3)	7.400(−5)	1.808(−3)	2.125(−4)	1.226(−3)	8.409(−4)
32	4.522(−4)	1.807(−3)	1.783(−3)	7.549(−5)	9.922(−4)	1.139(−3)	4.446(−5)	1.371(−3)	1.873(−4)	8.975(−4)	6.843(−4)
33	3.331(−4)	1.339(−3)	1.338(−3)	6.224(−5)	7.253(−4)	8.643(−4)	2.712(−5)	1.018(−3)	1.547(−4)	6.483(−4)	5.347(−4)

Read 3.058(−3) as 3.058×10^{-3}.

TABLE 1b. Franck-Condon Factors for Ionization of $O_2(X^3\Sigma_g^-; v'' = 11 - 21)$ to $O_2^+(A^2\Pi_u; v')$

	v''										
v'	11	12	13	14	15	16	17	18	19	20	21
0	3.438(−3)	9.476(−4)	2.229(−4)	4.479(−5)	7.679(−6)	1.118(−6)	1.378(−7)	1.420(−8)	1.199(−9)	8.528(−11)	4.381(−12)
1	5.020(−2)	2.119(−2)	7.343(−3)	2.115(−3)	5.100(−4)	1.032(−4)	1.751(−5)	2.481(−6)	2.917(−7)	2.786(−8)	2.180(−9)
2	1.424(−1)	1.098(−1)	6.264(−2)	2.788(−2)	9.966(−3)	2.906(−3)	6.979(−4)	1.384(−4)	2.262(−5)	3.034(−6)	3.280(−7)
3	2.973(−2)	1.030(−1)	1.374(−1)	1.138(−1)	6.747(−2)	3.055(−2)	1.092(−2)	3.136(−3)	7.308(−4)	1.383(−4)	2.120(−5)
4	5.735(−2)	4.217(−3)	2.258(−2)	9.485(−2)	1.338(−1)	1.130(−1)	6.708(−2)	2.996(−2)	1.043(−2)	2.878(−3)	6.338(−4)
5	9.973(−3)	6.637(−2)	5.592(−2)	4.134(−3)	2.284(−2)	9.507(−2)	1.322(−1)	1.093(−1)	6.298(−2)	2.703(−2)	8.937(−3)
6	5.711(−2)	1.483(−2)	1.130(−2)	6.578(−2)	5.081(−2)	2.165(−3)	2.834(−2)	1.011(−1)	1.317(−1)	1.031(−1)	5.610(−2)
7	7.541(−3)	2.058(−2)	5.387(−2)	9.950(−3)	1.606(−2)	6.721(−2)	4.263(−2)	2.269(−4)	3.893(−2)	1.110(−1)	1.304(−1)
8	1.436(−2)	4.417(−2)	3.260(−3)	2.684(−2)	4.928(−2)	4.444(−3)	2.425(−2)	6.821(−2)	3.168(−2)	8.008(−4)	5.491(−2)
9	3.923(−2)	6.131(−3)	2.119(−2)	3.844(−2)	3.255(−4)	3.483(−2)	4.195(−2)	5.703(−4)	3.551(−2)	6.619(−2)	1.905(−2)
10	1.756(−2)	8.151(−3)	3.633(−2)	1.297(−3)	2.888(−2)	2.997(−2)	7.314(−4)	4.235(−2)	3.158(−2)	6.872(−4)	4.803(−2)
11	2.500(−5)	2.999(−2)	8.640(−3)	1.551(−2)	3.012(−2)	9.363(−5)	3.503(−2)	1.984(−2)	5.327(−3)	4.684(−2)	1.977(−2)
12	1.043(−2)	2.304(−2)	1.717(−3)	3.045(−2)	2.439(−3)	2.281(−2)	2.179(−2)	2.928(−3)	3.788(−2)	1.039(−2)	1.333(−2)
13	2.306(−2)	4.846(−3)	1.739(−2)	1.473(−2)	6.728(−3)	2.723(−2)	2.649(−5)	2.821(−2)	1.315(−2)	8.884(−3)	3.694(−2)
14	2.116(−2)	4.894(−4)	2.362(−2)	5.742(−4)	2.208(−2)	7.259(−3)	1.298(−2)	2.137(−2)	1.328(−3)	3.042(−2)	5.994(−3)
15	1.069(−2)	8.213(−3)	1.482(−2)	4.116(−3)	2.031(−2)	3.309(−4)	2.356(−2)	2.247(−3)	1.858(−2)	1.461(−2)	5.310(−3)
16	2.263(−3)	1.561(−2)	4.033(−3)	1.361(−2)	8.147(−3)	9.080(−3)	1.503(−2)	2.907(−3)	2.209(−2)	1.200(−4)	2.227(−2)
17	3.230(−5)	1.656(−2)	7.085(−6)	1.714(−2)	5.593(−4)	1.663(−2)	3.235(−3)	1.337(−2)	9.638(−3)	6.748(−3)	1.871(−2)
18	2.283(−3)	1.244(−2)	2.187(−3)	1.361(−2)	1.233(−3)	1.552(−2)	1.259(−4)	1.707(−2)	6.510(−4)	1.608(−2)	5.246(−3)
19	5.780(−3)	6.976(−3)	6.335(−3)	7.498(−3)	5.752(−3)	9.315(−3)	3.985(−3)	1.234(−2)	1.528(−3)	1.570(−2)	3.514(−6)
20	8.355(−3)	2.766(−3)	9.292(−3)	2.655(−3)	9.460(−3)	3.468(−3)	8.678(−3)	5.491(−3)	6.697(−3)	8.982(−3)	3.596(−3)
21	9.324(−3)	5.651(−4)	1.010(−2)	3.437(−4)	1.057(−2)	4.734(−4)	1.073(−2)	1.125(−3)	1.028(−2)	2.824(−3)	8.671(−3)
22	8.928(−3)	1.188(−7)	9.199(−3)	7.624(−5)	9.498(−3)	8.835(−5)	9.981(−3)	4.759(−6)	1.054(−2)	1.666(−4)	1.073(−2)
23	7.723(−3)	3.564(−4)	7.436(−3)	8.460(−4)	7.368(−3)	1.060(−3)	7.722(−3)	8.634(−4)	8.543(−3)	3.788(−4)	9.631(−3)
24	6.224(−3)	1.024(−3)	5.516(−3)	1.832(−3)	5.125(−3)	2.289(−3)	5.212(−3)	2.263(−3)	5.856(−3)	1.768(−3)	7.031(−3)
25	4.769(−3)	1.631(−3)	3.836(−3)	2.589(−3)	3.268(−3)	3.188(−3)	3.143(−3)	3.354(−3)	3.506(−3)	3.086(−3)	4.391(−3)
26	3.522(−3)	2.020(−3)	2.539(−3)	2.976(−3)	1.935(−3)	3.594(−3)	1.710(−3)	3.869(−3)	1.854(−3)	3.823(−3)	2.397(−3)
27	2.535(−3)	2.165(−3)	1.619(−3)	3.021(−3)	1.074(−3)	3.572(−3)	8.390(−4)	3.867(−3)	8.617(−4)	3.956(−3)	1.146(−3)
28	1.792(−3)	2.109(−3)	1.005(−3)	2.819(−3)	5.611(−4)	3.265(−3)	3.667(−4)	3.524(−3)	3.428(−4)	3.666(−3)	4.708(−4)
29	1.253(−3)	1.916(−3)	6.130(−4)	2.475(−3)	2.773(−4)	2.810(−3)	1.386(−4)	3.012(−3)	1.089(−4)	3.156(−3)	1.575(−4)
30	8.699(−4)	1.649(−3)	3.710(−4)	2.070(−3)	1.302(−4)	2.310(−3)	4.229(−5)	2.455(−3)	2.267(−5)	2.577(−3)	3.681(−5)
31	6.016(−4)	1.356(−3)	2.246(−4)	1.665(−3)	5.846(−5)	1.831(−3)	8.635(−6)	1.929(−3)	1.047(−6)	2.023(−3)	3.113(−6)
32	4.152(−4)	1.073(−3)	1.371(−4)	1.296(−3)	2.529(−5)	1.407(−3)	4.562(−7)	1.471(−3)	1.554(−6)	1.539(−3)	7.709(−7)
33	2.858(−4)	8.220(−4)	8.478(−5)	9.791(−4)	1.067(−5)	1.053(−3)	4.203(−7)	1.094(−3)	6.087(−6)	1.142(−3)	5.430(−6)

TABLE 1c. Franck-Condon Factors for Ionization of $O_2(X^3\Sigma_g^-; v'' = 22-25)$ to $O_2^+(A^2\Pi_u; v')$

	v''			
v'	22	23	24	25
0	1.734(−13)	1.402(−14)	1.358(−15)	1.458(−15)
1	1.301(−10)	5.255(−12)	3.902(−13)	2.301(−14)
2	2.842(−8)	1.915(−9)	8.125(−11)	5.250(−12)
3	2.597(−6)	2.497(−7)	1.865(−8)	9.033(−10)
4	1.114(−4)	1.547(−5)	1.660(−6)	1.365(−7)
5	2.308(−3)	4.675(−4)	7.378(−5)	8.873(−6)
6	2.258(−2)	6.909(−3)	1.624(−3)	2.926(−4)
7	9.406(−2)	4.720(−2)	1.737(−2)	4.786(−3)
8	1.224(−1)	1.266(−1)	8.221(−2)	3.720(−2)
9	6.715(−3)	7.602(−2)	1.330(−1)	1.193(−1)
10	5.900(−2)	7.356(−3)	2.053(−2)	1.016(−1)
11	6.192(−3)	5.850(−2)	4.635(−2)	4.604(−4)
12	4.703(−2)	9.229(−3)	1.657(−2)	6.410(−2)
13	3.429(−3)	2.321(−2)	4.265(−2)	1.985(−3)
14	1.634(−2)	3.251(−2)	1.707(−4)	3.272(−2)
15	2.951(−2)	1.487(−3)	2.373(−2)	2.542(−2)
16	8.420(−3)	1.061(−2)	2.612(−2)	1.064(−7)
17	4.815(−4)	2.378(−2)	3.776(−3)	1.602(−2)
18	1.057(−2)	1.456(−2)	2.530(−3)	2.333(−2)
19	1.708(−2)	2.260(−3)	1.369(−2)	1.046(−2)
20	1.343(−2)	6.014(−4)	1.683(−2)	6.189(−4)
21	6.132(−3)	5.578(−3)	1.097(−2)	1.808(−3)
22	1.245(−3)	9.781(−3)	4.001(−3)	7.144(−3)
23	6.771(−6)	1.044(−2)	4.421(−4)	1.021(−2)
24	9.526(−4)	8.500(−3)	1.820(−4)	9.795(−3)
25	2.404(−3)	5.760(−3)	1.414(−3)	7.443(−3)
26	3.440(−3)	3.381(−3)	2.696(−3)	4.808(−3)
27	3.830(−3)	1.747(−3)	3.422(−3)	2.736(−3)
28	3.697(−3)	7.957(−4)	3.551(−3)	1.396(−3)
29	3.259(−3)	3.133(−4)	3.269(−3)	6.430(−4)
30	2.698(−3)	1.015(−4)	2.780(−3)	2.668(−4)
31	2.134(−3)	2.358(−5)	2.238(−3)	9.849(−5)
32	1.631(−3)	2.278(−6)	1.731(−3)	3.133(−5)
33	1.213(−3)	2.267(−7)	1.296(−3)	7.972(−6)

transitions are indicated by negative band origins and transition probabilities. For strong bands with fairly low vibrational quantum number, intensity ratios computed with our transition probabilities agree to within a few percent with those computed with the Franck-Condon factors of James et al. [1988] and Schappe et al. [1988]. Significant differences arise for weaker bands and higher vibrational levels.

TABLE 2a. Transition Probabilities (s^{-1}) (Upper Entry) and Band Origins (nm) (Lower Entry) of the Second Negative Band System of $O_2^+(A; v' \rightarrow X; v'' = 0-10)$

	v''									
v'	0	1	2	3	4	5	6	7	8	9	10
0	7.400(0)	1.238(2)	9.789(2)	4.867(3)	1.707(4)	4.487(4)	9.179(4)	1.497(5)	1.990(5)	2.210(5)	2.069(5)
	249.56	261.80	275.05	289.43	305.11	322.24	341.03	361.74	384.70	410.25	438.67
1	6.164(1)	8.958(2)	6.021(3)	2.474(4)	6.913(4)	1.376(5)	1.979(5)	2.017(5)	1.353(5)	4.590(4)	5.126(2)
	244.25	255.96	268.61	282.32	297.21	313.44	331.19	350.69	372.23	396.10	422.53
2	2.736(2)	3.453(3)	1.967(4)	6.621(4)	1.444(5)	2.077(5)	1.879(5)	8.728(4)	5.956(3)	2.124(4)	8.561(4)
	239.32	250.55	262.66	275.75	289.94	305.36	322.19	340.61	360.89	383.29	407.99
3	8.608(2)	9.436(3)	4.535(4)	1.236(5)	2.042(5)	1.961(5)	8.541(4)	1.885(3)	3.827(4)	9.808(4)	6.650(4)
	234.73	245.53	257.14	269.68	283.23	297.94	313.93	331.40	350.56	371.65	394.83
4	2.155(3)	2.051(4)	8.279(4)	1.800(5)	2.154(5)	1.180(5)	7.607(3)	3.332(4)	1.001(5)	5.931(4)	4.857(2)
	230.46	240.86	252.03	264.05	277.04	291.09	306.34	322.95	341.12	361.06	382.89
5	4.570(3)	3.774(4)	1.272(5)	2.161(5)	1.743(5)	3.624(4)	1.249(4)	9.408(4)	7.345(4)	2.056(3)	3.712(4)
	226.48	236.51	247.28	258.84	271.31	284.77	299.35	315.19	332.47	351.39	372.04
6	8.528(3)	6.108(4)	1.707(5)	2.203(5)	1.052(5)	4.608(2)	6.506(4)	9.753(4)	1.449(4)	2.205(4)	7.010(4)
	222.78	232.47	242.86	254.01	266.00	278.93	292.90	308.05	324.54	342.54	362.13
7	1.436(4)	8.918(4)	2.049(5)	1.930(5)	4.114(4)	1.700(4)	1.029(5)	5.055(4)	3.050(3)	6.470(4)	3.748(4)
	219.31	228.71	238.75	249.52	261.08	273.53	286.95	301.47	317.25	334.43	353.08

8	2.222(4) 216.09	1.196(5) 225.20	2.235(5) 234.93	1.448(5) 245.35	5.139(3) 256.52	5.924(4) 268.52	9.689(4) 281.45	7.834(3) 295.41	3.722(4) 310.54	6.367(4) 326.98	2.108(3) 344.78
9	3.196(4) 213.08	1.490(5) 221.93	2.237(5) 231.38	9.063(4) 241.48	2.755(3) 252.29	9.469(4) 263.89	5.952(4) 276.36	2.804(3) 289.81	6.821(4) 304.36	2.812(4) 320.13	1.042(4) 337.18
10	4.300(4) 210.28	1.736(5) 218.89	2.064(5) 228.08	4.401(4) 237.89	2.467(4) 248.37	1.046(5) 259.61	2.051(4) 271.67	2.789(4) 284.65	6.616(4) 298.68	2.000(3) 313.85	3.946(4) 330.22
11	5.428(4) 207.69	1.901(5) 216.09	1.759(5) 225.04	1.354(4) 234.58	5.473(4) 244.77	8.897(4) 255.68	1.142(3) 267.37	5.586(4) 279.93	3.943(4) 293.48	5.461(3) 308.13	5.104(4) 323.89
12	6.507(4) 205.31	1.981(5) 213.52	1.400(5) 222.25	8.530(2) 231.56	7.940(4) 241.48	6.054(4) 252.09	4.220(3) 263.44	6.752(4) 275.64	1.250(4) 288.76	2.589(4) 302.93	3.802(4) 318.15
13	7.479(4) 203.13	1.985(5) 211.17	1.044(5) 219.70	2.207(3) 228.79	9.224(4) 238.47	3.227(4) 248.81	2.041(4) 259.87	6.065(4) 271.72	3.973(2) 284.47	4.301(4) 298.21	1.662(4) 312.94
14	8.263(4) 201.14	1.917(5) 209.01	7.284(4) 217.37	1.203(4) 226.26	9.246(4) 235.73	1.193(4) 245.82	3.843(4) 256.61	4.291(4) 268.16	3.754(3) 280.57	4.662(4) 293.93	2.533(3) 308.24
15	8.854(4) 199.32	1.803(5) 207.05	4.746(4) 215.25	2.510(4) 223.96	8.352(4) 233.23	1.815(3) 243.11	5.102(4) 253.65	2.394(4) 264.94	1.527(4) 277.04	3.847(4) 290.05	5.540(2) 303.98
16	9.216(4) 197.66	1.653(5) 205.26	2.852(4) 213.31	3.755(4) 221.87	6.938(4) 230.96	2.505(2) 240.65	5.564(4) 250.98	9.657(3) 262.02	2.713(4) 273.85	2.517(4) 286.56	6.892(3) 300.14
17	9.371(4) 196.16	1.488(5) 203.63	1.551(4) 211.56	4.729(4) 219.97	5.386(4) 228.91	4.081(3) 238.42	5.337(4) 248.55	1.987(3) 259.38	3.478(4) 270.97	1.283(4) 283.40	1.552(4) 296.68
18	9.331(4) 194.79	1.319(5) 202.17	7.314(3) 209.98	5.348(4) 218.26	3.940(4) 227.06	1.023(4) 236.41	4.665(4) 246.37	5.961(0) 257.00	3.707(4) 268.38	4.520(3) 280.57	2.216(4) 293.58
19	9.112(4) 193.57	1.152(5) 200.85	2.710(3) 208.55	5.615(4) 216.72	2.727(4) 225.39	1.642(4) 234.60	3.792(4) 244.41	1.679(3) 254.87	3.495(4) 266.05	6.301(2) 278.03	2.512(4) 290.80
20	8.748(4) 192.46	9.960(4) 199.66	5.805(2) 207.27	5.590(4) 215.34	1.790(4) 223.90	2.137(4) 232.99	2.910(4) 242.66	4.995(3) 252.96	3.020(4) 263.98	1.116(2) 275.76	2.472(4) 288.32
21	8.269(4) 191.48	8.533(4) 198.60	1.740(0) 206.13	5.348(4) 214.11	1.113(4) 222.57	2.457(4) 231.55	2.128(4) 241.09	8.483(3) 251.26	2.444(4) 262.13	1.511(3) 273.74	2.206(4) 286.12
22	7.695(4) 190.61	7.249(4) 197.66	2.788(2) 205.12	4.956(4) 213.02	6.515(3) 221.39	2.598(4) 230.27	1.493(4) 239.71	1.129(4) 249.76	1.878(4) 260.49	3.591(3) 271.96	1.833(4) 284.17
23	7.052(4) 189.84	6.109(4) 196.83	9.265(2) 204.23	4.475(4) 212.06	3.554(3) 220.35	2.588(4) 229.15	1.009(4) 238.49	1.307(4) 248.44	1.384(4) 259.06	5.536(3) 270.40	1.443(4) 282.46
24	6.364(4) 189.16	5.108(4) 196.11	1.633(3) 203.45	3.953(4) 211.22	1.775(3) 219.44	2.462(4) 228.17	6.603(3) 237.43	1.381(4) 247.29	9.868(3) 257.80	6.937(3) 269.03	1.090(4) 280.97
25	5.653(4) 188.58	4.238(4) 195.48	2.218(3) 202.77	3.426(4) 210.49	7.860(2) 218.66	2.258(4) 227.32	4.196(3) 236.51	1.365(4) 246.29	6.856(3) 256.72	7.671(3) 267.85	7.983(3) 279.69
26	4.938(4) 188.08	3.485(4) 194.94	2.599(3) 202.20	2.917(4) 209.87	2.886(2) 217.99	2.009(4) 226.59	2.599(3) 235.73	1.284(4) 245.44	4.667(3) 255.79	7.790(3) 266.85	5.708(3) 278.59
27	4.236(4) 187.66	2.837(4) 194.49	2.757(3) 201.71	2.441(4) 209.34	7.431(1) 217.42	1.738(4) 225.98	1.575(3) 235.06	1.158(4) 244.72	3.131(3) 255.01	7.422(3) 265.99	4.013(3) 277.66
28	3.563(4) 187.30	2.282(4) 194.11	2.714(3) 201.30	2.006(4) 208.90	6.457(0) 216.94	1.467(4) 225.46	9.378(2) 234.51	1.007(4) 244.12	2.080(3) 254.36	6.721(3) 265.29	2.789(3) 276.89

TABLE 2a. (continued)

	v''										
v'	0	1	2	3	4	5	6	7	8	9	10
29	2.933(4) 187.01	1.810(4) 193.80	2.513(3) 200.97	1.618(4) 208.54	2.672(0) 216.56	1.207(4) 225.05	5.523(2) 234.05	8.484(3) 243.63	1.375(3) 253.83	5.829(3) 264.71	1.924(3) 276.26
30	2.361(4) 186.78	1.413(4) 193.55	2.209(3) 200.70	1.280(4) 208.25	1.831(1) 216.24	9.692(3) 224.71	3.238(2) 233.69	6.933(3) 243.23	9.082(2) 253.40	4.867(3) 264.24	1.322(3) 275.75
31	1.856(4) 186.60	1.084(4) 193.35	1.855(3) 200.48	9.916(3) 208.02	3.297(1) 216.00	7.597(3) 224.44	1.905(2) 233.40	5.506(3) 242.92	6.013(2) 253.06	3.926(3) 263.87	9.073(2) 275.35
32	1.425(4) 186.46	8.168(3) 193.20	1.495(3) 200.32	7.525(3) 207.85	4.017(1) 215.81	5.815(3) 224.24	1.132(2) 233.18	4.255(3) 242.68	3.998(2) 252.80	3.069(3) 263.59	6.223(2) 275.04
33	1.069(4) 186.35	6.038(3) 193.09	1.162(3) 200.20	5.593(3) 207.71	4.017(1) 215.66	4.349(3) 224.09	6.835(1) 233.01	3.205(3) 242.50	2.669(2) 252.61	2.331(3) 263.38	4.265(2) 274.81

TABLE 2b. Transition Probabilities (s^{-1}) (Upper Entry) and Band Origins (nm) (Lower Entry) of the Second Negative Band System of $O_2^+(A; v' \rightarrow X; v'' = 11 - 21)$

	v''										
v'	11	12	13	14	15	16	17	18	19	20	21
0	1.578(5) 470.40	9.855(4) 506.49	5.397(4) 547.59	2.463(4) 594.15	9.084(3) 648.20	2.693(3) 710.50	5.916(2) 783.98	1.048(2) 870.78	1.488(1) 976.00	1.303(0) 1104.22	3.903(-2) 1266.05
1	2.518(4) 451.89	8.078(4) 485.09	1.168(5) 522.66	1.081(5) 564.92	7.217(4) 613.56	3.700(4) 669.10	1.400(4) 733.87	4.005(3) 809.39	8.197(2) 899.53	1.266(2) 1007.35	1.407(1) 1140.31
2	9.454(4) 435.29	3.858(4) 466.01	3.956(2) 500.58	2.384(4) 539.21	7.269(4) 583.36	9.214(4) 633.34	6.991(4) 691.08	3.650(4) 757.65	1.311(4) 836.07	3.371(3) 928.43	6.018(2) 1040.23
3	4.607(3) 420.35	1.990(4) 448.93	6.693(4) 480.93	5.296(4) 516.47	6.899(3) 556.83	9.905(3) 602.20	5.556(4) 654.16	8.001(4) 713.50	6.087(4) 782.64	2.929(4) 863.00	9.273(3) 958.78
4	3.763(4) 406.85	6.720(4) 433.56	2.180(4) 463.33	3.130(3) 496.24	4.425(4) 533.38	4.794(4) 574.87	7.118(3) 622.03	1.004(4) 675.45	5.505(4) 737.10	7.238(4) 807.95	4.867(4) 891.31
5	6.715(4) 394.61	1.342(4) 419.69	1.114(4) 447.53	5.104(4) 478.15	2.442(4) 512.54	1.258(3) 550.73	3.709(4) 593.87	3.811(4) 642.38	2.336(3) 697.88	1.848(4) 761.08	6.197(4) 834.60
6	1.881(4) 383.48	1.001(4) 407.13	5.162(4) 433.27	1.882(4) 461.91	5.380(3) 493.93	4.092(4) 529.30	1.782(4) 569.03	3.410(3) 613.41	3.787(4) 663.82	2.459(4) 720.74	2.779(2) 786.35
7	2.549(3) 373.34	4.893(4) 395.72	2.489(4) 420.37	3.617(3) 447.28	3.973(4) 477.24	1.447(4) 510.17	6.993(3) 546.98	3.563(4) 587.87	7.569(3) 634.01	1.131(4) 685.74	3.738(4) 744.87
8	3.618(4) 364.08	3.974(4) 385.33	5.682(1) 408.67	3.549(4) 434.05	2.024(4) 462.21	4.075(3) 493.04	3.335(4) 527.34	6.064(3) 565.23	1.395(4) 607.76	2.793(4) 655.14	2.287(2) 708.90
9	5.290(4) 355.62	6.388(3) 375.86	2.229(4) 398.03	3.276(4) 422.08	9.478(1) 448.65	3.018(4) 477.64	1.122(4) 509.76	8.977(3) 545.09	2.634(4) 584.54	1.487(2) 628.23	2.351(4) 677.50
10	3.143(4)	3.631(3)	4.055(4)	5.647(3)	1.888(4)	2.295(4)	1.675(3)	2.702(4)	2.411(3)	1.732(4)	1.388(4)

	347.89	367.24	388.37	411.23	436.41	463.80	494.02	527.13	563.93	604.49	649.98
11	5.363(3)	2.574(4)	2.654(4)	2.737(3)	3.145(4)	2.021(3)	2.011(4)	1.174(4)	7.352(3)	1.954(4)	5.950(2)
	340.86	359.42	379.64	401.45	425.42	451.40	479.98	511.17	545.71	583.60	625.88
12	1.346(3)	3.888(4)	5.318(3)	2.018(4)	1.823(4)	4.668(3)	2.347(4)	7.959(0)	2.100(4)	2.233(3)	1.537(4)
	334.51	352.36	371.78	392.67	415.57	440.33	467.48	497.02	529.61	565.23	604.80
13	1.505(4)	3.150(4)	6.639(2)	2.995(4)	2.487(3)	1.913(4)	9.115(3)	9.269(3)	1.388(4)	3.424(3)	1.619(4)
	328.76	345.99	364.69	384.77	406.74	430.42	456.33	484.44	515.34	549.01	586.26
14	2.965(4)	1.482(4)	1.077(4)	2.322(4)	1.442(3)	2.309(4)	1.269(2)	1.873(4)	1.833(3)	1.419(4)	3.873(3)
	323.57	340.24	358.31	377.68	398.82	421.56	446.39	473.25	502.70	534.68	569.95
15	3.474(4)	2.734(3)	2.221(4)	1.009(4)	1.064(4)	1.483(4)	4.036(3)	1.582(4)	1.290(3)	1.502(4)	3.647(2)
	318.88	335.07	352.58	371.31	391.72	413.64	437.51	463.29	491.48	522.00	555.57
16	2.994(4)	2.036(2)	2.624(4)	1.427(3)	1.873(4)	4.702(3)	1.226(4)	6.729(3)	8.319(3)	7.281(3)	6.382(3)
	314.66	330.41	347.42	365.60	385.37	406.57	429.61	454.43	481.52	510.78	542.88
17	2.031(4)	4.657(3)	2.258(4)	4.246(2)	2.012(4)	1.246(2)	1.627(4)	7.339(2)	1.323(4)	9.994(2)	1.144(4)
	310.86	326.22	342.80	360.48	379.69	400.25	422.56	446.55	472.68	500.85	531.68
18	1.079(4)	1.124(4)	1.519(4)	4.424(3)	1.591(4)	1.465(3)	1.443(4)	5.502(2)	1.249(4)	3.853(2)	1.079(4)
	307.46	322.48	338.66	355.91	374.62	394.62	416.29	439.55	464.85	492.07	521.79
19	4.102(3)	1.638(4)	7.961(3)	9.473(3)	9.733(3)	5.500(3)	9.506(3)	3.785(3)	8.254(3)	3.381(3)	6.624(3)
	304.41	319.12	334.96	351.83	370.11	389.61	410.72	433.35	457.92	484.31	513.07
20	7.539(2)	1.871(4)	2.970(3)	1.301(4)	4.481(3)	9.176(3)	4.641(3)	7.229(3)	3.824(3)	6.573(3)	2.551(3)
	301.69	316.14	331.68	348.21	366.10	385.17	405.79	427.87	451.80	477.46	505.40
21	1.227(1)	1.842(4)	5.276(2)	1.426(4)	1.308(3)	1.105(4)	1.460(3)	9.125(3)	1.014(3)	8.114(3)	3.761(2)
	299.28	313.49	328.77	345.00	362.55	381.25	401.44	423.03	446.41	471.45	498.67
22	7.825(2)	1.640(4)	1.141(1)	1.359(4)	8.732(1)	1.108(4)	1.325(2)	9.235(3)	2.724(1)	7.870(3)	5.233(1)
	297.15	311.16	326.20	342.17	359.43	377.80	397.62	418.79	441.69	466.19	492.79
23	2.120(3)	1.359(4)	5.700(2)	1.176(4)	1.488(2)	9.839(3)	1.029(2)	8.119(3)	2.565(2)	6.527(3)	7.528(2)
	295.29	309.11	323.95	339.70	356.70	374.79	394.28	415.09	437.58	461.61	487.67
24	3.403(3)	1.066(4)	1.498(3)	9.512(3)	7.977(2)	8.036(3)	6.918(2)	6.471(3)	9.868(2)	4.838(3)	1.689(3)
	293.66	307.33	321.99	337.55	354.33	372.17	391.39	411.88	434.02	457.65	483.25
25	4.321(3)	8.045(3)	2.353(3)	7.316(3)	1.539(3)	6.176(3)	1.393(3)	4.801(3)	1.718(3)	3.290(3)	2.408(3)
	292.25	305.79	320.31	335.69	352.29	369.92	388.90	409.13	430.96	454.25	479.46
26	4.783(3)	5.891(3)	2.927(3)	5.423(3)	2.106(3)	4.540(3)	1.932(3)	3.379(3)	2.212(3)	2.088(3)	2.761(3)
	291.05	304.48	318.86	334.11	350.55	368.00	386.78	406.78	428.35	451.35	476.24
27	4.826(3)	4.222(3)	3.174(3)	3.915(3)	2.407(3)	3.233(3)	2.215(3)	2.287(3)	2.414(3)	1.252(3)	2.782(3)
	290.04	303.37	317.65	332.78	349.08	366.38	384.99	404.80	426.16	448.93	473.53
28	4.546(3)	2.982(3)	3.134(3)	2.774(3)	2.453(3)	2.251(3)	2.255(3)	1.506(3)	2.369(3)	7.165(2)	2.571(3)
	289.20	302.45	316.64	331.67	347.86	365.04	383.51	403.17	424.35	446.91	471.29
29	4.054(3)	2.085(3)	2.886(3)	1.941(3)	2.305(3)	1.545(3)	2.112(3)	9.741(2)	2.157(3)	3.954(2)	2.232(3)
	288.51	301.69	315.81	330.76	346.86	363.94	382.30	401.83	422.86	445.27	469.46
30	3.453(3)	1.449(3)	2.513(3)	1.348(3)	2.033(3)	1.052(3)	1.856(3)	6.249(2)	1.853(3)	2.127(2)	1.848(3)
	287.96	301.09	315.15	330.04	346.06	363.06	381.33	400.76	421.68	443.95	468.00

TABLE 2b. (continued)

	v''										
v'	11	12	13	14	15	16	17	18	19	20	21
31	2.825(3)	1.004(3)	2.089(3)	9.324(2)	1.704(3)	7.138(2)	1.549(3)	4.003(2)	1.521(3)	1.128(2)	1.472(3)
	287.52	300.61	314.63	329.46	345.44	362.37	380.56	399.91	420.74	442.91	466.85
32	2.231(3)	6.935(2)	1.668(3)	6.432(2)	1.368(3)	4.839(2)	1.240(3)	2.575(2)	1.201(3)	5.981(1)	1.136(3)
	287.19	300.24	314.23	329.02	344.95	361.84	379.97	399.26	420.02	442.12	465.97
33	1.707(3)	4.781(2)	1.286(3)	4.426(2)	1.059(3)	3.281(2)	9.569(2)	1.668(2)	9.171(2)	3.209(1)	8.527(2)
	286.93	299.97	313.92	328.69	344.59	361.44	379.53	398.77	419.48	441.52	465.30

TABLE 2c. Transition Probabilities (s^{-1}) (Upper Entry) and Band Origins (nm) (Lower Entry) of the Second Negative Band System of $O_2^+(A;v' \rightarrow X;v'' = 22 - 32)$

	v''										
v'	22	23	24	25	26	27	28	29	30	31	32
0	8.752(–3)	1.238(–3)	9.630(–4)	5.098(–5)	5.827(–5)	3.616(–5)	1.132(–6)	1.414(–11)	–1.749(–6)	–1.268(–5)	–7.481(–6)
	1473.53	1751.05	2140.65	2721.98	3690.37	5615.77	11244.16	318425.22	–12580.88	–6299.33	–4261.07
1	8.919(–1)	3.207(–2)	3.711(–3)	1.592(–5)	4.886(–5)	5.946(–5)	6.406(–6)	5.099(–8)	7.058(–10)	–7.327(–7)	–1.996(–6)
	1305.93	1519.34	1804.27	2200.34	2792.75	3771.24	5680.86	11082.14	131421.33	–13956.31	–6775.61
2	7.335(1)	5.811(0)	2.762(–1)	7.898(–3)	7.929(–5)	7.241(–7)	1.350(–7)	9.518(–8)	5.563(–9)	8.965(–13)	–2.468(–9)
	1176.31	1346.69	1565.88	1855.79	2260.15	2860.87	3840.11	5726.91	10870.97	78574.06	–15820.48
3	1.977(3)	2.807(2)	2.431(1)	1.336(0)	4.425(–2)	1.045(–4)	4.256(–5)	1.655(–6)	5.861(–6)	1.108(–6)	2.404(–9)
	1073.22	1213.26	1388.34	1611.56	1907.99	2319.08	2923.37	3902.03	5758.69	10594.41	54190.63
4	1.959(4)	5.068(3)	8.254(2)	8.303(1)	4.869(0)	1.745(–1)	1.580(–3)	2.551(–6)	2.655(–5)	8.595(–6)	4.229(–7)
	989.39	1107.21	1251.20	1429.67	1658.21	1960.19	2375.19	2983.08	3958.86	5769.13	10266.90
5	6.331(4)	3.400(4)	1.062(4)	2.043(3)	2.353(2)	1.531(1)	5.531(–1)	8.991(–3)	2.123(–5)	7.170(–6)	3.070(–7)
	920.00	1021.03	1142.25	1289.16	1472.12	1705.36	2011.05	2430.39	3041.07	4006.89	5759.25
6	3.546(4)	6.693(4)	4.907(4)	1.931(4)	4.392(3)	5.732(2)	4.252(1)	1.668(0)	2.830(–2)	3.656(–4)	1.317(–6)
	861.71	949.73	1053.75	1177.55	1328.34	1515.35	1752.00	2061.93	2485.36	3095.07	4045.98
7	8.371(3)	1.035(4)	5.585(4)	6.121(4)	3.090(4)	8.350(3)	1.265(3)	1.058(2)	4.651(0)	9.202(–2)	1.734(–3)
	812.15	889.88	980.57	1086.90	1214.12	1368.49	1558.60	1799.19	2113.37	2538.60	3144.84
8	2.488(4)	2.624(4)	3.194(1)	3.526(4)	6.629(4)	4.397(4)	1.448(4)	2.566(3)	2.429(2)	1.231(1)	3.428(–1)
	769.57	839.02	919.18	1011.98	1121.38	1251.80	1409.01	1602.76	1847.41	2164.33	2590.00
9	1.337(4)	5.486(3)	3.287(4)	6.724(3)	1.434(4)	6.129(4)	5.675(4)	2.325(4)	4.848(3)	5.384(2)	3.329(1)
	732.70	795.38	867.07	949.17	1044.78	1157.09	1290.15	1450.73	1648.31	1896.02	2214.91
10	4.558(3)	2.502(4)	6.325(2)	2.283(4)	2.110(4)	1.581(3)	4.697(4)	6.651(4)	3.478(4)	8.807(3)	1.195(3)
	700.62	757.72	822.50	896.02	980.74	1079.06	1193.89	1330.13	1494.37	1695.16	1945.60
11	2.165(4)	1.562(3)	1.766(4)	1.149(4)	6.835(3)	3.000(4)	1.876(3)	2.684(4)	6.897(4)	4.853(4)	1.553(4)
	672.71	725.18	784.29	850.87	926.90	1014.24	1115.05	1233.00	1372.86	1540.49	1744.57
12	7.218(3)	9.100(3)	1.364(4)	3.205(3)	2.129(4)	2.154(1)	2.574(4)	1.371(4)	7.900(3)	5.981(4)	6.157(4)
	648.41	697.02	751.46	812.36	881.39	960.00	1049.84	1153.76	1275.33	1418.75	1590.05

13	7.385(2) 627.16	1.714(4) 672.52	2.558(0) 723.06	1.745(4) 779.28	1.295(3) 842.58	1.687(4) 914.14	7.340(3) 995.23	1.169(4) 1088.14	2.738(4) 1195.64	6.729(−1) 1320.81	3.936(4) 1468.05
14	1.088(4) 608.53	5.741(3) 651.15	8.692(3) 698.41	7.802(3) 750.72	6.820(3) 809.29	1.122(4) 875.09	4.411(3) 949.12	1.828(4) 1033.26	7.122(2) 1129.71	2.997(4) 1240.81	7.996(3) 1369.89
15	1.401(4) 592.16	8.719(1) 632.44	1.360(4) 676.94	1.106(1) 725.97	1.402(4) 780.60	1.196(1) 841.64	1.541(4) 909.90	3.749(2) 986.95	1.843(4) 1074.57	3.852(3) 1174.62	1.759(4) 1289.65
16	7.010(3) 577.77	5.659(3) 616.05	6.536(3) 658.19	5.713(3) 704.45	6.291(3) 755.78	6.319(3) 812.85	6.575(3) 876.35	7.023(3) 947.59	8.662(3) 1028.09	7.053(3) 1119.30	1.629(4) 1223.27
17	8.163(2) 565.09	1.062(4) 601.66	4.414(2) 641.79	1.048(4) 685.70	1.351(2) 734.23	1.096(4) 787.99	3.201(0) 847.51	1.210(4) 913.97	2.781(1) 988.63	1.499(4) 1072.68	5.472(0) 1167.80
18	5.767(2) 553.93	9.366(3) 589.03	1.154(3) 627.44	8.008(3) 669.34	2.185(3) 715.51	6.731(3) 766.46	3.733(3) 822.66	5.663(3) 885.13	5.873(3) 954.98	5.289(3) 1033.18	8.273(3) 1121.14
19	3.820(3) 544.12	4.851(3) 577.94	4.888(3) 614.88	3.020(3) 655.06	6.304(3) 699.22	1.401(3) 747.79	7.825(3) 801.20	3.455(2) 860.34	9.419(3) 926.17	5.344(−1) 999.55	1.159(4) 1081.65
20	6.708(3) 535.50	1.230(3) 568.23	7.191(3) 603.89	2.410(2) 642.61	7.483(3) 685.05	5.435(1) 731.61	7.172(3) 782.65	9.651(2) 838.98	6.229(3) 901.47	3.087(3) 970.84	5.232(3) 1048.11
21	7.542(3) 527.95	5.538(0) 559.73	6.906(3) 594.31	3.367(2) 631.77	5.747(3) 672.74	1.674(3) 717.59	3.929(3) 766.63	3.807(3) 820.60	1.901(3) 880.28	6.380(3) 946.31	4.545(2) 1019.58
22	6.596(3) 521.36	5.630(2) 552.33	5.061(3) 585.97	1.792(3) 622.35	3.147(3) 662.08	3.631(3) 705.47	1.193(3) 752.81	5.355(3) 804.79	5.563(1) 862.12	6.268(3) 925.35	4.905(2) 995.28
23	4.844(3) 515.64	1.743(3) 545.91	2.975(3) 578.75	3.159(3) 614.22	1.170(3) 652.88	4.529(3) 695.04	6.687(1) 740.94	4.996(3) 791.24	4.425(2) 846.58	4.101(3) 907.47	2.466(3) 974.64
24	3.097(3) 510.70	2.737(3) 540.38	1.395(3) 572.54	3.815(3) 607.22	2.048(2) 644.98	4.315(3) 686.09	1.587(2) 730.78	3.634(3) 779.66	1.562(3) 833.35	1.905(3) 892.28	3.832(3) 957.13
25	1.747(3) 506.46	3.239(3) 535.64	4.802(2) 567.22	3.778(3) 601.25	2.682(0) 638.24	3.488(3) 678.47	7.224(2) 722.14	2.193(3) 769.84	2.404(3) 822.13	5.697(2) 879.44	3.983(3) 942.38
26	8.677(2) 502.87	3.275(3) 531.63	8.720(1) 562.72	3.312(3) 596.19	1.740(2) 632.55	2.523(3) 672.04	1.247(3) 714.86	1.120(3) 761.57	2.687(3) 812.71	5.697(1) 868.67	3.347(3) 930.01
27	3.709(2) 499.86	2.995(3) 528.26	1.585(−2) 558.95	2.679(3) 591.96	4.289(2) 627.78	1.687(3) 666.67	1.534(3) 708.79	4.782(2) 754.68	2.530(3) 804.87	1.988(1) 859.71	2.467(3) 919.75
28	1.286(2) 497.36	2.559(3) 525.47	4.484(1) 555.83	2.053(3) 588.46	6.206(2) 623.85	1.067(3) 662.24	1.581(3) 703.78	1.604(2) 749.00	2.146(3) 798.41	1.537(2) 852.35	1.670(3) 911.34
29	3.060(1) 495.33	2.083(3) 523.20	1.170(2) 553.29	1.517(3) 585.61	7.064(2) 620.65	6.491(2) 658.63	1.459(3) 699.71	3.468(1) 744.40	1.701(3) 793.18	2.887(2) 846.40	1.071(3) 904.53
30	2.342(0) 493.70	1.635(3) 521.38	1.690(2) 551.26	1.094(3) 583.34	6.986(2) 618.10	3.862(2) 655.75	1.251(3) 696.46	1.544(0) 740.72	1.290(3) 789.01	3.631(2) 841.65	6.645(2) 899.11
31	1.057(0) 492.42	1.247(3) 519.96	1.890(2) 549.66	7.764(2) 581.55	6.287(2) 616.09	2.277(2) 653.50	1.017(3) 693.92	2.859(0) 737.85	9.499(2) 785.75	3.743(2) 837.94	4.064(2) 894.88
32	6.248(0) 491.43	9.297(2) 518.86	1.821(2) 548.44	5.451(2) 580.18	5.283(2) 614.55	1.347(2) 651.77	7.931(2) 691.97	1.116(1) 735.64	6.849(2) 783.25	3.418(2) 835.09	2.481(2) 891.63
33	1.025(1) 490.69	6.795(2) 518.03	1.590(2) 547.51	3.796(2) 579.15	4.210(2) 613.39	8.058(1) 650.46	5.987(2) 690.50	1.673(1) 733.98	4.864(2) 781.36	2.872(2) 832.95	1.527(2) 889.19

TABLE 2d. Transition Probabilities (s^{-1}) (Upper Entry) and Band Origins (nm) (Lower Entry) of the Second Negative Band System of $O_2^+(A;v' \rightarrow X;v'' = 33-43)$

	v''										
v'	33	34	35	36	37	38	39	40	41	42	43
0	−6.373(−6)	−9.087(−5)	−1.948(−4)	−1.629(−4)	−3.337(−5)	−2.065(−5)	−2.154(−4)	−4.667(−4)	−5.583(−4)	−4.224(−4)	−1.802(−4)
	−3251.42	−2649.11	−2250.17	−1967.22	−1756.32	−1593.18	−1463.45	−1358.13	−1271.17	−1198.36	−1136.64
1	−2.145(−7)	−1.952(−5)	−6.500(−5)	−7.752(−5)	−3.030(−5)	−9.555(−7)	−7.139(−5)	−2.105(−4)	−3.029(−4)	−2.700(−4)	−1.434(−4)
	−4535.91	−3443.63	−2798.63	−2373.96	−2073.50	−1849.86	−1677.23	−1540.33	−1429.43	−1338.01	−1261.53
2	−2.782(−8)	−2.631(−8)	−2.382(−9)	−1.247(−7)	−3.210(−7)	−3.275(−7)	−1.354(−7)	−1.483(−9)	−9.217(−8)	−3.220(−7)	−4.983(−7)
	−7348.41	−4854.08	−3663.84	−2968.61	−2513.21	−2192.01	−1953.73	−1770.43	−1625.48	−1508.30	−1411.81
3	−4.061(−9)	−1.162(−6)	−7.058(−6)	−1.132(−5)	−4.723(−6)	−7.027(−7)	−2.157(−5)	−6.240(−5)	−9.050(−5)	−8.046(−5)	−4.089(−5)
	−18375.19	−8041.85	−5228.06	−3918.56	−3162.21	−2669.95	−2324.61	−2069.66	−1874.28	−1720.18	−1595.79
4	4.175(−10)	−6.128(−8)	−1.575(−6)	−4.369(−6)	−2.680(−6)	−1.898(−7)	−1.218(−5)	−4.061(−5)	−6.405(−5)	−6.066(−5)	−3.291(−5)
	40773.41	−22025.20	−8902.46	−5673.80	−4214.29	−3383.04	−2847.12	−2473.87	−2199.78	−1990.49	−1825.81
5	7.496(−10)	2.876(−9)	−6.922(−9)	−7.008(−8)	−3.990(−8)	−1.945(−8)	−4.323(−7)	−1.505(−6)	−2.742(−6)	−3.076(−6)	−2.053(−6)
	9924.65	32434.99	−27704.63	−9998.49	−6209.08	−4558.75	−3636.38	−3048.86	−2643.00	−2346.56	−2121.03
6	5.756(−8)	2.818(−7)	2.154(−8)	−2.994(−9)	−1.277(−8)	−1.345(−8)	−4.982(−7)	−2.494(−6)	−5.542(−6)	−6.679(−6)	−4.250(−6)
	5737.75	9582.59	26716.59	−37749.84	−11424.73	−6857.14	−4963.42	−3929.79	−3280.49	−2835.83	−2512.92
7	7.573(−5)	1.328(−6)	6.757(−7)	8.838(−8)	−1.375(−9)	−1.716(−8)	−9.948(−7)	−3.851(−6)	−6.735(−6)	−7.596(−6)	−5.266(−6)
	4079.86	5708.47	9237.67	22556.91	−59855.28	−13331.38	−7653.94	−5445.31	−4273.31	−3548.51	−3056.97
8	8.681(−3)	3.413(−4)	1.339(−5)	5.485(−9)	1.093(−9)	−1.180(−11)	−5.945(−9)	−7.322(−7)	−3.377(−6)	−3.933(−6)	−1.312(−6)
	3192.59	4110.20	5669.86	8892.76	19450.83	−145088.95	−15991.56	−8656.09	−6028.03	−4679.68	−3860.97
9	1.291(0)	3.820(−2)	3.625(−4)	3.743(−5)	3.678(−7)	3.044(−7)	1.200(−11)	−6.273(−9)	−1.564(−7)	−2.433(−9)	−1.180(−6)
	2641.23	3239.57	4136.39	5623.14	8561.84	17095.96	350548.81	−19944.17	−9949.65	−6742.91	−5164.85
10	9.282(1)	4.510(0)	1.298(−1)	4.294(−4)	2.694(−6)	1.441(−5)	6.386(−8)	1.908(−9)	−2.565(−8)	−5.704(−8)	−1.423(−6)
	2267.03	2694.13	3286.76	4160.93	5577.51	8265.31	15302.95	80943.88	−26307.57	−11653.68	−7626.46
11	2.622(3)	2.535(2)	1.461(1)	4.476(−1)	4.003(−3)	9.455(−5)	1.473(−5)	2.316(−6)	6.957(−9)	−4.037(−9)	−1.839(−7)
	1998.67	2323.40	2751.20	3338.25	4192.55	5548.94	8027.37	13970.16	47136.37	−37618.19	−13909.08
12	2.568(4)	5.445(3)	6.518(2)	4.554(1)	1.698(0)	2.903(−2)	5.581(−4)	1.057(−5)	2.776(−6)	6.639(−8)	−1.336(−10)
	1798.44	2057.16	2385.60	2814.83	3398.79	4238.75	5547.00	7856.38	13000.68	34339.36	−61760.88
13	6.835(4)	3.869(4)	1.052(4)	1.581(3)	1.363(2)	6.348(0)	1.587(−1)	3.020(−3)	9.835(−6)	1.117(−6)	1.705(−7)
	1643.93	1857.46	2121.14	2453.84	2886.12	3470.04	4300.32	5569.54	7741.02	12287.42	27722.72
14	1.541(4)	6.318(4)	5.202(4)	1.870(4)	3.581(3)	3.852(2)	2.280(1)	7.557(−1)	1.544(−2)	6.718(−5)	1.191(−9)
	1521.81	1703.04	1922.12	2191.36	2529.73	2967.40	3554.24	4379.02	5618.12	7680.64	11780.65
15	2.418(4)	8.478(2)	4.413(4)	6.014(4)	2.985(4)	7.418(3)	1.010(3)	7.641(1)	3.287(0)	7.990(−2)	5.849(−4)
	1423.43	1580.77	1767.80	1993.00	2269.03	2614.98	3060.24	3652.59	4476.02	5694.29	7674.47
16	2.616(3)	3.154(4)	4.765(3)	1.857(4)	5.672(4)	4.162(4)	1.382(4)	2.428(3)	2.369(2)	1.313(1)	3.971(−1)
	1342.99	1482.19	1645.41	1838.81	2071.28	2355.78	2711.15	3166.01	3766.64	4593.67	5801.20

17	2.021(4)	2.182(3)	2.055(4)	2.097(4)	1.463(3)	3.929(4)	4.867(4)	2.264(4)	5.267(3)	6.702(2)	4.800(1)
	1276.43	1401.53	1546.60	1716.27	1917.11	2158.36	2452.94	2819.43	3286.06	3898.37	4734.74
18	7.360(3)	8.993(3)	1.520(4)	3.489(3)	2.942(4)	3.957(3)	1.543(4)	4.481(4)	3.164(4)	1.009(4)	1.699(3)
	1220.89	1334.85	1465.80	1617.33	1794.49	2004.18	2255.72	2561.97	2941.54	3422.78	4051.08
19	1.427(2)	1.536(4)	1.200(1)	2.027(4)	2.041(3)	1.819(4)	1.882(4)	7.307(2)	2.867(4)	3.600(4)	1.662(4)
	1174.21	1279.25	1399.02	1536.42	1695.42	1881.39	2101.37	2364.69	2684.41	3079.54	3578.96
20	5.978(3)	5.175(3)	8.590(3)	7.534(3)	8.098(3)	1.502(4)	2.057(3)	2.433(4)	4.721(3)	8.877(3)	3.070(4)
	1134.79	1232.60	1343.42	1469.62	1614.44	1782.20	1978.38	2210.08	2486.91	2822.41	3236.30
21	9.016(3)	2.861(0)	1.182(4)	4.202(1)	1.509(4)	7.742(1)	1.737(4)	3.336(3)	1.170(4)	1.682(4)	2.252(0)
	1101.41	1193.32	1296.90	1414.12	1547.72	1701.23	1879.11	2086.92	2332.04	2624.59	2978.86
22	6.282(3)	2.494(3)	5.941(3)	5.005(3)	6.451(3)	6.236(3)	9.102(3)	4.283(3)	1.452(4)	1.936(2)	1.663(4)
	1073.12	1160.18	1257.85	1367.83	1492.43	1634.67	1798.23	1987.63	2208.75	2469.46	2780.60
23	2.444(3)	5.505(3)	9.644(2)	8.520(3)	3.034(2)	1.100(4)	2.713(2)	1.246(4)	1.274(3)	1.106(4)	5.827(3)
	1049.15	1132.22	1225.05	1329.13	1446.48	1579.70	1731.93	1906.95	2109.56	2346.13	2625.21
24	3.614(2)	5.890(3)	8.056(1)	6.980(3)	1.065(3)	7.527(3)	2.168(3)	8.371(3)	2.042(3)	1.012(4)	5.060(2)
	1028.90	1108.67	1197.53	1296.79	1408.26	1534.23	1677.43	1841.08	2029.25	2247.22	2501.99
25	2.951(1)	4.460(3)	1.281(3)	3.712(3)	3.671(3)	2.663(3)	5.954(3)	2.075(3)	7.084(3)	2.440(3)	6.415(3)
	1011.87	1088.92	1174.51	1269.84	1376.54	1496.66	1632.61	1787.24	1964.03	2167.51	2403.58
26	4.901(2)	2.691(3)	2.482(3)	1.303(3)	4.878(3)	2.984(2)	6.650(3)	4.253(0)	7.529(3)	1.035(1)	7.822(3)
	997.63	1072.44	1155.37	1247.50	1350.32	1465.72	1595.86	1743.29	1911.09	2103.21	2324.77
27	1.015(3)	1.353(3)	2.953(3)	2.247(2)	4.526(3)	7.463(1)	5.089(3)	7.870(2)	4.934(3)	1.482(3)	4.791(3)
	985.83	1058.83	1139.58	1229.11	1328.80	1440.40	1565.89	1707.59	1868.27	2051.47	2261.71
28	1.312(3)	5.682(2)	2.803(3)	2.311(−1)	3.473(3)	6.250(2)	3.118(3)	1.967(3)	2.339(3)	3.067(3)	1.802(3)
	976.17	1047.69	1126.69	1214.13	1311.31	1419.86	1541.66	1678.81	1833.87	2010.07	2211.49
29	1.362(3)	1.914(2)	2.344(3)	1.107(2)	2.385(3)	1.121(3)	1.641(3)	2.533(3)	8.155(2)	3.509(3)	3.557(2)
	968.36	1038.70	1116.30	1202.07	1297.26	1403.40	1522.27	1655.85	1806.51	1977.24	2171.82
30	1.247(3)	4.480(1)	1.816(3)	2.620(2)	1.535(3)	1.325(3)	7.691(2)	2.492(3)	1.825(2)	3.117(3)	3.763(0)
	962.15	1031.56	1108.06	1192.52	1286.14	1390.40	1506.99	1637.78	1785.02	1951.53	2140.84
31	1.051(3)	3.841(0)	1.344(3)	3.488(2)	9.545(2)	1.285(3)	3.279(2)	2.127(3)	1.124(1)	2.428(3)	7.253(1)
	957.31	1025.99	1101.63	1185.08	1277.49	1380.30	1495.13	1623.78	1768.41	1931.69	2116.99
32	8.382(2)	8.666(−1)	9.654(2)	3.629(2)	5.862(2)	1.111(3)	1.287(2)	1.673(3)	7.909(0)	1.762(3)	1.961(2)
	953.59	1021.73	1096.72	1179.40	1270.89	1372.60	1486.09	1613.13	1755.78	1916.63	2098.91
33	6.408(2)	6.287(0)	6.808(2)	3.283(2)	3.606(2)	8.917(2)	4.671(1)	1.251(3)	3.713(1)	1.229(3)	2.600(2)
	950.81	1018.53	1093.03	1175.14	1265.94	1366.83	1479.33	1605.17	1746.35	1905.40	2085.45

TABLE 2e. Transition Probabilities (s^{-1}) (Upper Entry) and Band Origins (nm) (Lower Entry) of the Second Negative Band System of $O_2^+(A;v' \rightarrow X;v'' = 44 - 54)$

	v''										
v'	44	45	46	47	48	49	50	51	52	53	54
0	−1.602(−5)	−3.433(−5)	−2.144(−4)	−4.565(−4)	−6.538(−4)	−7.420(−4)	−7.110(−4)	−5.915(−4)	−4.310(−4)	−2.727(−4)	−1.449(−4)
	−1083.78	−1038.14	−998.47	−963.80	−933.38	−906.60	−882.95	−862.03	−843.51	−827.10	−812.57
1	−2.690(−5)	−6.239(−6)	−9.527(−5)	−2.449(−4)	−3.852(−4)	−4.644(−4)	−4.651(−4)	−4.010(−4)	−3.013(−4)	−1.966(−4)	−1.083(−4)
	−1196.75	−1141.34	−1093.57	−1052.12	−1015.98	−984.32	−956.51	−932.01	−910.39	−891.30	−874.45
2	−5.097(−7)	−3.789(−7)	−2.004(−7)	−6.155(−8)	−2.341(−9)	−1.680(−8)	−7.483(−8)	−1.436(−7)	−1.997(−7)	−2.323(−7)	−2.405(−7)
	−1331.17	−1262.97	−1204.73	−1154.62	−1111.24	−1073.48	−1040.48	−1011.56	−986.14	−963.78	−944.11
3	−5.793(−6)	−4.658(−6)	−4.232(−5)	−1.008(−4)	−1.543(−4)	−1.834(−4)	−1.819(−4)	−1.551(−4)	−1.150(−4)	−7.338(−5)	−3.890(−5)
	−1493.53	−1408.20	−1336.19	−1274.83	−1222.15	−1176.63	−1137.10	−1102.64	−1072.51	−1046.12	−1022.98
4	−5.467(−6)	−2.823(−6)	−3.134(−5)	−7.845(−5)	−1.236(−4)	−1.503(−4)	−1.519(−4)	−1.320(−4)	−9.981(−5)	−6.518(−5)	−3.566(−5)
	−1693.17	−1584.34	−1493.76	−1417.49	−1352.65	−1297.12	−1249.25	−1207.78	−1171.72	−1140.29	−1112.86
5	−5.474(−7)	−3.303(−8)	−1.328(−6)	−4.043(−6)	−6.995(−6)	−9.014(−6)	−9.513(−6)	−8.581(−6)	−6.745(−6)	−4.634(−6)	−2.742(−6)
	−1944.10	−1801.99	−1685.72	−1589.22	−1508.18	−1439.46	−1380.74	−1330.26	−1286.65	−1248.85	−1216.02
6	−7.795(−7)	−4.415(−7)	−5.088(−6)	−1.313(−5)	−2.107(−5)	−2.574(−5)	−2.574(−5)	−2.168(−5)	−1.545(−5)	−9.127(−6)	−4.168(−6)
	−2268.34	−2077.20	−1924.22	−1799.48	−1696.27	−1609.84	−1536.75	−1474.48	−1421.09	−1375.12	−1335.42
7	−1.192(−6)	−5.399(−7)	−7.912(−6)	−2.209(−5)	−3.687(−5)	−4.610(−5)	−4.725(−5)	−4.144(−5)	−3.168(−5)	−2.105(−5)	−1.183(−5)
	−2702.49	−2435.48	−2227.82	−2062.32	−1927.88	−1817.00	−1724.43	−1646.40	−1580.12	−1523.49	−1474.92
8	−9.891(−10)	−1.003(−6)	−2.914(−6)	−5.530(−6)	−9.419(−6)	−1.444(−5)	−1.906(−5)	−2.109(−5)	−1.942(−5)	−1.476(−5)	−9.071(−6)
	−3312.24	−2919.90	−2626.39	−2399.39	−2219.33	−2073.66	−1953.96	−1854.37	−1770.71	−1699.90	−1639.65
9	−2.360(−6)	−6.621(−7)	−3.517(−7)	−3.168(−6)	−4.705(−6)	−3.070(−6)	−8.071(−7)	−1.674(−9)	−2.840(−7)	−5.380(−7)	−3.828(−7)
	−4227.89	−3608.92	−3170.93	−2845.86	−2596.04	−2398.92	−2240.16	−2110.24	−2002.57	−1912.47	−1836.55
10	−1.684(−6)	−4.010(−12)	−3.547(−6)	−1.011(−5)	−1.085(−5)	−5.756(−6)	−1.159(−6)	−1.221(−8)	−7.133(−7)	−1.157(−6)	−8.585(−7)
	−5746.12	−4659.89	−3954.58	−3461.48	−3098.78	−2821.99	−2604.83	−2430.80	−2289.04	−2172.08	−2074.66
11	−1.300(−7)	−5.070(−8)	−3.098(−7)	−8.754(−10)	−1.573(−6)	−7.383(−6)	−1.419(−5)	−1.667(−5)	−1.345(−5)	−7.449(−6)	−2.406(−6)
	−8710.54	−6436.23	−5164.11	−4354.14	−3795.35	−3388.31	−3080.00	−2839.62	−2648.04	−2492.76	−2365.30
12	−1.193(−7)	−8.401(−7)	−1.020(−6)	−3.838(−7)	−6.109(−8)	−8.717(−8)	−6.397(−7)	−2.308(−6)	−4.610(−6)	−6.119(−6)	−5.930(−6)
	−16920.63	−10033.47	−7249.52	−5748.36	−4812.87	−4176.61	−3717.87	−3373.19	−3106.22	−2894.71	−2724.24
13	−3.285(−10)	−2.808(−9)	−5.723(−7)	−2.335(−6)	−2.869(−6)	−1.339(−6)	−9.058(−8)	−1.658(−7)	−4.995(−7)	−3.551(−7)	−5.090(−8)
	−146274.03	−21095.53	−11671.71	−8216.95	−6430.32	−5342.86	−4614.50	−4095.13	−3708.22	−3410.70	−3176.50
14	1.275(−7)	3.499(−12)	−1.461(−8)	−6.828(−9)	−4.799(−7)	−1.741(−6)	−2.391(−6)	−1.518(−6)	−2.956(−7)	−5.129(−8)	−7.035(−7)
	23822.59	709202.75	−27126.87	−13720.03	−9372.08	−7227.92	−5956.12	−5118.25	−4527.80	−4091.96	−3759.41
15	3.474(−6)	1.337(−7)	9.034(−10)	−1.923(−8)	−6.775(−8)	−6.054(−9)	−1.551(−7)	−8.929(−7)	−1.724(−6)	−1.821(−6)	−1.123(−6)
	11442.42	21355.11	116913.39	−36404.70	−16317.81	−10760.18	−8164.76	−6668.36	−5699.93	−5026.03	−4533.47
16	4.790(−3)	3.791(−5)	2.168(−7)	4.871(−9)	−9.605(−9)	−9.177(−8)	−1.185(−7)	−3.158(−8)	−2.217(−8)	−2.839(−7)	−7.566(−7)
	7723.79	11248.19	19751.39	68460.21	−52065.08	−19662.11	−12437.58	−9269.05	−7498.24	−6373.97	−5602.06

17	1.858(0)	3.306(−2)	3.103(−4)	6.932(−7)	7.290(−9)	−2.701(−9)	−8.065(−8)	−1.949(−7)	−1.907(−7)	−7.523(−8)	−6.092(−14)
	5941.88	7829.02	11178.67	18714.76	50968.40	−83108.18	−24053.06	−14480.33	−10577.77	−8470.16	−7159.28
18	1.585(2)	7.977(0)	1.965(−1)	2.306(−3)	6.316(−6)	1.736(−9)	−3.042(−10)	−4.807(−8)	−1.661(−7)	−2.138(−7)	−1.422(−7)
	4903.40	6120.96	7993.66	11226.26	18095.25	42353.85	−168587.34	−29925.69	−16979.43	−12133.22	−9612.08
19	3.794(3)	4.669(2)	3.087(1)	1.029(0)	1.583(−2)	6.989(−5)	3.748(−8)	−6.648(−13)	−1.758(−8)	−9.418(−8)	−1.740(−7)
	4228.28	5103.71	6342.67	8220.99	11386.13	17801.95	37549.71	−1172204.18	−37976.91	−20058.04	−13991.34
20	2.259(4)	7.270(3)	1.205(3)	1.060(2)	4.753(0)	9.871(−2)	6.879(−4)	1.179(−6)	4.732(−11)	−5.635(−9)	−3.533(−8)
	3758.17	4434.20	5340.57	6612.73	8517.18	11660.81	17788.82	34806.08	307511.56	−49330.05	−23872.58
21	1.641(4)	2.382(4)	1.156(4)	2.667(3)	3.174(2)	1.923(1)	5.465(−1)	5.818(−3)	1.747(−5)	1.230(−9)	−3.575(−9)
	3415.41	3964.73	4673.99	5620.26	6938.96	8891.94	12059.95	18039.26	33382.34	155462.33	−65854.36
22	6.314(3)	2.884(3)	1.737(4)	1.452(4)	4.910(3)	8.114(2)	6.730(1)	2.645(0)	4.164(−2)	1.868(−4)	2.359(−8)
	3157.30	3621.09	4203.70	4953.84	5950.62	7331.52	9358.47	12599.13	18555.67	32929.01	114273.79
23	4.304(3)	1.330(4)	7.397(2)	6.514(3)	1.321(4)	7.198(3)	1.723(3)	1.999(2)	1.097(1)	2.488(−1)	1.638(−3)
	2958.46	3361.95	3858.43	4481.28	5281.60	6341.80	7803.85	9934.70	13301.65	19359.17	33291.56
24	1.153(4)	6.189(2)	7.845(3)	6.850(3)	1.611(2)	7.241(3)	7.836(3)	2.921(3)	4.905(2)	3.815(1)	1.238(0)
	2802.89	3162.48	3597.99	4133.75	4805.45	5667.50	6807.24	8373.95	10645.17	14201.37	20492.52
25	4.202(3)	3.598(3)	7.145(3)	2.572(2)	7.475(3)	2.183(3)	1.238(3)	5.540(3)	3.723(3)	9.580(2)	1.084(2)
	2679.98	3006.88	3397.93	3871.85	4455.12	5186.49	6124.96	7364.76	9065.93	11523.45	15346.34
26	1.977(1)	7.398(3)	6.163(2)	5.322(3)	2.760(3)	1.514(3)	4.808(3)	2.948(2)	1.777(3)	3.209(3)	1.412(3)
	2582.36	2884.54	3242.53	3671.35	4191.72	4832.95	5637.91	6671.72	8038.09	9912.36	12615.64
27	1.484(3)	4.986(3)	7.718(2)	5.223(3)	3.525(1)	4.511(3)	5.572(2)	2.041(3)	2.234(3)	4.383(0)	1.479(3)
	2504.79	2788.09	3121.15	3516.52	3991.08	4568.17	5280.84	6177.44	7331.34	8859.19	10957.75
28	3.416(3)	1.707(3)	2.965(3)	2.029(3)	1.838(3)	2.568(3)	5.230(2)	2.692(3)	1.154(1)	1.632(3)	7.285(2)
	2443.34	2712.17	3026.31	3396.59	3837.31	4367.84	5014.94	5816.67	6828.69	8135.54	9871.67
29	3.824(3)	2.087(2)	3.613(3)	2.531(2)	2.968(3)	4.913(2)	1.936(3)	9.046(2)	7.806(2)	1.201(3)	5.754(1)
	2395.01	2652.74	2952.52	3303.91	3719.43	4215.75	4815.49	5550.04	6464.12	7623.31	9127.49
30	3.195(3)	1.995(1)	2.974(3)	2.781(1)	2.597(3)	1.142(0)	2.068(3)	4.155(1)	1.380(3)	2.103(2)	6.493(2)
	2357.39	2606.67	2895.55	3232.74	3629.49	4100.57	4665.78	5352.12	6197.20	7254.81	8604.21
31	2.305(3)	2.409(2)	2.026(3)	3.070(2)	1.738(3)	2.277(2)	1.453(3)	8.840(1)	1.129(3)	4.890(0)	7.531(2)
	2328.50	2571.39	2852.09	3178.66	3561.45	4013.94	4553.95	5205.48	6001.44	6987.97	8231.43
32	1.543(3)	4.285(2)	1.255(3)	5.296(2)	1.017(3)	4.656(2)	8.354(2)	3.016(2)	6.754(2)	1.359(2)	5.045(2)
	2306.65	2544.77	2819.38	3138.08	3510.59	3949.45	4471.12	5097.54	5858.43	6794.83	7964.74
33	9.974(2)	4.879(2)	7.462(2)	5.876(2)	5.588(2)	5.410(2)	4.354(2)	3.999(2)	3.466(2)	2.392(2)	2.653(2)
	2290.41	2525.02	2795.14	3108.09	3473.10	3902.06	4410.49	5018.87	5754.76	6655.76	7774.34

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