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Fourier transform emission spectroscopy of the second negative ($A^2\Pi_u$- $X^2\Pi_g$) system of the O_2^+ ion

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The second negative ($A^2\Pi_u$- $X^2\Pi_g$) system of the O_2^+ ion was produced in a tungsten hollow cathode discharge tube using oxygen in neon. This spectrum was recorded with the McMath–Pierce Fourier transform spectrometer of the National Solar Observatory. A total of ten bands with $v' = 0$ and 1 and $v'' = 6$ to 12 in the range 15 945–30 218 cm^{-1} were observed and rotationally analysed. The line positions of all these bands, along with those of a few additional bands available in the literature, were combined in a global least-squares fit. Many molecular parameters for the various vibrational levels and the equilibrium molecular constants for the X and A states were estimated. RKR potential energy curves were constructed and Franck–Condon factors were calculated for the vibrational bands of the second negative (A–X) system. Some additional information obtained from threshold photoelectron spectroscopy was used to extend the $X^2\Pi_g$ potential curve up to $v = 24$.

1. Introduction

Oxygen, being one of the most abundant constituents in the Earth's atmosphere, is of great interest to many different researchers. The oxygen molecule (O_2) and its ions have been investigated by spectroscopists for more than a century. The band systems of molecular oxygen and its ions play a significant role in the aurora, airglow and nightglow [1, 2]. Molecular oxygen may also be an important astronomical molecule although it is difficult to detect from the surface of the Earth. The microwave spectrum (60 GHz) of molecular oxygen [3] is suggested as a useful probe of the thermal structure of the Earth's atmosphere. While the Schumann–Runge ($B^3\Sigma_u^-$- $X^3\Sigma_g^-$) band system in the spectral region 1750–5350 Å is the only prominent electric dipole transition of molecular oxygen, the singly ionized molecular ion O_2^+ has three allowed electric dipole transitions: the first negative ($b^4\Sigma_g^-$- $a^4\Pi_u$) system (4990–8530 Å), the second negative ($A^2\Pi_u$- $X^2\Pi_g$) system (1940–6530 Å), and the Hopfield ($c^4\Sigma_u^-$- $b^4\Sigma_g^-$) system (1940–2360 Å). The second negative system of O_2^+ is the subject of this paper.

Although the first spectroscopic observation of the second negative system of O_2^+ was made in 1914 by Stark [4], the emitter was not correctly identified as O_2^+ until the work of Stevens [5] in 1931. Almost 120 bands of this system were observed at low resolution and significant contributions were made by several researchers [6–12]. The vibrational assignments for these bands were originally made by Birge in 1925 and soon the v'' number became a topic for further investigations. Mulliken [13] used Birge's original numbering in his review article on the interpretation of band spectra. Mulliken and Stevens [14] increased the v'' values proposed by Birge by two units. Later on Bhale and Rao [12] in 1968 made an upward revision of Mulliken and Steven's [14] lower state vibrational quantum numbers by one more unit. Albritton *et al.* [15], Edqvist *et al.* [16] and Jonathan *et al.* [17] calculated the Franck–Condon factors for the $A^2\Pi_u$- $X^2\Pi_g$ system of O_2^+, $O_2^+ X^2\Pi_g$ $O_2 X^3\Sigma_g^-$, and $O_2^+ X^2\Pi_g$ $O_2 a^1\Delta_g$ transitions, respectively, using the vibrational numbering of the $X^2\Pi_g$ state proposed by Bhale and Rao [12] and confirmed that the latest revision of v'' numbering is the correct one.

The rotational and fine structure analysis of the second negative system is not as extensive as the low resolution work. Stevens [5] and Bozoky [18] were the first to perform rotational analyses of some of these bands. Stevens [5], who presented the first rotational analysis of this system, erroneously concluded that the upper state is a regular Π state. He analysed only the bands with $v' = 0$ and 1. The work of Bozoky [18], in which the bands with $v' = 0$, 1, 5, 6, 7 and 8 were rotationally analysed, demonstrated that the spin–orbit coupling constant varies from negative at low v to positive at high v. Bhale [19] analysed the rotational structure of the 0–8 and 1–7 bands. On the basis of first lines in each branch and their intensities Bhale concluded that the upper state of these two bands is indeed an inverted state. Raftery and Richards [20] calculated that the spin–orbit coupling constant for the $A^2\Pi_u$ state varies from positive at low v to negative at high v. However, this proposal was convincingly disproved by subsequent researchers. Albritton *et al.* [21] and also more recently Coxon and Haley [22] determined the spin–orbit coupling constants for the vibrational levels of the A state using least-squares fitting techniques and confirmed Bhale's [19] conclusions.

Significant contributions to the rotational analysis of the bands of the second negative system of O_2^+ came from the work of Albritton *et al.* [21], Bhale and Narasimham [23], and Colbourn and Douglas [24]. While Albritton *et al.* [21] were the first to perform least-squares fits of the data of this band system, Bhale and Narasimham [23] re-photographed and analysed some of the bands analysed by Stevens [5] and Bozoky [18] at a higher dispersion (0·55 Å mm^{-1}) than their predecessors. Colbourn and Douglas [24] extended the rotational analysis to bands with high v' values, $v' = 11$ to 15, and $v'' = 0$ and 1. For the literature on the second negative system of O_2^+ prior to 1977, the reader is referred to the review article by Krupenie [25] and Huber and Herzberg [26].

Spectroscopic work on the second negative system of O_2^+ in the 1980s and the 1990s is limited. Coxon and Haley [22] combined their data of this system obtained from grating spectra with that of Colbourn and Douglas [24] and performed a comprehensive least-squares analysis using an effective $^2\Pi$ Hamiltonian and the method of merging. Schappe *et al.* [27] produced this band system in emission and measured optical-emission cross-sections for $v' = 0$ to 13. Yeager *et al.* [28] obtained potential energy curves for various electronic states of the O_2^+ molecule using the multiconfigurational spin tensor electron propagator (MCSTEP) method. They also reported the molecular constants obtained using the MCSTEP method. Kong and Hepburn [29], in their photoelectron spectroscopic study of O_2 using coherent XUV, observed high vibrational levels (up to $v = 24$) of the $X^2\Pi_g$ state of O_2^+.

In the present study we investigated the second negative ($A^2\Pi_u$-$X^2\Pi_g$) system of O_2^+, in the spectral region 15 945–30 218 cm^{-1}, produced in a tungsten hollow cathode source and recorded using a Fourier transform spectrometer. Ten bands with $v' = 0$ and 1 and $v'' = 6$ to 12 were observed and their rotational structure analysed. The rotational structure of the 0–11 and 0–12 bands are analysed for the first time and that of the 0–10 band is analysed for the first time since the initial analysis of Bozoky [18] in 1937. The wavenumber data obtained from our Fourier transform spectra were combined with selected data of Coxon and Haley [22] in a global least-squares fit. For the first time, using the data of Kong and Hepburn [29], the RKR potential energy curve for the $X^2\Pi_g$ state of this molecule is extended up to the vibrational level $v = 24$. Franck–Condon factors for the vibrational bands of the second negative (A–X) system were also calculated.

2. Experimental details

The second negative ($A^2\Pi_u$-$X^2\Pi_g$) system of the O_2^+ ion was produced by accident in a tungsten hollow cathode discharge. The original goal was to record a spectrum of WO. Oxygen at a pressure of 0·2 Torr and 3·5 Torr of neon were used in a continuous fast flow for the production of the O_2^+ ions in a discharge with 221 mA of current. The radiation emitted by O_2^+ was directed into the entrance aperture of the McMath-Pierce Fourier transform spectrometer of the National Solar Observatory at Kitt Peak. Eight scans were co-added in 54 min of integration at a resolution of 0·03 cm^{-1}. Silicon photodiode detectors were used with $CuSO_4$ optical filters to limit the spectral region to 15 900–30 200 cm^{-1}. The O_2^+ spectrum recorded in this source contained many atomic lines of neon and this enabled us to calibrate the spectrum using the line positions reported by Palmer and Engleman [30]. No calibration factor was necessary.

3. Analysis and results

The bands of the second negative ($A^2\Pi_u$-$X^2\Pi_g$) system of the O_2^+ ion show double-headed features that are degraded to longer wavelengths. In the present work ten bands with $v' = 0$ and 1, and $v'' = 6$ to 12 were observed in the spectral region of 18 500–30 210 cm^{-1}. The tungsten hollow cathode discharge used in our work provided a very intense spectrum of O_2^+. In the case of the strong 0–8 to 0–12 bands, the rotational energy levels higher than $J = 50$ were populated. The bands of the second negative system in the 16 000–18 500 cm^{-1} region are severely overlapped by the stronger bands of the first negative ($b^4\Sigma_g^-$-$a^4\Pi_u$) system. Hence in this spectral region, no rotational analysis was performed in spite of having a rich spectrum of O_2^+.

The computer program PC-DECOMP, developed by J. W. Brault at the National Solar Observatory, was used to measure the line positions. The rotational line profiles were fitted to Voigt lineshape functions. The strong lines show 'ringing' caused by the (sin x/x) lineshape function of the Fourier transform spectrometer. The ringing was eliminated by using the 'filter fitting' option. The signal-to-noise ratio is about 25 for the intense lines in the spectrum. The rotational quantum numbers and the vacuum wavenumbers of the spectral lines of the 10 bands observed in the present work are listed in table 1.

The two electronic states $X^2\Pi_g$ and $A^2\Pi_u$ involved in the second negative system of O_2^+ belong to Hund's case (a) and Hund's case (b) respectively. For the vibrational level of the $A^2\Pi_u$ state, the spin–orbit coupling constants are not only very small (for $v = 0$, $A_v = -3{\cdot}5\ \mathrm{cm}^{-1}$) but change sign for the vibrational levels above $v = 6$. Eight different branches, four P and four R, are identified for each vibrational band. The satellite Q branches that are expected in a Π–Π transition are not observed in our spectra because the weak Q branches are completely overlapped by the stronger P and R branches. In our earlier work on the Swan ($^3\Pi$-$^3\Pi$) system of the C_2 molecule [31], the satellite Q branches were observed in the spectrum produced in a supersonic jet source but not in the spectrum produced in a hollow cathode source.

The O_2^+ ion is a homonuclear diatomic molecule and the nuclear spin I of oxygen is zero. Hence the antisymmetric (a) energy levels are not populated [32]. Since the s/a symmetry (associated with the permutation of the two identical nuclei) alternates with J, every alternate spectral line is missing in the spectrum. For a $^2\Pi$-$^2\Pi$ transition this effect is not obvious because of the two-fold orbital degeneracy of the Π states. In this case one of the two Λ-doublets is missing for each J and, apart from the slight 'staggering' of the lines in a branch, the spectrum has a normal appearance. In table 1, the spectral lines with even $(J - \frac{1}{2})$ values represent an $e \rightarrow e$ transition and those with odd $(J - \frac{1}{2})$ values represent an $f \rightarrow f$ transition.

Initially, band-by-band fits of the wavenumber data of table 1 were made using the effective $\mathbf{N}^2$ Hamiltonian of Brown *et al.* [33]. The matrix elements for a $^2\Pi$ state were explicitly listed by Amiot *et al.* [34]. In the present work, wavenumber data of the 2–5, 2–6, 3–4, 4–2, 4–4, 4–5, 5–3, and 5–11 bands from Coxon and Haley [22] were combined with our Fourier transform data, in the final global least-squares fit. Initially, many other bands from Coxon and Haley [22] were included in our fit. However, our least-squares fits indicated problems with systematic errors in their data, so that only the data from the eight bands mentioned above were used. The data from Colbourn and Douglas [24], used by Coxon and Haley [22], were not used in our global fit because of their fragmentary nature. Our final data set contained more than 4000 transitions that were fitted together simultaneously in a nonlinear least-squares fit and 122 parameters were estimated. The variance of this global fit was 1·667. Of the 122 parameters estimated in this fit 82 of them A_v, B_v, D_v, $q_v$and p_v for the levels $v = 2$ to 12, T_v and A_{D_v} for $v = 3$ to 12, H_v for $v = 8$ to 11, and p_{D_v} for $v = 9$ to 11 were for the $X^2\Pi_g$ state and the remaining 40, T_v, A_v, A_{D_v}, B_v, D_v, q_v and p_v for the levels $v = 0$ to 5 (A_{D_v} and q_v were not estimated for the $v = 2$ level) were for the $A^2\Pi_u$ state. All these parameters along with one standard deviation errors are listed in table 2 for the $X^2\Pi_g$ state and in table 3 for the $A^2\Pi_u$ state. In table 1, the observed minus calculated values obtained for the line positions using the constants listed in tables 2 and 3 are also listed. The obs.- calc. values are not given for a few spectral lines which were not included in the least-squares fit. The molecular constants reported in tables 2 and 3 are an improvement on the previous work because the majority of the measurements were made with a Fourier transform spectrometer.

Kong and Hepburn [29], in their recent study of the threshold photoelectron spectrum of O_2 using coherent XUV radiation, observed several vibrational levels (up to $v = 24$, except $v = 22$) of the $X^2\Pi_g$ state of the O_2^+ ion. The T_v values reported by them for the vibrational levels $v = 13$ to 24 were used in our work. Their term values were shifted linearly to bring them to the same wavenumber scale as the term values obtained from the constants in table 2. The B_v and T_v values listed in table 3 for the $A^2\Pi_u$ state and those listed in table 2 for the $X^2\Pi_g$ state, along with the adjusted term values for the $v = 13$ to 24 levels were fitted to the usual polynomial expressions [32] in powers of $(v + \frac{1}{2})$ to obtain equilibrium molecular constants. From these fits the equilibrium constants B_e, α_e, γ_e, etc., and ω_e, $\omega_e x_e$, $\omega_e y_e$, etc., were estimated for the $X^2\Pi_g$ and $A^2\Pi_u$ states, and reported along with one standard deviation in table 4. The equilibrium internuclear distance, r_e, is calculated using the corresponding B_e value for the X and A states and is given in the same table.

The RKR potential energy curve for the X state was calculated using the equilibrium constants given in table 4. The RKR turning points obtained for the observed vibrational levels of the X state are listed, for convenience, in table 5. The RKR potential energy curve is shown in figure 1. The potential energy curve for the

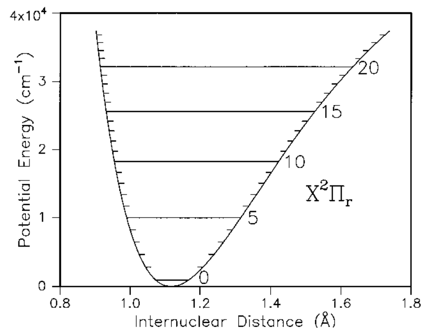

Figure 1. The RKR potential energy curve for the $X^2\Pi_g$ state of the O_2^+ ion.

Table 1. Vacuum wavenumbers[a,b] (in cm^{-1}) for the rotational lines of the bands of the second negative ($A\,^2\Pi_u$-$X\,^2\Pi_g$) system of the O_2^+ molecule.

J	R_{11}	R_{12}	R_{21}	R_{22}	P_{11}	P_{12}	P_{21}	P_{22}
				0–12 band				
1·5					19 840·927 (- 14)			
2·5	19 851·826 (28)		19 841·874 (0)	19 654·015 (3)	19 837·558 (2)			
3·5	19 852·030 (2)		19 840·314 (1)	19 652·366 (8)	19 833·426 (- 5)			19 637·320 (4)
4·5	19 851·826 (- 15)	19 663·605 (- 7)	19 838·152 (- 1)	19 649·921 (- 3)	19 828·911 (- 1)		19 818·994 (7)	19 630·757 (- 2)
5·5	19 850·575 (22)	19 662·183 (6)	19 834·961 (6)	19 646·585 (6)	19 823·388 (6)	19 635·008 (0)	19 811·661 (- 7)	19 623·297 (5)
6·5	19 848·952 (10)	19 660·174 (1)	19 831·291 (- 1)	19 642·523 (0)	19 817·511 (3)	19 628·738 (0)	19 803·832 (12)	19 615·052 (2)
7·5	19 846·101 (- 1)	19 657·132 (0)	19 826·495 (5)	19 637·498 (- 24)	19 810·461 (- 4)	19 621·498 (3)	19 794·864 (- 2)	19 605·905 (8)
8·5	19 843·040 (- 4)	19 653·561 (- 0)	19 821·342 (- 3)	19 631·869 (6)	19 803·169 (1)	19 613·689 (3)	19 785·521 (2)	19 596·026 (- 10)
9·5	19 838·638 (1)	19 648·904 (1)	19 814·955 (4)	19 625·220 (3)	19 794·581 (4)	19 604·837 (- 5)	19 774·972 (7)	19 585·237 (6)
10·5	19 834·117 (- 4)	19 643·718 (- 39)	19 808·327 (- 4)	19 617·963 (- 5)	19 785·833 (- 3)	19 595·479 (7)	19 764·135 (- 3)	19 573·778 (4)
11·5	19 828·150 (8)	19 637·498 (24)	19 800·357 (6)	19 609·683 (1)	19 775·688 (4)	19 585·015 (- 0)	19 751·993 (- 6)	19 561·331 (1)
12·5	19 822·154 (- 6)	19 630·757 (7)	19 792·257 (- 1)	19 600·843 (- 4)	19 765·487 (- 3)	19 574·081 (2)	19 739·702 (2)	19 548·286 (- 3)
13·5	19 814·607 (2)	19 622·838 (1)	19 782·689 (- 4)	19 590·921 (- 3)	19 753·774 (3)	19 562·006 (3)	19 725·983 (3)	19 534·214 (2)
14·5	19 807·154 (2)	19 614·532 (- 0)	19 773·118 (- 9)	19 580·504 (- 3)	19 742·109 (- 7)	19 549·493 (- 4)	19 712·215 (0)	19 519·594 (- 1)
15·5	19 798·016 (- 1)	19 604·984 (- 4)	19 761·977 (- 1)	19 568·946 (- 2)	19 728·831 (1)	19 535·800 (0)	19 696·919 (2)	19 503·886 (- 2)
16·5	19 789·087 (- 2)	19 595·105 (3)	19 750·938 (- 1)	19 556·953 (1)	19 715·708 (- 2)	19 521·726 (2)	19 681·682 (- 4)	19 487·700 (1)
17·5	19 778·374	19 583·925 (- 0)	19 738·200 (- 6)	19 543·753 (- 4)	19 700·856 (3)	19 506·403 (- 1)	19 664·812 (- 1)	19 470·356 (- 8)
18·5	19 767·963 (- 1)	19 572·455 (- 3)	19 725·686 (- 5)	19 530·218 (34)	19 686·264 (- 1)	19 490·754 (- 4)	19 648·113 (- 2)	19 452·605 (- 3)
19·5	19 755·669 (2)	19 559·645 (- 0)	19 711·375	19 515·328 (- 25)	19 669·840 (3)	19 473·816 (1)	19 629·672 (3)	19 433·644 (- 3)
20·5	19 743·770 (- 4)	19 546·594 (- 4)	19 697·381 (- 3)	19 500·203 (- 4)	19 653·773 (- 4)	19 456·598 (- 2)	19 611·502 (- 2)	19 414·321 (- 6)
21·5	19 729·900 (7)	19 532·223 (73)	19 681·481 (- 1)	19 483·733 (- 7)	19 635·777 (- 0)	19 438·032 (- 2)	19 591·485 (0)	19 393·735 (- 7)
22·5	19 716·507 (- 5)	19 517·521 (- 1)	19 666·010 (- 1)	19 467·023 (2)	19 618·239 (- 3)	19 419·250 (- 3)	19 571·847 (- 4)	19 372·857 (- 5)
23·5	19 701·041 (- 3)	19 501·438 (1)	19 648·521 (- 3)	19 448·918 (1)	19 598·673 (3)	19 399·064 (1)	19 550·258 (- 2)	19 350·649 (- 4)
24·5	19 686·175 (4)	19 485·227 (- 2)	19 631·566 (- 4)	19 430·631 (2)	19 579·656 (- 2)	19 378·717	19 529·153 (- 4)	19 328·205 (- 10)
25·5	19 669·116 (- 0)	19 467·505 (- 1)	19 612·492 (- 6)	19 410·969 (81)	19 558·511 (- 2)	19 356·905 (2)	19 505·991 (- 2)	19 304·380 (- 3)
26·5	19 652·753 (7)	19 449·717 (- 4)	19 594·054 (- 4)	19 391·024 (- 10)	19 538·019 (0)	19 334·992 (- 2)	19 483·414 (- 4)	19 280·394 (0)
27·5	19 634·104 (1)	19 430·538	19 573·401 (1)	19 369·655 (0)	19 515·328 (26)	19 311·558 (1)	19 458·682 (- 2)	19 254·943 (4)
28·5	19 616·231	19 410·969 (- 27)	19 553·474 (4)	19 348·234 (- 1)	19 493·331 (8)	19 288·085 (- 2)	19 434·636 (0)	19 229·417 (17)
29·5	19 596·026 (27)	19 389·992	19 531·227 (3)	19 325·225 (7)	19 469·040 (7)	19 263·028 (2)	19 408·329 (- 0)	19 202·322 (- 0)
30·5	19 576·627 (6)	19 369·054 (0)	19 509·801 (- 3)	19 302·234 (- 1)	19 445·568 (2)	19 238·020 (22)	19 382·807 (2)	19 175·231 (- 7)
31·5	19 554·800 (3)	19 346·400 (- 8)	19 485·969 (- 0)	19 277·575 (- 4)	19 419·705 (2)	19 211·301 (- 12)	19 354·921 (- 8)	19 146·529 (- 10)
32·5	19 533·912 (1)	19 323·900 (5)	19 463·063 (11)	19 253·034 (- 3)	19 394·752 (7)	19 184·741 (11)	19 327·928 (1)	19 117·934 (23)
33·5	19 510·494 (- 0)	19 299·611 (4)	19 437·631 (2)	19 226·746 (6)	19 367·311 (2)	19 156·421 (1)	19 298·476 (- 3)	19 087·650 (58)
34·5	19 488·092 (- 0)	19 275·519 (- 2)	19 413·220 (7)	19 200·663 (22)	19 340·858 (2)	19 128·280 (- 4)	19 270·000 (3)	19 057·434 (8)
35·5	19 463·063 (- 19)	19 249·583 (- 4)	19 386·199 (1)	19 172·703	19 311·848 (3)	19 098·351	19 238·977 (- 3)	19 025·423 (- 61)
36·5	19 439·161	19 223·928 (- 2)	19 360·290 (11)	19 145·019 (- 29)	19 283·895	19 068·727 (63)	19 209·025 (10)	18 993·859 (76)
37·5	19 412·556	19 196·351 (- 0)	19 331·671 (- 2)	19 115·468	19 253·298 (- 13)	19 037·119 (13)	19 176·417 (- 9)	18 960·258 (37)
38·5	19 387·104 (- 6)	19 169·121 (- 1)	19 304·265 (17)	19 086·263 (3)	19 223·858	19 005·867 (- 3)	19 145·019 (42)	18 926·989
39·5	19 358·918 (9)	19 139·897 (1)	19 274·046 (- 3)	19 055·035 (- 1)	19 191·693 (- 7)	18 972·694 (6)	19 110·816 (- 2)	18 891·819 (14)
40·5		19 111·113 (15)	19 245·117 (3)	19 024·278	19 160·665 (- 78)	18 939·915 (8)	19 077·888 (7)	18 857·040 (- 5)
41·5		19 080·226 (2)	19 213·280 (- 42)	18 991·410		18 905·113 (13)	19 042·141 (- 11)	18 820·226 (14)
42·5		19 049·829 (- 29)	19 182·889 (16)	18 959·103		18 870·780 (5)	19 007·695 (- 29)	
43·5		19 017·281 (- 52)	19 149·504 (18)	18 924·582 (- 8)		18 834·342 (- 1)	18 970·427 (2)	
44·5		18 985·409 (9)	19 117·550 (30)			18 798·475 (- 2)	18 934·505	
45·5		18 951·166 (- 59)	19 082·516 (- 21)			18 760·409 (- 10)	18 895·636	

46·5		18 917·723 (− 2)	19 049·023 (− 27)				18 858·236 (15)	
47·5		18 881·899 (2)	19 012·501 (32)				18 817·782	
48·5			18 977·440 (− 18)				18 778·865 (− 5)	
49·5			18 939·280				18 736·860	
50·5			18 902·697 (− 43)				18 696·442 (− 6)	
51·5							18 652·868	
52·5							18 610·971 (18)	
53·5							18 565·804	
54·5							18 522·338 (− 45)	
				0–11 band				
1·5					21 355·333 (21)			
2·5					21 351·826			21 156·209 (− 22)
3·5	21 366·122 (− 35)	21 177·171 (− 4)	21 354·449 (7)	21 165·459 (− 1)	21 347·557 (− 3)			21 150·418 (− 1)
4·5	21 365·792 (3)	21 176·531 (2)	21 352·109 (7)	21 162·840 (− 1)	21 342·858 (− 2)		21 332·946 (10)	21 143·642 (− 32)
5·5	21 364·284 (4)	21 174·861 (− 5)	21 348·679 (− 4)	21 159·319 (50)	21 337·113 (2)	21 147·695 (− 2)	21 325·388 (− 8)	21 136·048 (66)
6·5	21 362·407 (− 1)	21 172·589 (− 4)	21 344·758	21 154·944 (0)	21 330·976 (3)	21 141·160 (2)	21 317·292 (6)	21 127·471
7·5	21 359·221 (− 45)	21 169·247 (3)	21 339·683 (28)	21 149·631 (− 1)	21 323·638 (9)	21 133·605 (− 1)	21 308·028 (− 3)	21 118·01 (3)
8·5	21 355·867 (1)	21 165·319 (− 3)	21 334·173 (5)	21 143·642 (19)	21 315·993 (3)	21 125·447 (2)	21 298·337 (− 3)	21 107·793 (− 2)
9·5	21 351·079 (1)	21 160·271 (1)	21 327·392 (− 0)	21 136·580 (− 5)	21 307·018 (1)	21 116·210 (1)	21 287·415 (10)	21 096·596 (− 2)
10·5	21 346·140 (2)	21 154·689 (− 2)	21 320·348 (− 1)	21 128·902	21 297·854 (1)	21 106·407 (0)	21 276·159 (5)	21 084·707 (− 1)
11·5	21 339·683 (− 14)	21 147·928 (− 4)	21 311·909 (4)	21 120·146 (5)	21 287·233 (− 7)	21 095·476 (2)	21 263·554 (1)	21 071·779 (− 10)
12·5	21 333·214 (4)	21 140·695 (3)	21 303·309 (0)	21 110·790	21 276·545 (4)	21 084·023 (1)	21 250·751	21 058·259 (27)
13·5	21 325·115 (2)	21 132·219 (− 2)	21 293·199 (− 2)	21 100·306 (− 3)	21 264·283 (4)	21 071·386 (− 1)	21 236·492 (3)	21 043·596 (− 0)
14·5	21 317·077 (3)	21 123·313 (− 5)	21 283·052 (2)	21 089·293 (− 0)	21 252·041 (1)	21 058·259 (− 24)	21 222·138 (1)	21 028·378 (− 2)
15·5	21 307·321 (4)	21 113·131 (− 2)	21 271·290 (13)	21 077·091 (− 3)	21 238·131 (1)	21 043·946 (1)	21 206·218 (1)	21 012·027 (− 6)
16·5	21 297·721 (− 2)	21 102·565 (− 1)	21 259·569 (− 4)	21 064·413 (− 3)	21 224·348 (4)	21 029·187 (− 1)	21 190·320 (1)	20 995·164 (1)
17·5	21 286·304	21 090·665 (− 0)	21 246·136 (0)	21 050·490 (− 7)	21 208·786 (3)	21 013·145 (0)	21 172·743 (− 0)	20 977·103 (− 1)
18·5	21 275·146 (− 2)	21 078·437 (3)	21 232·875 (0)	21 036·161	21 193·446 (− 3)	20 996·732 (− 2)	21 155·299 (0)	20 958·585 (1)
19·5	21 262·072 (7)	21 064·815 (− 1)	21 217·773	21 020·521 (− 2)	21 176·241 (6)	20 978·985 (− 0)	21 136·048 (− 19)	20 938·814 (− 4)
20·5	21 249·345 (− 1)	21 050·942 (21)	21 202·954 (0)	21 004·528 (− 3)	21 159·319 (− 29)	20 960·922 (− 2)	21 117·076 (1)	20 918·648 (− 2)
21 5	21 234·597 (1)	21 035·584 (0)	21 186·184 (− 2)	20 987·172 (− 2)	21 140·485 (3)	20 941·467 (− 1)	21 096·196 (8)	20 897·169 (− 7)
22·5	21 220·309 (2)	21 020·023 (− 4)	21 169·803 (− 3)	20 969·523 (− 2)	21 122·039 (0)	20 921·754 (− 3)	21 075·647 (− 0)	20 875·365 (− 1)
23·5	21 203·893 (1)	21 002·969	21 151·374 (2)	20 950·447 (− 3)	21 101·520 (2)	20 900·599 (4)	21 053·106 (− 1)	20 852·183 (− 2)
24·5	21 188·029 (0)	20 985·749 (− 1)	21 133·428 (− 0)	20 931·149 (− 1)	21 081·514 (− 2)	20 879·237	21 031·014 (− 1)	20 828·729 (− 7)
25·5	21 169·946 (2)	20 966·972 (1)	21 113·327 (1)	20 910·352 (− 1)	21 059·340 (− 1)	20 856·370 (2)	21 006·818 (− 3)	20 803·845 (− 3)
26·5	21 152·504 (0)	20 948·091 (− 0)	21 093·817 (1)	20 889·403 (− 1)	21 037·779 (3)	20 833·362 (− 2)	20 983·177 (1)	20 778·760 (− 3)
27·5	21 132·751 (2)	20 927·593 (4)	21 072·048 (3)	20 866·881 (− 5)	21 013·946 (− 0)	20 808·784 (− 3)	20 957·331 (2)	20 752·168 (− 1)
28·5	21 113·725	20 907·050 (2)	21 050·945 (− 19)	20 844·288 (0)	20 990·816 (− 0)	20 784·138 (− 2)	20 932·128 (− 1)	20 725·453
29·5	21 092·306 (9)	20 884·822	21 027·523 (− 0)	20 820·047 (− 1)	20 965·325 (− 7)	20 757·858 (2)	20 904·627 (− 1)	20 697·143 (− 10)
30·5	21 071·674 (− 14)	20 862·618 (− 6)	21 004·871 (2)	20 795·804 (− 2)	20 940·632 (− 0)	20 731·574 (6)	20 877·870 (− 2)	20 668·779 (− 29)
31·5	21 048·588 (2)	20 838·678 (7)	20 979·759 (2)	20 769·840 (− 2)	20 913·496 (5)	20 703·580 (4)	20 848·714 (− 3)	20 638·803 (1)
32·5	21 026·385 (1)	20 814·817 (2)	20 955·529 (3)	20 743·956 (− 0)	20 887·213 (− 6)	20 675·647 (− 2)	20 820·401 (0)	20 608·830 (− 1)
33·5	21 001·603 (− 4)	20 789·138 (3)	20 928·744 (4)	20 716·275 (6)	20 858·416 (− 5)	20 645·949 (− 0)	20 789·589 (− 3)	20 577·121 (1)
34·5	20 977·804 (− 4)	20 763·625 (3)	20 902·933 (4)	20 688·755 (13)	20 830·567 (− 5)	20 616·373 (− 12)	20 759·714	20 545·538 (11)
35·5	20 951·350 (− 4)	20 736·217 (3)	20 874·471 (2)	20 659·332 (3)	20 800·114 (− 4)	20 584·979 (2)	20 727·251	20 512·105 (− 6)
36·5	20 925·958 (4)	20 709·052 (7)	20 847·075 (2)	20 630·176 (12)	20 770·707 (19)	20 553·776 (− 3)	20 695·812 (4)	20 478·895 (− 4)
37·5	20 897·820	20 679·901 (− 5)	20 816·941 (4)	20 599·037 (14)	20 738·576 (1)	20 520·656 (− 5)	20 661·688 (− 2)	20 443·780 (3)
38·5	20 870·811 (− 3)	20 651·086 (3)	20 787·962 (10)	20 568·231 (10)	20 707·556 (− 6)	20 487·833 (2)	20 628·680	20 408·959 (9)

(*continued*)

Table 1 (*continued*)

J	R_{11}	R_{12}	R_{21}	R_{22}	P_{11}	P_{12}	P_{21}	P_{22}
				0–11 band				
39·5	20 840·985 (- 14)	20 620·222 (10)	20 756·150 (10)	20 535·365 (13)	20 673·792 (1)	20 453·000 (- 3)	20 592·909 (1)	20 372·140 (19)
40·5	20 812·394 (13)	20 589·732 (- 3)	20 812·382	20 502·905 (- 9)	20 641·190	20 418·544 (0)	20 558·329 (1)	20 335·699 (18)
41·5	20 780·876 (- 8)	20 557·129 (0)	20 692·064 (- 6)	20 468·347 (32)	20 605·759	20 382·010 (5)	20 520·883 (- 17)	20 297·145
42·5		20 525·001 (1)	20 659·903 (8)	20 434·245	20 571·553 (- 13)	20 345·917 (1)	20 484·749 (3)	20 259·096
43·5		20 490·651 (- 7)	20 624·722 (- 1)	20 397·946 (31)		20 307·668 (1)	20 445·666 (4)	20 218·894 (41)
44·5		20 456·868 (- 9)	20 590·948 (0)			20 269·948 (- 4)	20 407·959 (26)	
45·5		20 420·780 (- 16)	20 554·093			20 229·991 (0)	20 367·197 (5)	
46·5		20 385·364 (1)	20 518·712 (- 1)			20 190·671 (20)	20 327·886 (2)	
47·5		20 347·532 (- 10)	20 480·180 (7)			20 148·951 (- 24)	20 285·485	
48·5		20 310·450 (- 8)	20 443·175 (- 8)			20 108·015 (1)	20 244·593 (- 2)	
49·5		20 270·883 (- 11)				20 064·628 (4)	20 200·538	
50·5						20 022·047 (7)	20 158·089 (26)	
51·5						19 976·902 (- 31)	20 112·387 (40)	
52·5							20 068·286 (2)	
				0–10 band				
1·5					22 902·396 (9)			
2·5					22 898·801			22 702·242 (10)
3·5	22 913·014 (21)	22 723·036 (4)	22 901·298 (21)	22 711·315 (- 3)	22 894·396 (1)			22 696·277 (- 0)
4·5	22 912·442 (- 3)	22 722·205 (4)	22 898·784 (27)	22 708·515 (2)	22 889·517 (1)	22 699·328 (55)	22 879·553 (- 39)	22 689·352 (4)
5·5	22 910·715 (- 2)	22 720·312 (- 2)	22 895·112 (- 6)	22 704·719 (3)	22 883·543 (- 4)	22 693·142 (- 3)	22 871·833 (1)	22 681·435 (5)
6·5	22 908·583 (- 2)	22 717·771 (- 3)	22 890·935	22 700·124 (- 1)	22 877·153 (3)	22 686·339 (- 1)	22 863·510 (47)	22 672·652
7·5	22 905·144 (1)	22 714·135 (18)	22 885·558 (26)	22 694·505 (- 1)	22 869·518 (12)	22 678·480 (0)	22 853·907 (- 1)	22 662·886 (4)
8·5	22 901·395 (- 8)	22 709·843 (- 4)	22 879·688 (- 18)	22 688·150 (2)	22 861·529 (1)	22 669·973 (2)	22 843·876 (- 1)	22 652·333 (12)
9·5	22 896·234 (- 2)	22 704·408 (2)	22 872·548 (- 2)	22 680·714 (- 6)	22 852·178 (3)	22 660·352 (8)	22 832·553 (- 11)	22 640·733 (- 1)
10·5	22 890·893 (16)	22 698·394 (- 3)	22 865·083 (- 4)	22 672·607	22 842·589 (- 2)	22 650·112 (0)	22 820·897 (4)	22 628·413 (- 1)
11·5	22 883·972 (- 4)	22 691·165 (- 1)	22 856·196 (11)	22 663·365 (- 10)	22 831·521 (3)	22 638·695 (- 13)	22 807·828 (- 4)	22 615·022 (- 0)
12·5	22 876·990 (- 1)	22 683·413 (- 1)	22 847·085 (- 3)	22 653·511	22 820·319 (- 1)	22 626·734 (- 9)	22 794·532 (2)	22 600·953 (- 0)
13·5	22 868·359 (6)	22 674·387 (- 2)	22 836·439 (- 1)	22 642·474 (- 2)	22 807·525 (6)	22 613·559 (4)	22 779·734 (5)	22 585·766 (2)
14·5	22 859·731 (- 4)	22 664·887 (- 4)	22 825·712 (2)	22 630·860 (- 6)	22 794·701 (1)	22 599·856 (- 0)	22 764·799 (1)	22 569·955 (1)
15·5	22 849·355 (- 2)	22 654·071 (1)	22 813·318 (- 0)	22 618·027 (- 3)	22 780·169 (- 1)	22 584·883 (0)	22 748·259 (1)	22 552·970 (- 0)
16·5	22 839·101 (- 2)	22 642·824 (- 2)	22 800·962 (9)	22 604·674 (- 3)	22 765·725 (- 0)	22 569·450 (2)	22 731·698 (- 2)	22 535·523 (99)
17·5	22 826·984	22 630·211 (3)	22 786·814 (- 2)	22 590·037 (- 3)	22 749·466 (3)	22 552·688 (1)	22 713·425 (2)	22 516·646 (- 1)
18·5	22 815·082 (- 6)	22 617·220 (2)	22 772·811 (- 3)	22 574·944	22 733·387 (- 1)	22 535·428 (- 90)	22 695·240 (2)	22 497·365 (- 3)
19·5	22 801·224 (- 0)	22 602·797 (- 2)	22 756·932	22 558·503 (- 3)	22 715·397 (3)	22 516·970 (2)	22 675·225 (- 1)	22 476·798 (- 3)
20·5	22 787·679 (- 4)	22 588·063 (- 1)	22 741·291 (- 1)	22 541·671 (- 2)	22 697·684 (- 2)	22 498·066 (- 1)	22 655·411 (- 1)	22 455·792 (- 0)
21·5	22 772·072 (- 1)	22 571·844 (1)	22 723·662 (- 1)	22 523·432 (- 1)	22 677·959 (1)	22 477·730 (2)	22 633·600 (- 65)	22 433·435 (- 0)
22·5	22 756·915 (33)	22 555·342 (- 21)	22 706·382 (1)	22 504·860 (- 3)	22 658·615 (2)	22 457·095 (1)	22 612·221 (- 0)	22 410·703 (0)
23·5	22 739·531 (6)	22 537·342 (2)	22 687·005 (0)	22 484·819 (- 2)	22 637·151 (1)	22 434·965 (- 1)	22 588·738 (- 2)	22 386·556 (1)
24·5	22 722·680 (2)	22 519·114 (- 1)	22 668·080 (2)	22 464·513 (- 2)	22 616·165 (- 1)	22 412·603	22 565·666 (- 2)	22 362·104 (3)
25·5	22 703·574 (3)	22 499·288 (- 0)	22 646·951 (- 3)	22 442·667 (- 4)	22 592·970 (2)	22 388·685 (0)	22 540·446 (- 2)	22 336·163 (- 2)
26·5	22 685·066 (- 1)	22 479·320 (- 1)	22 626·377 (- 2)	22 420·626 (- 6)	22 570·334 (- 6)	22 364·594 (0)	22 515·739 (1)	22 309·991 (- 2)
27·5	22 664·210 (2)	22 457·689 (2)	22 603·504 (- 1)	22 396·985 (1)	22 545·403 (- 3)	22 338·886 (0)	22 488·787 (- 2)	22 282·286 (18)
28·5	22 644·039	22 435·978 (0)	22 581·280 (2)	22 373·215 (- 1)	22 521·132 (2)	22 313·068 (- 0)	22 462·442 (- 1)	22 254·383 (2)
29·5	22 621·431 (4)	22 412·537	22 556·653 (0)	22 347·760 (- 3)	22 494·462 (1)	22 285·571 (0)	22 433·753 (- 4)	22 224·867 (- 0)

30·5	22 599·590 (1)	22 389·087 (2)	22 532·772 (1)	22 322·274 (7)	22 468·541 (8)	22 258·030 (− 1)	22 405·773 (1)	22 195·269 (− 1)
31·5	22 575·203 (− 19)	22 363·837 (0)	22 506·404 (11)	22 295·005 (− 2)	22 440·126 (− 1)	22 228·743 (1)	22 375·351 (− 2)	22 163·974 (7)
32·5	22 551·709 (− 2)	22 338·648 (3)	22 480·857 (5)	22 267·793 (7)	22 412·569 (24)	22 199·475 (− 4)	22 345·727 (− 0)	22 132·659 (− 2)
33·5	22 525·591 (5)	22 311·592 (7)	22 452·720 (− 0)	22 238·727 (8)	22 382·393 (− 8)	22 168·395 (− 4)	22 313·569 (− 3)	22 099·568 (− 2)
34·5	22 500·401 (5)	22 284·656 (2)	22 425·520 (4)	22 209·776 (1)	22 353·156 (− 4)	22 137·416 (− 2)	22 282·301	22 066·567 (8)
35·5	22 472·497 (− 17)	22 255·784 (1)	22 395·629 (0)	22 178·907 (9)	22 321·268 (− 9)	22 104·543 (− 2)	22 248·407 (− 3)	22 031·686 (7)
36·5	22 445·628 (− 11)	22 227·115 (2)	22 366·760 (3)	22 148·244 (13)	22 290·364 (− 8)	22 071·843 (− 4)	22 215·491 (− 1)	21 996·996 (29)
37·5	22 415·982 (− 13)	22 196·429 (2)	22 335·120 (8)	22 115·567 (24)	22 256·742 (− 8)	22 037·181 (− 1)	22 179·862 (− 3)	21 960·296 (− 1)
38·5	22 387·430 (− 1)	22 166·029 (9)	22 304·576 (7)	22 083·158 (1)	22 224·169 (− 10)	22 002·767 (− 1)	22 145·297 (− 0)	21 923·884 (− 2)
39·5	22 356·020 (− 5)	22 133·512 (− 5)	22 271·168 (3)	22 048·675 (17)	22 188·810 (− 6)	21 966·307 (− 2)	22 107·934 (1)	21 885·442 (15)
40·5	22 325·744 (− 22)	22 101·373 (− 1)	22 238·956 (11)	22 014·563 (10)	22 154·564 (− 10)	21 930·176 (− 6)	22 071·713 (1)	21 847·330 (10)
41·5	22 292·563 (− 31)	22 067·045 (− 9)	22 203·788 (8)	21 978·253 (13)	22 117·470	21 891·923 (− 6)	22 032·610 (0)	21 807·069
42·5		22 033·172 (− 1)	22 169·880 (− 1)	21 942·419	22 081·556 (3)	21 854·089 (− 1)	21 994·732 (− 0)	21 767·270
43·5		21 996·996 (− 36)	22 132·950 (− 3)	21 904·286 (− 3)	22 042·718 (12)	21 814·039 (− 3)	21 953·897 (5)	21 725·249 (21)
44·5		21 961·420 (3)	22 097·363 (− 7)	21 866·743 (− 10)		21 774·490 (− 2)	21 914·363 (8)	
45·5		21 923·432 (− 22)	22 058·676 (0)			21 732·649 (1)	21 871·781 (6)	
46·5		21 886·099 (− 3)	22 021·400 (− 3)			21 691·388 (− 2)	21 830·577 (2)	
47·5		21 846·282 (− 31)	21 980·948 (5)			21 647·742 (− 4)	21 786·261 (6)	
48·5		21 807·169 (− 57)	21 941·968 (− 8)			21 604·778 (− 4)	21 743·394 (7)	
49·5		21 765·560 (− 50)				21 559·328 (− 12)	21 697·326 (− 0)	
50·5						21 514·672 (3)	21 652·793 (3)	
51·5						21 467·429 (4)	21 604·969 (− 17)	
52·5							21 558·782 (7)	
53·5							21 509·228 (0)	
54·5							21 461·339 (− 1)	
				0–9 band				
1·5				24 293·000 (− 0)				
2·5	24 492·638 (− 5)		24 482·721 (3)	24 291·947 (1)	24 478·409 (8)			24 280·928 (10)
3·5	24 492·450 (− 3)		24 480·738	24 289·863 (2)	24 473·854 (− 2)		24 465·681 (− 17)	24 274·810 (− 11)
4·5	24 491·742 (14)	24 300·556 (− 6)	24 478·039 (− 1)	24 286·874	24 468·798 (− 0)		24 458·874	24 267·713 (5)
5·5	24 489·777 (− 4)	24 298·453 (3)	24 474·191 (9)	24 282·852 (− 0)	24 462·610 (− 1)	24 271·289 (9)	24 450·905 (10)	24 259·571 (6)
6·5	24 487·396 (5)	24 295·648 (2)	24 469·746 (4)	24 277·986 (− 10)	24 455·953 (− 4)	24 264·207 (− 4)	24 442·289 (20)	24 250·523 (− 1)
7·5	24 483·650 (− 2)	24 291·686 (3)	24 464·044 (3)	24 272·074 (2)	24 448·003 (− 11)	24 256·075 (30)	24 432·425 (8)	24 240·444 (− 4)
8·5	24 479·555 (− 21)	24 287·067 (1)	24 457·867 (− 10)	24 265·383 (15)	24 439·704 (4)	24 247·190	24 422·053 (3)	24 229·539 (− 2)
9·5	24 474·029 (− 1)	24 281·238 (− 0)	24 450·346 (1)	24 257·547 (− 6)	24 429·965 (− 4)	24 237·173 (− 4)	24 410·356 (− 2)	24 217·563 (− 3)
10·5	24 468·252 (− 4)	24 274·810 (8)	24 442·461 (− 5)	24 249·012 (0)	24 419·969 (− 2)	24 226·459 (− 57)	24 398·271 (− 2)	24 204·823 (5)
11·5	24 460·899 (1)	24 267·101 (− 1)	24 433·108 (1)	24 239·310 (− 0)	24 408·445 (5)	24 214·645 (2)	24 384·754 (0)	24 190·958 (0)
12·5	24 453·417 (0)	24 258·838 (− 2)	24 423·515 (− 0)	24 228·936 (− 2)	24 396·744 (− 3)	24 202·175 (5)	24 370·956 (− 1)	24 176·394 (15)
13·5	24 444·239 (− 4)	24 249·269 (5)	24 412·330 (− 1)	24 217·359 (7)	24 383·410 (1)	24 188·432 (0)	24 355·619 (1)	24 160·642 (2)
14·5	24 435·050 (− 0)	24 239·181 (5)	24 401·021 (− 4)	24 205·146 (− 6)	24 370·016 (1)	24 174·143 (2)	24 340·113 (− 0)	24 144·238 (− 1)
15·5	24 424·062 (6)	24 227·721 (− 1)	24 388·012 (− 4)	24 191·673 (− 10)	24 354·871 (3)	24 158·537 (1)	24 322·958 (2)	24 126·624 (1)
16·5	24 413·141 (− 6)	24 215·805 (− 2)	24 374·998 (1)	24 177·654 (− 4)	24 339·772 (3)	24 142·428 (− 1)	24 305·745 (1)	24 108·403 (− 1)
17·5	24 400·341 (10)	24 202·474 (0)	24 360·162 (− 1)	24 162·304 (− 2)	24 322·822 (11)	24 124·954 (1)	24 286·794 (24)	24 088·914 (1)
18·5	24 387·703 (1)	24 188·729 (− 2)	24 345·429 (1)	24 146·457 (− 0)	24 306·003 (1)	24 107·030 (− 0)	24 267·848 (− 3)	24 068·886 (6)
19·5	24 373·052 (− 9)	24 173·517 (2)	24 328·766 (− 3)	24 129·216 (− 6)	24 287·242 (12)	24 087·684 (1)	24 247·079 (17)	24 047·517 (− 1)
20·5	24 358·708 (3)	24 157·941 (− 4)	24 312·312 (− 2)	24 111·549 (− 4)	24 268·717 (9)	24 067·944 (4)	24 226·434	24 025·672 (− 2)
21·5	24 342·242 (3)	24 140·849 (3)	24 293·828 (− 1)	24 092·433 (− 3)	24 248·126 (3)	24 046·731 (0)	24 203·830 (− 1)	24 002·437 (− 1)
22·5	24 326·154 (1)	24 123·448 (− 1)	24 275·646 (− 6)	24 072·949 (− 0)	24 227·884 (− 0)	24 025·180 (− 1)	24 181·494 (1)	23 978·749 (− 40)

(*continued*)

Table 1 (*continued*)

J	R_{11}	R_{12}	R_{21}	R_{22}	P_{11}	P_{12}	P_{21}	P_{22}
				0–19 band				
23·5	24 307·866 (7)	24 104·466 (- 0)	24 255·335 (- 5)	24 051·942 (- 4)	24 205·501 (16)	24 002·092 (0)	24 157·075 (1)	23 953·741 (59)
24·5	24 290·043 (5)	24 085·243 (- 1)	24 235·436 (- 1)	24 030·639 (- 4)	24 183·529 (5)	23 978·756 (26)	24 133·020 (- 3)	23 928·229 (- 1)
25·5	24 269·931 (18)	24 064·375 (2)	24 213·295 (- 1)	24 007·755 (0)	24 159·315 (5)	23 953·741 (- 29)	24 106·786 (- 5)	23 901·247 (- 3)
26·5	24 250·350 (- 3)	24 043·326 (0)	24 191·673 (8)	23 984·640 (2)	24 135·621 (- 5)	23 928·593 (- 6)	24 081·024 (- 2)	23 893·999 (1)
27·5	24 228·396 (- 1)	24 020·571 (4)	24 167·693 (- 1)	23 959·858 (- 5)	24 109·592 (- 4)	23 901·767 (1)	24 052·977 (- 1)	23 845·148 (0)
28·5	24 207·085 (- 6)	23 997·695 (- 1)	24 144·330 (- 0)	23 934·931 (- 4)	24 084·183 (- 0)	23 874·785 (- 3)	24 025·492 (- 3)	23 816·095 (- 5)
29·5	24 183·293 (- 8)	23 973·051 (4)	24 118·527 (- 0)	23 908·271 (- 2)	24 056·336 (0)	23 846·083 (2)	23 995·630 (- 2)	23 785·380 (2)
30·5	24 160·244 (- 2)	23 948·352 (- 1)	24 093·427 (- 0)	23 881·536 (1)	24 029·195 (5)	23 817·296 (- 2)	23 966·422 (- 8)	23 754·541 (4)
31·5	24 134·621 (1)	23 921·816 (4)	24 065·793 (2)	23 852·985 (1)	23 999·531 (6)	23 786·720 (2)	23 934·745 (- 6)	23 721·948 (5)
32·5	24 109·804 (- 5)	23 895·296 (- 1)	24 038·949 (- 1)	23 824·444 (6)	23 970·643 (0)	23 756·133 (2)	23 903·827 (2)	23 689·308 (- 5)
33·5	24 082·340 (- 6)	23 866·870 (7)	24 009·481 (1)	23 794·006 (10)	23 939·151 (- 9)	23 723·676 (- 1)	23 870·330 (- 1)	23 654·848 (0)
34·5	24 055·800 (26)	23 838·527 (2)	23 980·896 (2)	23 763·653 (8)	23 908·535 (- 2)	23 691·289	23 837·676 (- 3)	23 620·428 (- 2)
35·5	24 026·457 (- 14)	23 808·198 (3)	23 949·586 (0)	23 731·330 (19)	23 875·234 (- 0)	23 656·961 (2)	23 802·366 (- 2)	23 584·093 (1)
36·5	23 998·138 (5)	23 778·039 (1)	23 919·257 (5)	23 699·178 (22)	23 842·870 (3)	23 622·769 (- 3)	23 767·987 (0)	23 547·896 (4)
37·5	23 966·944 (- 44)	23 745·817 (6)	23 886·103 (- 2)		23 807·719 (- 24)	23 586·569 (3)	23 730·855 (- 4)	
38·5	23 936·873 (- 5)	23 713·838 (4)	23 854·018 (1)			23 550·572 (- 10)	23 694·744 (- 1)	
39·5		23 679·706 (- 1)	23 819·037 (8)			23 512·500 (1)	23 655·790 (- 8)	
40·5		23 645·905 (- 6)	23 785·191 (9)			23 474·717 (- 2)	23 617·950 (1)	
41·5		23 609·875 (- 7)	23 748·355 (2)			23 434·756 (- 1)	23 577·177 (- 6)	
42·5		23 574·269 (2)	23 712·742 (- 1)			23 395·192 (8)	23 537·595 (1)	
43·5		23 536·329 (- 4)	23 674·073 (4)			23 353·345 (3)	23 495·013 (5)	
44·5		23 498·892 (- 8)	23 636·697 (6)			23 311·980 (4)	23 453·670 (- 6)	
45·5		23 459·049 (- 11)	23 596·165 (- 5)			23 268·250 (- 4)	23 409·277 (8)	
46·5		23 419·809 (0)	23 557·018 (- 1)			23 225·101 (4)	23 366·187 (- 3)	
47·5		23 378·046 (- 12)	23 514·650 (2)			23 179·492 (0)	23 319·958 (- 2)	
48·5		23 336·969 (- 21)	23 473·709 (- 11)				23 275·142 (10)	
49·5							23 227·084 (6)	
50·5							23 180·499 (3)	
				0–8 band				
0·5	26 102·645 (- 6)		26 095·940					
1·5	26 104·047		26 095·888		26 094·372 (10)			
2·5	26 104·793 (- 28)		26 094·897		26 090·591 (12)			25 892·190 (- 40)
3·5	26 104·463 (- 30)	25 912·747	26 092·784 (5)	25 901·032 (0)	26 085·874 (- 23)	25 894·150	26 077·728 (- 10)	25 886·026 (35)
4·5	26 103·592 (2)	25 911·550	26 089·903	25 897·865 (2)	26 080·671 (9)	25 888·621	26 070·737	25 878·684 (- 13)
5·5	26 101·434 (7)	25 909·211 (- 5)	26 085·829	25 893·609 (- 9)	26 074·265 (8)	25 882·044 (- 3)	26 062·542	25 870·343 (11)
6·5	26 098·798 (16)	25 906·150 (2)	26 081·134 (2)	25 888·475 (- 23)	26 067·349 (2)	25 874·712 (- 2)	26 053·633 (26)	25 861·037 (11)
7·5	26 094·745 (- 2)	25 901·909 (28)	26 075·140 (4)	25 882·260 (- 11)	26 059·124 (15)	25 866·246 (2)	26 043·518 (6)	25 850·653 (6)
8·5	26 090·332 (- 3)	25 896·911 (- 10)	26 068·639 (2)	25 875·228 (6)	26 050·454 (- 5)	25 857·037 (- 8)	26 032·816 (6)	25 839·415 (19)
9·5	26 084·415 (- 1)	25 890·709 (1)	26 060·741 (11)	25 866·959 (- 63)	26 040·357 (2)	25 846·635 (- 12)	26 020·744	25 827·033 (- 3)
10·5	26 078·258 (31)	25 883·843 (- 2)	26 052·435 (- 2)	25 858·054 (- 2)	26 029·951 (9)	25 835·560	26 008·243 (- 0)	25 813·865 (3)
11·5	26 070·425 (9)	25 875·689 (10)	26 042·633 (9)	25 847·878 (- 10)	26 017·966 (8)	25 823·234 (12)	25 994·274 (2)	25 799·531 (- 5)
12·5	26 062·449 (8)	25 866·962 (51)	26 032·538 (- 1)	25 836·949 (- 60)	26 005·763 (- 8)	25 810·242 (1)	25 979·990 (8)	25 784·452 (0)
13·5	26 052·731 (- 4)	25 856·796 (7)	26 020·792 (- 30)	25 824·859 (- 18)	25 991·904 (2)	25 795·964 (8)	25 964·111 (0)	25 768·159 (- 6)
14·5	26 042·966 (- 4)	25 846·113	26 008·950 (5)	25 812·080 (- 8)	25 977·939 (4)	25 781·084 (6)	25 948·027 (- 5)	25 751·261 (86)

15·5	26 031·372	(8)	25 834·032	(1)	25 995·316	(−9)	25 797·985	(−7)	25 962·181	(5)	25 764·850	(6)	25 930·266	(2)	25 732·932	
16·5	26 019·816	(13)	25 821·450	(4)	25 981·656	(3)	25 783·296		25 946·427	(2)	25 748·068	(−0)	25 912·400	(0)	25 714·043	
17·5	26 006·288	(−8)	25 807·404	(−0)	25 966·127	(−1)	25 767·233	(−4)	25 928·776	(−0)	25 729·883	(−1)	25 892·739	(3)	25 693·847	(3)
18·5	25 992·936	(2)	25 792·907	(−3)	25 950·665	(3)	25 750·640	(3)	25 911·233	(−2)	25 711·216	(6)	25 873·085	(1)	25 673·054	(−6)
19·5	25 977·528	(4)	25 776·904	(−1)	25 933·237	(5)	25 732·625	(13)	25 891·701	(7)	25 691·070	(−5)	25 851·526	(−1)	25 650·907	
20·5	25 962·355	(−2)	25 760·504	(2)	25 915·950	(−15)	25 714·085	(−25)	25 872·360	(1)	25 670·503	(−1)	25 830·090	(4)	25 628·233	(2)
21·5	25 945·057	(15)	25 742·531	(−2)	25 896·628	(−3)	25 694·128	(6)	25 850·934	(8)	25 648·410	(−7)	25 806·633	(−1)	25 604·125	(1)
22·5	25 928·063	(−1)	25 724·226	(5)	25 877·552	(−11)	25 673·716	(−4)	25 829·785	(−9)	25 625·956	(4)	25 783·394	(−9)	25 579·559	(−1)
23·5	25 908·829	(−12)	25 704·287	(2)	25 856·314	(−7)	25 651·753	(−13)	25 806·466	(−1)	25 601·915	(3)	25 758·050	(−6)	25 553·500	(−2)
24·5	25 890·052	(4)	25 684·073	(6)	25 835·469	(22)	25 629·477	(11)	25 783·535		25 577·550	(−3)	25 732·992	(−42)	25 527·051	(−1)
25·5	25 868·921	(5)	25 662·162	(−2)	25 812·301	(3)	25 605·545	(−1)	25 758·308	(−4)	25 551·559	(−2)	25 705·786	(−7)	25 499·032	(−9)
26·5	25 848·314	(12)	25 640·037	(−0)	25 789·617	(2)	25 581·372	(22)	25 733·559	(−16)	25 525·319	(8)	25 678·967	(−8)	25 470·710	(1)
27·5	25 825·297	(39)	25 616·169	(4)	25 764·553	(−2)	25 555·462		25 706·448	(−9)	25 497·359	(−5)	25 649·829	(−10)	25 440·742	(−4)
28·5	25 802·773	(−46)	25 592·136	(4)	25 740·048	(−11)	25 529·377	(5)	25 679·911		25 469·225	(1)	25 621·217	(−7)	25 410·530	(−7)
29·5	25 777·867	(6)	25 566·292	(2)	25 713·090	(3)	25 501·520	(5)	25 650·899	(3)	25 439·325	(2)	25 590·186	(−6)	25 378·628	(8)
30·5	25 753·553	(−39)	25 540·361	(10)	25 686·767	(−7)	25 473·548	(15)	25 622·507	(−29)	25 409·300	(5)	25 559·766	(−10)	25 346·525	(−10)
31·5	25 726·718		25 512·539	(3)	25 657·886	(−3)	25 443·638	(−69)	25 591·605	(−18)	25 377·447	(6)	25 526·847	(2)	25 312·668	(1)
32·5	25 700·626	(14)	25 484·707	(15)	25 629·755	(1)	25 413·822	(−13)	25 561·457	(10)	25 345·534	(7)	25 494·628	(−1)	25 278·731	(22)
33·5	25 671·815	(−6)	25 454·894	(−9)	25 598·949	(−5)	25 382·026	(−10)	25 528·627	(−7)	25 311·721	(4)	25 459·795	(−10)	25 242·882	(−6)
34·5	25 643·825	(−48)	25 425·169	(14)	25 568·989	(−5)	25 350·236	(−39)	25 496·659	(22)	25 277·909	(−10)	25 425·778	(−0)	25 207·037	(−24)
35·5	25 613·134	(−27)	25 393·395	(6)	25 536·283	(7)	25 316·515	(11)	25 461·927	(3)	25 242·140	(−13)	25 389·060	(3)	25 169·297	(10)
36·5	25 583·366		25 361·782	(44)	25 504·490	(5)	25 282·854	(−3)	25 428·152	(52)	25 206·486	(13)	25 353·221	(0)	25 131·656	(64)
37·5	25 550·741	(10)	25 327·995		25 469·871	(22)	25 247·080	(−31)			25 168·751	(2)	25 314·600	(−1)	25 091·871	(6)
38·5			25 294·416	(−25)	25 436·217	(−5)	25 211·601	(23)			25 131·195	(6)	25 276·955	(5)	25 052·307	
39·5			25 258·723	(7)	25 399·650	(−14)	25 173·873	(17)			25 091·505	(−3)	25 236·426	(−7)	25 010·625	
40·5			25 223·270	(11)	25 364·182	(−15)	25 136·439				25 052·068		25 196·968	(5)		
41·5			25 185·554	(2)	25 325·716		25 096·785	(47)			25 010·420	(−7)	25 154·526	(−20)		
42·5			25 148·106	(−87)	25 288·433	(28)					24 969·110	(−0)	25 113·256	(0)		
43·5			25 108·482	(−19)	25 247·955	(−43)					24 925·532	(22)	25 068·934	(−3)		
44·5			25 069·253	(13)	25 208·837						24 882·338	(22)	25 025·814	(−8)		
45·5			25 027·526	(−34)	25 166·510	(8)					24 836·732	(−23)	24 979·597	(−4)		
46·5					25 125·487	(1)					24 791·715	(30)	24 934·655	(−3)		
47·5											24 744·164	(3)	24 886·534	(0)		
48·5											24 697·221	(4)	24 839·747	(−11)		
49·5											24 647·701	(−27)	24 789·740	(12)		
50·5											24 598·898	(−14)	24 741·116			
51·5													24 689·181			

0–7 band

1·5	27 748·875	(−7)					27 548·439	(15)	27 739·133	(−65)						
2·5	27 749·546	(−13)	27 557·184	(92)			27 547·162	(−6)	27 735·301	(−16)					27 536·160	(20)
3·5	27 749·094	(1)	27 556·455	(−60)	27 737·398	(20)	27 544·800		27 730·496				27 722·372	(34)	27 529·806	(46)
4·5	27 748·035	(21)	27 555·137		27 734·313	(−14)	27 541·429	(−20)	27 725·088	(2)			27 715·236	(75)	27 522·285	(2)
5·5	27 745·633	(−1)	27 552·580	(−1)	27 730·050	(13)	27 536·965	(−19)	27 718·473	(9)	27 525·461	(50)	27 706·806	(57)	27 513·723	(27)
6·5	27 742·736	(2)	27 549·249	(−2)	27 725·085		27 531·605	(4)	27 711·297	(−3)	27 517·804	(−13)	27 697·623	(11)	27 504·135	(6)
7·5	27 738·398	(−6)	27 544·714	(33)	27 718·793	(−0)	27 525·056	(−15)	27 702·747	(−20)	27 509·099	(55)	27 687·111	(−58)	27 493·463	(17)
8·5	27 733·670	(10)	27 539·368	(−10)	27 712·018	(56)	27 517·687	(7)	27 693·782	(−2)	27 499·537	(35)	27 676·133	(−1)	27 481·861	(9)
9·5	27 727·363	(−3)	27 532·768	(−13)	27 703·687	(7)	27 509·099	(3)	27 683·298	(−7)	27 488·757	(36)	27 663·692	(2)	27 469·127	(18)
10·5	27 720·759	(−7)	25 525·538	(43)	27 694·962	(−15)	27 499·701	(−6)	27 672·484	(3)	27 477·221	(10)	27 650·779	(−4)	27 455·507	(−6)

(*continued*)

Table 1 (*continued*)

J	R_{11}	R_{12}	R_{21}	R_{22}	P_{11}	P_{12}	P_{21}	P_{22}
				0–7 band (*continued*)				
11·5	27 712·504 (3)	27 516·866 (0)	27 684·726 (16)	27 489·071 (- 4)	27 660·052 (8)	27 464·362 (- 46)	27 636·358 (1)	27 440·692 (- 30)
12·5	27 704·024 (- 13)	27 507·590 (- 4)	27 674·161 (26)	27 477·701 (10)	27 647·362 (- 4)	27 450·924 (1)	27 621·578 (1)	27 425·132 (- 2)
13·5	27 693·782 (- 16)	27 486·917 (- 9)	27 661·877 (- 9)	27 465·019 (5)	27 632·970 (5)	27 436·091 (- 2)	27 605·169 (- 4)	27 408·295 (- 7)
14·5	27 683·456 (- 9)	27 485·657 (- 9)	27 649·433 (- 6)	27 451·630 (- 11)	27 618·419 (- 10)	27 420·624 (- 6)	27 588·527	27 390·728 (- 0)
15·5	27 671·251 (3)	27 472·952 (- 6)	27 635·213 (5)	27 436·922 (3)	27 602·067 (7)	27 403·787 (16)	27 570·153 (6)	27 371·833 (- 25)
16·5	27 659·042 (3)	27 459·697 (- 11)	27 620·881 (- 8)	27 421·558 (- 0)	27 585·671 (10)	27 386·337 (8)	27 551·650 (14)	27 352·306 (1)
17·5	27 644·839 (- 3)	27 444·955 (- 4)	27 604·667 (- 7)	27 404·786 (- 5)	27 567·319 (- 3)	27 367·439 (1)	27 531·283 (1)	27 331·403 (4)
18·5	27 630·756 (2)	27 429·715 (- 4)	27 588·481	27 387·442 (- 3)	27 549·056 (2)	27 348·012 (- 7)	27 510·916 (12)	27 309·866 (- 3)
19·5	27 614·576 (1)	27 412·916 (- 10)	27 570·286 (3)	27 368·631 (- 3)	27 528·744 (- 0)	27 327·097 (2)	27 488·593 (16)	27 286·930 (2)
20·5	27 598·593 (- 9)	27 395·695 (- 2)	27 552·200 (- 11)	27 349·304 (- 1)	27 508·603 (- 1)	27 305·702 (2)	27 466·334 (3)	27 263·433 (7)
21·5	27 580·425 (- 13)	27 376·855 (- 3)	27 532·035 (8)	27 328·440 (- 8)	27 486·290 (- 32)	27 282·695 (- 47)	27 442·027 (2)	27 238·451 (1)
22·5	27 562·595 (20)	27 357·621 (- 20)	27 512·078 (4)	27 307·148 (9)	27 464·362 (56)	27 259·383 (12)	27 417·919 (4)	27 212·959 (- 21)
23·5	27 542·421 (- 4)	27 336·746 (- 8)	27 489·906 (1)	27 284·234	27 440·059 (8)	27 234·379 (- 1)	27 391·653 (13)	27 185·955 (- 15)
24·5	27 522·669 (2)	27 315·559 (11)	27 468·074 (7)	27 260·965 (18)	27 416·157 (3)	27 209·040 (4)	27 365·657 (4)	27 158·522 (- 12)
25·5	27 500·549 (21)	27 292·621 (8)	27 443·910 (0)	27 235·966 (- 28)	27 389·924 (- 1)	27 182·011 (2)	27 337·405 (- 0)	27 129·520 (30)
26·5	27 478·896 (26)	27 269·414 (- 5)	27 420·192 (10)	27 210·743 (11)	27 364·107 (- 37)	27 154·693 (0)	27 309·538 (- 5)	27 100·126 (34)
27·5	27 454·718 (- 22)	27 244·420 (- 13)	27 394·040 (3)	27 183·739 (9)	27 335·931 (- 8)	27 125·626 (- 6)	27 279·316 (- 5)	27 069·009 (- 5)
28·5	27 431·171 (- 6)	27 219·255 (1)	27 368·412 (- 5)	27 156·484 (- 9)	27 308·271 (2)	27 096·345 (- 0)	27 249·571 (- 10)	27 037·647 (- 11)
29·5	27 405·068 (14)	27 192·208 (- 7)	27 340·277 (- 2)	27 127·423 (- 18)	27 278·118 (30)	27 065·250 (1)	27 217·385 (1)	27 004·560 (14)
30·5	27 379·557 (- 23)	27 165·060 (10)	27 312·763 (0)	27 098·327 (95)	27 248·470 (- 55)	27 033·996 (1)	27 185·775 (10)	26 971·264 (30)
31·5	27 351·444 (- 18)	27 135·964 (7)	27 282·695 (62)	27 067·128	27 216·362 (- 5)	27 000·868 (6)	27 151·601 (8)	26 936·083 (- 5)
32·5	27 324·121 (49)	27 106·793 (- 13)	27 253·224 (11)	27 035·923 (- 26)	27 184·922 (17)	26 967·638 (- 4)	27 118·085 (- 3)	26 900·848 (24)
33·5	27 293·995 (40)	27 075·605 (- 52)	27 221·091 (1)	27 002·794 (3)	27 150·754 (- 16)	26 932·485 (14)	27 081·936 (- 5)	26 863·692 (50)
34·5	27 264·581 (- 62)	27 044·570 (47)	27 189·778 (15)	26 969·607 (- 37)	27 117·377 (- 29)	26 897·290 (3)	27 046·532 (- 17)	26 826·428
35·5	27 232·511 (- 17)	27 011·309 (- 6)	27 155·650 (7)	26 934·451 (20)	27 081·286 (- 5)	26 860·011 (- 68)	27 008·422 (- 3)	26 787·212
36·5	27 201·322 (35)	26 978·200 (2)	27 122·409 (3)	26 899·335 (19)	27 046·022 (1)	26 822·932	26 971·166 (25)	26 748·052
37·5		26 942·889 (- 41)	27 086·269 (- 18)	26 862·046	27 007·927 (2)	26 783·663 (- 21)	26 931·021 (- 20)	26 706·847 (47)
38·5		26 907·829	27 051·171 (38)	26 824·967	26 970·830 (87)	26 744·538 (- 39)	26 891·884 (22)	
39·5		26 870·506 (8)	27 013·038 (24)	26 785·616 (- 22)	26 930·612 (- 54)	26 703·263 (- 27)	26 849·793 (10)	
40·5		26 833·421 (5)	26 975·950 (10)			26 662·255 (31)	26 808·696 (- 10)	
41·5		26 794·020	26 935·779 (- 38)				26 764·647	
42·5		26 754·955	26 896·818 (1)				26 721·652 (- 16)	
43·5			26 854·764 (74)					
44·5			26 813·755 (- 4)					
45·5			26 769·631 (5)					
				0–6 band				
0·5	29 425·082 (98)							
1·5	29 426·309 (45)							
2·5	29 426·841	29 233·601 (15)	29 416·916		29 412·648 (49)			29 212·632
3·5	29 426·309 (68)	29 232·867	29 414·544 (17)		29 407·644			29 206·025 (- 86)
4·5	29 425·082 (99)	29 231·281 (- 28)	29 411·259 (- 36)	29 217·654 (33)	29 402·067 (13)		29 392·157 (27)	29 198·375 (- 81)
5·5	29 422·389 (- 3)	29 228·532	29 406·795	29 212·925 (- 9)	29 395·216 (- 6)	29 201·413 (50)	29 383·508	29 189·583 (- 65)
6·5	29 419·249 (15)	29 225·047 (106)	29 401·583 (- 1)	29 207·264 (- 27)	29 387·812 (12)	29 193·553 (47)	29 374·112	29 179·787 (- 31)

(*continued*)

7·5	29 414·614 (- 2)	29 220·071	29 394·974 (- 31)	29 200·460	29 378·940 (- 39)	29 184·433	29 363·381	29 168·818 (- 17)
8·5	29 409·529 (- 5)	29 214·498 (73)	29 387·812 (- 24)	29 192·760 (33)	29 369·653 (- 5)	29 174·550	29 351·992 (- 16)	29 156·900
9·5	29 402·854 (- 22)	29 207·528 (79)	29 379·154 (- 36)	29 183·735 (- 28)	29 358·817 (2)	29 163·356 (- 32)	29 339·165 (- 39)	29 143·768 (- 9)
10·5	29 395·855 (- 3)	29 199·740	29 370·044 (- 24)	29 173·953 (2)	29 347·573	29 151·453 (- 2)	29 325·870 (- 4)	29 129·816 (59)
11·5	29 387·098 (- 54)	29 190·694 (44)	29 359·374 (14)	29 162·828 (- 31)	29 334·668 (- 26)	29 138·266 (74)	29 310·976 (- 32)	29 114·523 (16)
12·5	29 378·165 (- 26)	29 180·879 (5)	29 348·273 (- 16)	29 150·924 (- 48)	29 321·545 (24)	29 124·291 (88)	29 295·772 (41)	29 098·405 (- 10)
13·5	29 367·383 (- 49)	29 169·708 (41)	29 335·520 (- 0)	29 137·752 (- 4)	29 306·585 (- 14)	29 108·829 (- 5)	29 278·750 (- 57)	29 080·976 (- 66)
14·5	29 356·444 (- 79)	29 157·878 (57)	29 322·498	29 123·779 (- 18)	29 291·520 (32)	29 092·786	29 261·597 (11)	29 062·841 (- 43)
15·5	29 343·669 (- 40)	29 144·499 (3)	29 307·650 (- 19)	29 108·466 (10)	29 274·532 (11)	29 075·312 (5)	29 242·564 (- 45)	29 043·330 (- 65)
16·5	29 330·818 (- 28)	29 130·560 (- 18)	29 292·653 (- 42)	29 092·391 (- 37)	29 257·469 (2)	29 057·155 (- 44)	29 223·408 (- 34)	29 023·232 (57)
17·5	29 315·972	29 115·131 (0)	29 275·766 (- 39)	29 074·979 (16)	29 238·426 (- 26)	29 037·610	29 202·381 (- 30)	29 001·590 (19)
18·5	29 301·151	29 099·218 (77)	29 258·852 (- 25)	29 056·975 (107)	29 219·445 (- 6)	29 017·457 (15)	29 181·283 (- 18)	28 979·286 (- 6)
19·5	29 284·237 (21)	29 081·595 (23)	29 239·923 (- 0)	29 037·346 (67)	29 198·375 (- 11)	28 995·748 (6)	29 158·205 (- 13)	28 955·556 (- 17)
20·5	29 267·506 (75)	29 063·511 (1)	29 221·108 (68)	29 017·187 (67)	29 177·473 (39)	28 973·464 (- 50)	29 135·125 (- 36)	28 931·233 (- 7)
21·5	29 248·435 (2)	29 043·777 (- 39)	29 200·017 (- 5)	28 995·397 (- 9)	29 154·317	28 949·689 (- 12)	29 110·024	28 905·426 (17)
22·5	29 229·694 (14)	29 023·702 (18)	29 179·196 (17)	28 973·248 (66)	29 131·381 (- 30)	28 925·447 (33)	29 085·020 (0)	28 879·101 (77)
23·5	29 208·538 (- 76)	29 001·920 (55)	29 156·134 (40)	28 949·345	29 106·267 (27)	28 899·476 (- 15)	29 057·824 (- 6)	28 851·055 (- 25)
24·5	29 188·004 (115)	28 979·707 (48)	29 133·293 (4)	28 925·059	29 081·406 (30)	28 873·159 (12)	29 030·826 (- 49)	28 822·713 (67)
25·5	29 164·869 (116)	28 955·729 (15)	29 108·142 (6)	28 899·096	29 054·136 (- 14)	28 845·085 (- 25)	29 001·677 (46)	28 792·577 (- 14)
26·5	29 142·093 (42)	28 931·444 (7)	29 083·377 (14)	28 872·740 (- 9)	29 027·324	28 816·704 (- 6)	28 972·691 (- 32)	28 762·144 (34)
27·5	29 116·842	28 905·364 (1)	29 056·144 (6)	28 844·617 (- 43)	28 998·057 (17)	28 786·584 (23)	28 941·387 (- 36)	28 729·960 (16)
28·5	29 092·157	28 879·021 (6)	29 029·390 (- 6)	28 816·314 (59)	28 969·258 (9)	28 756·095 (- 12)	28 910·583 (22)	28 697·407 (- 12)
29·5	29 064·859 (- 14)	28 850·761 (- 50)	29 000·123 (24)	28 786·023 (- 14)	28 937·920 (13)	28 723·733 (- 112)	28 877·190 (- 14)	
30·5		28 822·418 (26)	28 971·407 (26)	28 755·579 (5)	28 907·144	28 691·370 (33)	28 844·433 (49)	
31·5		28 792·043 (- 15)	28 940·029 (20)	28 723·290 (61)	28 873·690 (- 52)	28 657·005 (43)	28 808·950 (- 18)	
32·5			28 909·273 (- 39)	28 690·750 (41)	28 841·003 (- 2)		28 774·221 (34)	
33·5			28 875·893 (32)	28 656·234	28 805·541		28 736·665 (- 47)	
34·5					28 770·825 (- 0)		28 699·977 (10)	

1–8 band

0·5	26 973·798 (- 70)							
1·5	26 975·165			26 775·860 (19)	26 965·613 (- 16)			
2·5	26 975·768 (- 32)	26 784·206 (43)	26 966·148 (- 41)	26 774·567 (15)	26 961·796			
3·5	26 975·283	26 783·581 (44)	26 963·980 (81)	26 772·170 (18)	26 956·959 (- 56)	26 765·223 (- 45)		26 757·442 (24)
4·5	26 974·148 (- 7)	26 782·110 (- 5)	26 960·819	26 768·802 (23)	26 951·585 (- 56)	26 759·600	26 942·044 (15)	26 749·997 (7)
5·5	26 971·720 (3)	26 779·539 (34)	26 956·486 (- 12)	26 764·290 (3)	26 945·016 (- 31)	26 752·836	26 933·697 (34)	26 741·446 (- 6)
6·5	26 968·763 (- 1)	26 776·131 (1)	26 951·515 (- 6)	26 758·860 (- 29)	26 937·905 (- 6)	26 745·265 (- 13)	26 924·575	26 731·910 (- 32)
7·5	26 964·362 (- 8)	26 771·501 (- 4)	26 945·219 (18)	26 752·335	26 929·397 (- 2)	26 736·564 (31)	26 914·163 (- 18)	26 721·324 (9)
8·5	26 959·560 (- 11)	26 766·162 (5)	26 938·308 (- 38)	26 744·922 (- 9)	26 920·442 (1)	26 726·998 (- 29)	26 903·192 (- 7)	26 709·784 (- 1)
9·5	26 953·209 (- 3)	26 759·508 (4)	26 930·029 (- 7)	26 736·315 (- 12)	26 909·975 (- 3)	26 716·270	26 890·845 (36)	26 697·086 (- 15)
10·5	26 946·557 (0)	26 752·253 (78)	26 921·286 (- 23)	26 726·961 (34)	26 899·166 (- 12)	26 704·803 (6)	26 877·939 (- 13)	26 683·587 (17)
11·5	26 938·257 (34)	26 743·482 (- 5)	26 910·996 (- 17)	26 716·277	26 886·746 (- 7)	26 692·062 (44)	26 863·607 (30)	26 668·834 (- 7)
12·5	26 929·684 (- 20)	26 734·162 (- 11)	26 900·431 (15)	26 704·888 (2)	26 874·089 (- 12)	26 678·587 (17)	26 848·826 (- 27)	26 653·303 (- 20)
13·5	26 919·405 (12)	26 723·428 (- 19)	26 888·140 (3)	26 692·193 (2)	26 859·708 (- 0)	26 663·781 (18)	26 832·512 (13)	26 636·538 (- 16)
14·5	26 909·004	26 712·153 (6)	26 875·639 (- 30)	26 678·821 (9)	26 845·198 (2)	26 648·348 (9)	26 815·894 (- 16)	26 619·081 (29)
15·5	26 896·716 (4)	26 699·330 (- 50)	26 861·397 (- 9)	26 664·081 (7)	26 828·788 (- 46)	26 631·517 (16)	26 797·580 (2)	26 600·243 (- 3)
16·5	26 884·446 (- 3)	26 686·094 (2)	26 847·052 (- 13)	26 648·716 (8)	26 812·451 (- 7)	26 614·096 (- 6)	26 779·127 (3)	26 580·768 (1)
17·5	26 870·121 (- 53)	26 671·271 (- 11)	26 830·815 (- 4)	26 631·935 (9)	26 794·165 (41)	26 595·221 (- 10)	26 758·800 (18)	26 559·943 (17)
18·5	26 856·028 (- 4)	26 656·000 (- 8)	26 814·624 (22)	26 614·563 (- 14)	26 775·889 (9)	26 575·852 (- 4)	26 738·506 (9)	26 538·486 (14)

(continued)

Table 1 (*continued*)

J	R_{11}	R_{12}	R_{21}	R_{22}	P_{11}	P_{12}	P_{21}	P_{22}
				1–8 band (*continued*)				
19·5	26 839·750 (- 21)	26 639·142 (- 9)	26 796·354 (- 16)	26 595·747 (- 4)	26 755·571 (- 1)	26 554·947 (- 5)	26 716·251 (36)	26 515·608 (12)
20·5	26 823·665 (- 80)	26 621·898 (8)	26 778·266 (- 8)	26 576·454 (34)	26 735·455 (- 2)	26 533·603 (1)	26 694·013 (- 14)	26 492·170 (- 2)
21·5	26 805·480 (- 17)	26 602·940 (- 48)	26 758·071 (13)	26 555·555 (6)	26 713·173	26 510·660 (- 3)	26 669·796 (24)	26 467·307 (44)
22·5	26 787·571 (- 10)	26 583·744 (6)	26 738·079 (- 1)	26 534·224 (- 13)	26 691·156 (- 27)	26 487·346 (6)	26 645·711 (- 1)	26 441·881 (11)
23·5	26 767·381 (38)	26 562·802 (15)	26 715·928 (52)	26 511·320	26 666·921 (- 1)	26 462·363 (- 3)	26 619·472 (- 11)	26 414·929 (1)
24·5	26 747·550 (16)	26 541·545 (- 7)	26 694·021 (8)	26 488·062 (31)	26 643·064 (11)	26 437·098 (27)	26 593·541 (- 10)	26 387·597 (28)
25·5	26 725·373 (70)	26 518·553 (3)	26 669·819	26 463·041 (- 27)	26 616·788 (- 26)	26 410·059 (- 3)	26 565·350 (3)	26 358·570 (- 25)
26·5	26 703·619 (25)	26 495·332 (3)	26 646·073 (6)	26 437·801	26 591·069 (8)	26 382·796 (0)	26 537·547 (6)	26 329·265 (- 10)
27·5	26 679·380 (12)	26 470·291 (17)	26 619·869 (- 13)	26 410·835 (46)	26 562·878 (34)	26 353·735 (- 15)	26 507·352 (- 8)	26 298·304 (36)
28·5	26 655·741 (- 15)	26 445·061 (- 7)	26 594·227 (- 8)	26 383·456 (- 91)	26 535·294 (91)	26 324·509 (- 7)	26 477·682 (6)	26 266·947 (- 40)
29·5	26 629·549 (17)	26 417·965 (5)	26 566·032 (- 26)	26 354·486 (- 0)	26 505·003 (- 3)	26 293·446 (13)	26 445·507 (- 13)	26 233·911 (- 36)
30·5	26 604·053 (44)	26 390·760 (- 9)	26 538·512	26 325·278 (7)	26 475·473	26 262·208 (- 24)	26 413·959 (7)	26 200·732 (21)
31·5	26 575·786	26 361·597 (- 7)	26 508·349 (8)	26 294·105 (- 53)	26 443·270 (- 23)	26 229·098 (- 13)	26 379·811 (- 9)	26 165·609 (- 28)
32·5	26 548·348	26 332·377 (- 51)	26 478·869 (- 23)	26 262·972	26 411·894 (29)	26 195·922 (- 23)	26 346·375 (8)	26 130·344 (- 104)
33·5	26 518·104 (- 18)	26 301·225 (20)	26 446·761 (37)	26 229·828 (21)	26 377·702	26 160·785	26 310·254 (- 4)	26 093·341 (1)
34·5	26 488·763	26 270·023 (- 22)	26 415·366 (- 1)		26 344·440 (68)	26 125·680 (25)	26 274·893 (- 23)	26 056·220 (21)
35·5	26 456·591 (59)	26 236·778 (17)	26 381·214 (14)		26 308·226	26 088·448 (- 7)	26 236·801 (- 27)	
36·5	26 425·361 (115)	26 203·616 (- 2)	26 347·937 (7)		26 272·990	26 051·361 (- 2)	26 199·609 (15)	
37·5	26 391·081 (75)	26 168·233 (- 36)	26 311·766 (4)		26 234·900 (42)	26 012·112 (- 9)	26 159·523 (- 3)	
38·5		26 133·146 (1)	26 276·569 (- 5)		26 197·811 (100)	25 973·058 (- 10)	26 120·413 (17)	
39·5			26 238·417 (14)					
40·5			26 201·291					
41·5			26 161·084 (- 30)					
				1–7 band				
1·5	28 620·024 (23)	28 427·717 (15)			28 610·399 (- 65)			
2·5	28 620·496 (- 42)	28 428·072	28 610·986 (58)	28 418·463 (2)	28 606·574 (40)		28 600·103 (- 32)	28 407·666 (- 3)
3·5	28 619·889 (6)	28 427·306 (1)	28 608·475 (- 23)	28 415·949 (28)	28 601·695 (80)	28 409·037	28 593·758 (- 6)	28 401·164 (- 22)
4·5	28 618·550 (- 29)	28 425·685 (- 16)	28 605·224 (- 19)	28 412·377 (12)	28 596·061 (- 4)	28 403·165 (- 22)	28 586·494 (41)	28 393·581 (5)
5·5	28 615·905 (- 18)	28 422·933 (63)	28 600·719 (14)	28 407·666 (14)	28 589·266 (12)	28 396·214 (13)	28 577·870	28 384·825 (8)
6·5	28 612·683 (- 34)	28 419·216 (- 17)	28 595·442 (- 32)	28 401·966 (- 24)	28 581·830 (- 34)	28 388·388 (7)	28 568·521 (- 7)	28 375·053 (9)
7·5	28 607·991 (- 37)	28 414·303 (- 3)	28 588·871 (13)	28 395·131 (- 4)	28 573·031 (- 25)	28 379·321 (- 12)	28 557·884 (47)	28 364·101 (- 14)
8·5	28 602·875 (- 22)	28 408·566 (- 48)	28 581·717 (46)	28 387·385 (- 3)	28 563·805 (39)	28 369·480 (- 4)	28 546·564 (40)	28 352·252 (10)
9·5	28 596·180 (18)	28 401·584 (6)	28 573·034 (48)	28 378·444 (43)	28 552·927 (- 2)	28 358·344 (- 0)	28 533·802 (43)	28 339·185 (11)
10·5	28 589·111 (15)	28 393·834 (8)	28 563·805 (- 42)	28 368·568 (- 9)	28 541·707 (- 10)	28 346·457 (10)	28 520·494 (3)	28 325·219 (- 2)
11·5	28 580·307 (- 1)	28 384·714 (41)	28 553·059 (- 39)	28 357·465 (1)	28 528·817 (- 22)	28 333·221 (17)	28 505·660 (- 2)	28 310·023 (- 5)
12·5	28 571·294 (- 5)	28 374·877 (21)	28 542·002 (- 9)	28 345·569 (1)	28 515·736 (39)	28 319·251 (- 2)	28 490·457 (8)	28 294·020 (15)
13·5	28 560·473 (17)	28 363·578 (- 6)	28 529·190 (- 10)	28 332·319 (- 10)	28 500·789 (17)	28 303·925 (25)	28 473·583 (20)	28 276·649 (- 41)
14·5	28 549·545 (47)	28 351·705 (5)	28 516·141 (- 22)	28 318·356 (- 8)	28 485·686 (- 6)	28 287·897 (4)	28 456·394 (- 10)	28 258·624 (19)
15·5	28 536·585 (- 11)	28 338·332 (26)	28 501·286 (- 4)	28 302·984 (- 17)	28 468·707 (- 10)	28 270·450 (22)	28 437·469 (7)	28 239·200 (27)
16·5	28 523·686 (1)	28 324·330 (- 24)	28 486·329 (28)	28 286·957 (- 13)	28 451·673 (- 22)	28 252·365 (1)	28 418·364 (4)	28 219·084 (56)
17·5	28 508·691 (- 28)	28 308·841 (5)	28 469·383 (19)	28 269·506 (25)	28 432·675 (6)	28 232·797 (11)	28 397·363	28 197·510 (30)
18·5	28 493·853 (1)	28 292·811 (- 6)	28 452·415 (- 6)	28 251·388 (2)	28 413·728 (28)	28 212·699 (34)	28 376·324 (8)	28 175·256 (- 25)
19·5	28 476·818 (- 3)	28 275·159 (- 13)	28 433·419 (- 1)	28 231·793 (22)	28 392·613 (- 8)	28 190·989 (16)	28 353·259 (- 7)	28 151·616 (- 1)
20·5	28 459·985 (- 4)	28 257·084 (- 1)	28 414·531 (12)	28 211·615	28 371·692 (- 9)	28 168·797 (1)	28 330·275 (4)	28 127·362 (- 4)

21·5	28 440·899 (6)	28 237·311 (− 2)	28 393·471 (17)	28 189·884 (11)	28 348·543 (− 25)	28 145·001 (12)	28 305·160 (− 8)	28 101·573 (− 15)
22·5	28 422·125 (32)	28 217·168 (10)	28 372·584 (− 8)	28 167·665 (8)	28 325·709 (15)	28 120·759 (1)	28 280·199 (− 25)	28 075·294 (5)
23·5	28 400·907 (− 19)	28 195·245 (− 11)	28 349·458 (− 1)	28 143·791 (3)	28 300·495 (− 11)	28 094·863 (29)	28 253·069 (3)	28 047·411 (15)
24·5	28 380·147 (− 6)	28 173·061 (28)	28 326·642 (10)	28 119·453 (− 60)	28 275·658 (− 14)	28 068·548 (− 4)	28 226·159 (− 11)	28 019·045 (− 6)
25·5	28 356·934 (20)	28 148·997 (− 3)	28 301·431 (− 1)	28 093·520 (4)	28 248·416 (− 10)	28 040·529 (18)	28 196·981 (22)	27 989·071 (26)
26·5	28 334·212 (50)	28 124·696 (− 16)	28 276·649 (15)	28 067·208 (24)	28 221·627 (− 3)	28 012·186 (8)	28 168·121 (13)	27 958·691 (34)
27·5	28 308·841 (− 9)	28 098·541 (− 2)	28 249·363 (− 1)	28 039·088 (31)	28 192·297 (− 28)	27 982·012 (− 7)	28 136·831 (− 11)	27 926·523 (− 12)
28·5	28 284·072 (− 41)	28 072·231 (41)	28 222·634 (41)	28 010·642 (− 27)	28 163·603 (42)	27 951·671 (33)	28 106·041 (8)	27 894·098 (− 11)
29·5	28 256·682 (− 42)	28 043·876 (− 9)	28 193·193 (− 58)	27 980·406 (− 5)	28 132·181 (− 17)	27 919·367 (8)	28 072·676 (− 35)	27 859·881 (8)
30·5	28 230·027 (30)	28 015·413 (− 55)	28 164·484 (− 17)	27 949·927 (− 43)	28 101·397 (− 64)	27 886·896 (− 35)	28 039·946 (6)	27 825·416 (5)
31·5	28 200·476 (− 53)	27 985·034 (9)	28 133·089 (5)	27 917·580	28 068·046 (9)	27 852·524 (− 8)	28 004·564 (1)	27 789·058 (− 0)
32·5		27 954·545 (2)	28 102·400 (49)	27 885·059 (− 27)		27 818·067 (8)	27 969·833 (7)	27 752·554 (− 7)
33·5		27 921·944 (− 15)	28 068·862 (2)	27 850·517 (− 44)		27 781·536 (− 3)	27 932·387 (− 5)	
34·5		27 889·360 (− 53)	28 036·167 (30)	27 816·016 (− 1)			27 895·725 (39)	
35·5		27 854·684 (− 2)	28 000·567 (− 0)	27 779·344 (− 11)			27 856·164 (− 30)	
36·5		27 820·077	27 965·865 (15)					
37·5		27 783·238 (33)	27 928·156 (− 45)					
38·5			27 891·472 (− 13)					
39·5			27 851·703 (− 50)					
40·5			27 813·009 (− 24)					
41·5			27 771·203 (− 13)					
				1–6 band				
2·5				30 094·911 (− 42)				
3·5		30 103·657		30 092·279 (6)				
4·5		30 101·878 (5)		30 088·547 (10)		30 079·392 (33)		30 069·724 (− 24)
5·5		30 098·821		30 083·605 (2)		30 072·152		30 060·788 (20)
6·5		30 094·987 (64)		30 077·681		30 064·154 (84)		30 050·750 (16)
7·5		30 089·699 (4)		30 070·521 (− 4)		30 054·701 (− 22)		30 039·486 (− 19)
8·5		30 083·747 (85)		30 062·411 (− 25)		30 044·532 (1)		30 027·274 (− 16)
9·5		30 076·245 (− 0)		30 053·066 (− 3)		30 033·025 (14)	30 209·272 (4)	30 013·811 (− 30)
10·5		30 068·079 (9)		30 042·808 (− 14)	30 216·759 (− 51)	30 020·707 (15)	30 195·583	29 999·414 (− 52)
11·5		30 058·416 (− 41)		30 031·254 (6)	30 203·489	30 007·011 (22)	30 180·305 (− 8)	29 983·836 (25)
12·5		30 048·147 (11)		30 018·871 (22)	30 189·749 (− 101)	29 992·499 (− 34)	30 164·532 (− 70)	29 967·255 (− 31)
13·5		30 036·307 (− 18)	30 202·811 (− 24)	30 005·081 (11)	30 174·409 (3)	29 976·602 (− 39)	30 147·167 (− 29)	29 949·405 (− 26)
14·5		30 023·864 (8)	30 189·171 (− 51)	29 990·538 (18)	30 158·746 (− 4)	29 960·042 (− 6)	30 129·432 (− 31)	29 930·771 (10)
15·5	30 209·053 (− 3)	30 009·817 (− 26)	30 173·743 (− 7)	29 974·562 (25)	30 141·148 (− 30)	29 941·972 (7)	30 109·940 (17)	29 910·733 (24)
16·5	30 195·503 (11)	29 995·219 (− 5)	30 158·083 (− 24)	29 957·848 (8)	30 123·492 (− 9)	29 923·227 (− 7)	30 090·181 (15)	29 889·890 (− 9)
17·5	30 179·849 (− 0)	29 978·980 (− 28)	30 140·551 (57)	29 939·645 (− 8)	30 103·811 (11)	29 903·007 (49)	30 068·515 (22)	29 867·657 (5)
18·5	30 164·255 (7)	29 962·267 (28)	30 122·810 (− 8)	29 920·801 (− 8)	30 084·020 (− 77)	29 882·105 (17)	30 046·701 (− 12)	29 844·709 (5)
19·5	30 146·462	29 943·838 (20)	30 103·096 (34)	29 900·452 (35)	30 062·298 (36)	29 859·587 (− 31)	30 022·938 (31)	29 820·220 (− 43)
20·5	30 128·835 (16)	29 924·883 (− 15)	30 083·336 (− 14)	29 879·428	30 040·494 (− 38)	29 836·612 (1)	29 999·072 (− 29)	29 795·206 (26)
21·5	30 108·899 (11)	29 904·272 (1)	30 061·448	29 856·841 (8)	30 016·587 (24)	29 811·953 (5)	29 973·152 (− 10)	29 768·547
22·5	30 089·198	29 883·166 (− 36)	30 039·706 (9)	29 833·665 (− 35)	29 992·765 (− 33)	29 786·771 (− 32)	29 947·323 (− 6)	29 741·347 (15)
23·5	30 067·211 (95)	29 860·370 (4)	30 015·717 (68)	29 808·887 (− 13)	29 966·677 (− 18)	29 759·930 (− 15)	29 919·282 (26)	29 712·540 (33)
24·5	30 045·362 (− 13)	29 837·121 (− 24)	29 991·883 (29)	29 783·626 (1)	29 940·901 (8)	29 732·688 (24)	29 891·394 (2)	29 683·148 (− 15)
25·5	30 021·153 (13)	29 812·073 (− 27)	29 965·669 (12)	29 756·602 (− 15)	29 912·610 (− 42)	29 703·580 (− 32)	29 861·169 (− 16)	29 652·087 (− 58)
26·5	29 997·343	29 786·771 (41)	29 939·824 (10)	29 729·197 (− 4)	29 884·844 (35)	29 674·161 (− 35)	29 831·301 (13)	29 620·654 (− 20)
27·5	29 971·007 (55)	29 759·496 (23)	29 911·459 (− 7)	29 699·972 (− 15)	29 854·512 (84)	29 642·892 (− 57)	29 798·936 (− 9)	29 587·496 (31)

(*continued*)

Table 1 (*continued*)

J	R_{11}	R_{12}	R_{21}	R_{22}	P_{11}	P_{12}	P_{21}	P_{22}
28·5	29 945·200 (107)	29 731·936 (− 16)	29 883·660 (88)	29 670·485 (55)	29 824·540	29 611·384 (− 15)	29 767·053 (41)	29 553·775 (− 96)
29·5	29 916·558 (14)	29 702·474 (− 8)	29 853·047 (− 22)	29 638·994 (− 14)	29 792·020 (3)	29 577·947 (− 8)	29 732·620 (89)	29 518·470 (1)
30·5	29 888·702 (85)	29 672·849 (39)	29 823·093 (− 27)	29 607·351 (39)	29 760·147 (67)	29 544·262 (− 11)	29 698·553 (− 6)	29 482·752
31·5	29 857·909 (4)	29 641·127 (2)	29 790·496 (36)	29 573·680	29 725·408 (− 5)	29 508·514 (− 119)	29 661·992 (53)	
32·5	29 827·906	29 609·286 (− 17)	29 758·450 (0)	29 539·847	29 691·444 (21)	29 472·835 (16)	29 625·918 (− 7)	
33·5	29 795·029	29 575·405 (4)	29 723·633 (2)		29 654·600 (− 9)		29 587·208 (44)	
34·5	29 762·899 (− 53)	29 541·360 (− 68)	29 689·590 (35)		29 618·567 (6)		29 549·157 (53)	
35·5		29 505·269 (− 38)	29 652·518 (− 56)		29 579·576 (− 23)		29 508·236 (35)	
36·5		29 469·184	29 616·433 (5)		29 541·433 (− 55)			
37·5			29 577·340 (60)					
38·5			29 538·979 (− 81)					

[a]The number in the parentheses indicates $(\nu_{obs} - \nu_{calc}) \times 10^3$ in cm^{-1} units. If this number is not given, then the listed number is a calculated wavenumber.
[b]The spectral lines with even $(J - \frac{1}{2})$ values represent an e → e transition and those with odd $(J - \frac{1}{2})$ values represent an f → f transition.

Table 2. Molecular constants (in cm^{-1}) for the $X^2\Pi_g$ state of the O_2^+ molecule.

Vibrational level	T_v[a]	A_v	$A_{D_v}/10^{-5}$	B_v	$D_v/10^{-6}$	$H_v/10^{-11}$	$q_v/10^{-4}$	$p_v/10^{-2}$	$p_{D_v}/10^{-7}$
2	4662·33[b]	199·0191 (29)	—	1·641 295 (23)	5·410 (23)	—	3·82 (28)	1·756 (33)	—
3	6469·7027 (59)	198·3736 (38)	− 5·3 (15)	1·622 004 (28)	5·604 (42)	—	2·14 (41)	1·754 (36)	—
4	8244·5209 (36)	197·6496 (23)	− 2·06 (56)	1·602 269 (21)	5·495 (21)	—	1·61 (15)	1·724 (25)	—
5	9986·7681 (36)	196·9182 (25)	− 6·42 (80)	1·582 689 (18)	5·541 (20)	—	1·01 (20)	1·658 (22)	—
6	11 696·2739 (43)	196·1548 (23)	− 9·56 (52)	1·562 978 (11)	5·5628 (90)	—	0·69 (10)	1·651 (15)	—
7	13 373·3399 (47)	195·3294 (15)	− 10·77 (26)	1·543 1883 (67)	5·6296 (32)	—	1·295 (47)	1·7186 (91)	—
8	15 017·8424 (47)	194·4656 (12)	− 11·49 (17)	1·523 2907 (76)	5·6768 (63)	0·55 (18)	1·196 (29)	1·7028 (77)	—
9	16 629·7677 (47)	193·5646 (10)	− 14·72 (12)	1·503 3193 (70)	5·7455 (49)	1·11 (12)	1·325 (24)	1·7053 (85)	1·99 (62)
10	18 209·0913 (48)	192·6152 (12)	− 17·91 (13)	1·483 2262 (70)	5·8032 (44)	1·141 (93)	1·264 (24)	1·6968 (91)	1·87 (61)
11	19 755·7614 (48)	191·6055 (12)	− 20·49 (14)	1·463 0010 (73)	5·8588 (50)	1·09 (12)	1·248 (24)	1·6942 (97)	2·28 (73)
12	21 269·7034 (47)	190·5455 (12)	− 24·08 (16)	1·442 6210 (61)	5·8915 (24)	—	1·217 (28)	1·7040 (76)	—

[a]The term values reported here are with respect to the $v = 0$ level of the $X^2\Pi_r$ state.
[b]Fixed in the least-squares fit to the value reported by Coxon and Haley [22].

Table 3. Molecular constants (in cm^{-1}) for the $A\,^2\Pi_u$ state of the O_2^+ molecule.

Vibrational level	T_v[a]	A_v	$A_{D_v}/10^{-4}$	B_v	$D_v/10^{-6}$	$q_v/10^{-5}$	$p_v/10^{-2}$
0	41 018·7231 (47)	- 3·5049 (19)	- 7·386 (54)	1·052 1151 (58)	6·0627 (23)	2·732 (43)	- 2·3094 (67)
1	42 890·1749 (47)	- 3·2150 (59)	- 4·47 (22)	1·032 3073 (75)	6·1572 (41)	1·54 (18)	- 2·416 (12)
2	42 734·4552 (40)	- 2·7782 (53)	—	1·012 328 (14)	6·254 (12)	—	- 2·649 (22)
3	43 551·5277 (40)	- 2·3054 (89)	4·85 (58)	0·992 107 (22)	6·463 (21)	- 2·85 (42)	- 2·816 (32)
4	44 341·2006 (29)	- 1·6913 (77)	18·13 (61)	0·971 653 (18)	6·566 (18)	- 4·64 (31)	- 3·065 (25)
5	45 103·6477 (53)	- 0·9407 (96)	23·7 (13)	0·951 083 (19)	6·741 (25)	- 8·71 (68)	- 3·466 (34)

[a]The term values reported here with respect to the $v = 0$ level of the $X\,^2\Pi_r$ state.

Table 4. Equilibrium molecular constants for the $X\,^2\Pi_g$ and $A\,^2\Pi_u$ states of O_2^+. Constants are in inverse centimetres unless stated otherwise.

Molecular constant	$X\,^2\Pi_r$	$A\,^2\Pi_i$
T_e	0·0	40 572·785 (86)
$Y_{10}(\omega_e)$	1905·892 (82)	898·65 (12)
$-Y_{20}(\omega_e x_e)$	16·489 (13)	13·574 (46)
$Y_{30}(\omega_e y_e)$	0·020 57 (90)	- 0·0066 (51)
$Y_{40}(\omega_e z_e)$	- 0·737 (24) × 10^{-3}	—
$Y_{01}(B_e)$	1·689 824 (91)	1·061 939 (14)
$-Y_{11}(\alpha_e)$	0·019 363 (37)	0·019 598 (16)
$Y_{21}(\gamma_e)$	- 0·132 (47) × 10^{-4}	- 0·1019 (30) × 10^{-3}
Y_{31}	- 0·158 (19) × 10^{-5}	—
r_e (Å)	1·116 877 (30)	1·408 887 4 (93)

Table 5. RKR turning points for the $X\,^2\Pi_g$ state of the O_2^+ molecule.

Vibrational level	E_v (cm^{-1})	R_{min} (Å)	R_{max} (Å)
0	948·906	1·072 81	1·167 22
1	2 821·882	1·044 00	1·208 71
2	4 662·043	1·025 70	1·239 92
3	6 469·478	1·011 68	1·267 05
4	8 244·255	1·000 15	1·291 92
5	9 986·429	0·990 29	1·315 36
6	11 696·035	0·981 66	1·337 82
7	13 373·089	0·973 96	1·359 60
8	15 017·591	0·967 02	1·380 90
9	16 629·523	0·960 70	1·401 86
10	18 208·850	0·954 90	1·422 61
11	19 755·518	0·949 54	1·443 22
12	21 269·457	0·944 58	1·463 78
13	22 750·577	0·939 95	1·484 35
14	24 198·772	0·935 62	1·504 99
15	25 613·918	0·931 57	1·525 76
16	26 995·873	0·927 76	1·546 69
17	28 344·478	0·924 16	1·567 84
18	29 659·556	0·920 77	1·589 25
19	30 940·912	0·917 56	1·610 98
20	32 188·333	0·914 51	1·633 06
21	33 401·589	0·911 62	1·655 55
22	34 580·433	0·908 87	1·678 50
23	35 724·599	0·906 24	1·701 97
24	36 833·804	0·903 73	1·726 00

$X\,^2\Pi_g$ state of O_2^+ is extended up to $v = 24$ and calculated up to $v = 5$ for the $A\,^2\Pi_u$ state. These potentials were used to calculate the Franck–Condon factors for the bands of the second negative ($A\,^2\Pi_u$–$X\,^2\Pi_g$) system and are listed in table 6. These values are in good agreement with those available in the literature [25, 35, 36].

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Table 6. Franck–Condon factors for the bands of the second negative ($A\,^2\Pi_u$-$X\,^2\Pi_g$) system of O_2^+.

v′ v″	0	1	2	3	4	5	6	7	8
0	1·59E- 06	2·99E- 05	2·67E- 04	1·50E- 03	5·98E- 03	1·80E- 02	4·23E- 02	8·00E- 02	1·24E- 01
1	1·29E- 05	2·12E- 04	1·60E- 03	7·44E- 03	2·36E- 02	5·37E- 02	8·91E- 02	1·06E- 01	8·42E- 02
2	5·58E- 05	7·93E- 04	5·09E- 03	1·94E- 02	4·79E- 02	7·90E- 02	8·31E- 02	4·63E- 02	4·82E- 03
3	1·70E- 04	2·10E- 03	1·14E- 02	3·51E- 02	6·59E- 02	7·30E- 02	3·80E- 02	1·65E- 03	1·76E- 02
4	4·08E- 04	4·40E- 03	2·01E- 02	4·94E- 02	6·76E- 02	4·35E- 02	4·12E- 03	1·25E- 02	4·85E- 02
5	8·29E- 04	7·77E- 03	2·97E- 02	5·74E- 02	5·35E- 02	1·38E- 02	3·49E- 03	3·75E- 02	3·59E- 02

v′ v″	9	10	11	12	13	14	15	16	17
0	1·58E- 01	1·69E- 01	1·51E- 01	1·14E- 01	7·21E- 02	3·84E- 02	1·72E- 02	6·39E- 03	1·97E- 03
1	3·50E- 02	1·15E- 03	1·78E- 02	7·51E- 02	1·28E- 01	1·41E- 01	1·13E- 01	7·01E- 02	3·42E- 02
2	1·09E- 02	5·75E- 02	7·77E- 02	4·11E- 02	1·66E- 03	2·14E- 02	8·69E- 02	1·34E- 01	1·29E- 01
3	5·71E- 02	4·70E- 02	5·26E- 03	1·39E- 02	6·26E- 02	6·39E- 02	1·54E- 02	5·50E- 03	6·54E- 02
4	3·53E- 02	8·36E- 04	2·36E- 02	5·50E- 02	2·38E- 02	1·32E- 03	4·53E- 02	6·88E- 02	2·37E- 02
5	1·76E- 03	1·97E- 02	4·52E- 02	1·27E- 02	7·05E- 03	4·82E- 02	3·36E- 02	7·87E- 07	3·86E- 02

v′ v″	18	19	20	21	22	23	24
0	4·99E- 04	1·02E- 04	1·66E- 05	2·08E- 06	1·96E- 07	1·32E- 08	5·82E- 10
1	1·32E- 02	4·07E- 03	9·87E- 04	1·86E- 04	2·66E- 05	2·79E- 06	2·04E- 07
2	8·68E- 02	4·36E- 02	1·66E- 02	4·83E- 03	1·06E- 03	1·73E- 04	2·04E- 05
3	1·28E- 01	1·34E- 01	9·17E- 02	4·46E- 02	1·58E- 02	4·10E- 03	7·71E- 04
4	2·57E- 03	6·21E- 02	1·31E- 01	1·35E- 01	8·74E- 02	3·87E- 02	1·20E- 02
5	6·87E- 02	2·31E- 02	4·33E- 03	7·34E- 02	1·41E- 01	1·31E- 01	7·51E- 02

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