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LINEWIDTHS OF H_2S

G. D. T. Tejwani and E. S. Yeung

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Date Transmitted: August 1976

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ABSTRACT

Self-broadened and foreign-gas (N_2 and O_2) broadened linewidths of H_2S at $300^\circ K$ for a wide range of quantum numbers J and K_a , for both type A and type B bands, have been calculated using the Anderson-Tsao-Curnutte theory of line broadening. In the case of H_2S-H_2S collisions, dipole-dipole, dipole-quadrupole, quadrupole-dipole, and quadrupole-quadrupole interactions have been included. For H_2S-N_2 and H_2S-O_2 collisions, dipole-quadrupole and quadrupole-quadrupole interactions were taken into account. Computed values for self-broadened linewidths are in good agreement with the experimental results of Helminger and De Lucia. Air-broadened linewidths of H_2S at $200^\circ K$ have also been calculated, so that the temperature dependence can be established.

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I. INTRODUCTION

There is much interest currently centered on studies of the minor constituents of the earth's troposphere and stratosphere. Spectrometric observations throughout the infrared region¹ have had much success in the detection of minor constituents. However, accurate data on the spectral characteristics of the various molecules found in the atmosphere are necessary. One of the most useful parameters needed in determining the abundance of the molecular species is air-broadened linewidths.

Hydrogen sulfide is an asymmetric top molecule with C_{2v} symmetry and therefore has complex vibrational-rotational infrared spectra. The direct measurement of linewidths in the infrared bands of this molecule is possible only at very high resolution. So far, no such measurements have been reported. The only available experimental results on linewidths for individual transitions in H_2S bands are microwave studies by Helminger and De Lucia.² They have reported self-broadened linewidths for four transitions in the pure rotation band of H_2S .

We have used Anderson-Tsao-Curnette's theory of line broadening^{3,4} in our computations for the self- and foreign-gas-broadened transitions in the H_2S bands. Good agreement was obtained with the measured values in the self-broadening.² N_2 -, O_2 -, and self-broadened linewidths of H_2S at 300°K have been computed for all the transitions with $J \leq 12$ and $K_a \leq 8$ for

both type A and type B bands. In addition, air-broadened linewidths have also been computed at 200°K. The energy level of the lower state for each transition, along with an approximate value for the line position and the relative line intensity have also been calculated for ν_3 fundamental in type A and ν_2 fundamental in type B bands.

II. COMPUTATIONAL PROCEDURE

The line-broadening theory of the asymmetric top molecule developed by Yamamoto and Aoki⁵ in the framework of Anderson-Tsao-Curnutte's theory^{3,4} has been used in our calculations. Dipole-dipole, dipole-quadrupole, quadrupole-dipole, and quadrupole-quadrupole interactions have been included in H₂S self-broadening computations. For N₂- and O₂- broadened linewidths of H₂S, dipole-quadrupole and quadrupole-quadrupole interactions have been taken into account. Because of moderately large values^{6,7} of the dipole and quadrupole moments of H₂S, contributions from short-ranged higher order multipole, as well as induced and dispersion interactions to the linewidth should be insignificant and have been neglected in the present work. The contribution from these higher order interactions to the linewidth is estimated to be much less than one percent.

We have previously described the computer programs for asymmetric top linewidth calculations.⁸ These programs were utilized for ozone and nitrogen dioxide linewidth computations.^{9,10} The same computer programs have been used in this

work with some modifications. These modifications are necessitated due to the fact that all rotational levels occur in the ground state of H_2S . Whereas, in the case of O_3 and NO_2 only symmetric levels occur because of C_{2v} symmetry and zero spin of the ^{16}O nuclei. Because of this quantum number generation schemes in the computer programs for lower as well as upper states had to be modified. The pertinent selection rules are described in Ref. 8. For H_2S linewidth calculations also, the contribution to γ° through $S_2(b)$ from dipole transition probability terms for $|\Delta K_a|$ or $|\Delta K_c| > 4$, and from quadrupole transition probability terms for $|\Delta K_a|$ or $|\Delta K_c| > 6$ was found to be completely negligible. Furthermore, the contribution from $S_2(b)$ terms with $|\Delta K_a|$ and $|\Delta K_c| > 2$ for quadrupole transition probability and from terms with $|\Delta K_a|$ and $|\Delta K_c| > 1$ for dipole transition probability was insignificant compared to the remaining terms to the linewidth value for H_2S . Therefore, only for summation over J_{τ_2} (i.e., only for the perturbing molecule in the self-broadening), just as in the case of ozone and nitrogen dioxide linewidth calculations,⁸⁻¹¹ $S_2(b)$ terms involving $Q(J_{\tau_2}, J_{\tau_2'})$ and $D(J_{\tau_2}, J_{\tau_2'})$ were taken into account for $|\Delta K_{2a}|$ and $|\Delta K_{2c}| \leq 2$ and ≤ 1 , respectively. This approximation resulted in CPU time savings of more than 60%. The reader is referred to Ref. 8 for the notation used in the above discussion and elsewhere in this work. For the perturbing molecule, in self-broadening in this work, rotational levels with $J \leq 12$ and $K_a \leq 8$ were taken into account. This quantum

number range covers 99.86% of the population in the Boltzmann distribution for the ground vibrational state at 300°K. The effect of levels with $J > 12$ and $K_a > 8$ was included by a procedure outlined in Ref. 8. Further details of the computer programs can also be found in Ref. 8.

Rotational and centrifugal distortion constants, in the ground state of hydrogen sulfide, have been taken from Helminger *et al.*¹² Small differences in the rotational and centrifugal distortion constants between the ground and upper states of H_2S in the linewidth computations of vibration-rotation bands have been neglected. The ground state rotational and centrifugal distortion constants for nitrogen and oxygen were obtained from the pure rotational Raman spectra of these gases.¹³ Kinetic theory collision diameters for H_2S , N_2 , and O_2 were taken from Svehla.¹⁴

The quadrupole moments of N_2 and O_2 have been taken from the induced birefringence measurements of Buckingham *et al.*¹⁵ The dipole moment value for H_2S was obtained from Stark effect of millimeter wave transitions.⁶ The quadrupole moments of H_2S have been computed in two papers.^{7,16} Both of these are ab initio SCF calculations with Gaussian type wave functions. The results of these calculations are not much different. We have chosen to use the quadrupole moment components for hydrogen sulfide given by Rothenberg *et al.*⁷ in our linewidth computations.

Although linewidth results in this report are very general and should be applicable to all the bands of a particular band type, approximate line positions and relative line intensity calculations have been performed for ν_3 and ν_2 fundamentals among the type A and type B bands, respectively. The band origins for these two fundamentals have been taken from Ref. 17. A better value for the band center of ν_3 band has recently come to our attention.¹⁸

III. RESULTS AND DISCUSSION

In Table 1, measured self-broadened linewidths for four microwave transitions² in the pure rotational spectrum of hydrogen sulfide are compared with the computed values obtained in this work. The numbers in Ref. 19 are obtained from Ref. 2 after correcting for cell length effects. Measured linewidths show an unexpectedly large variation with respect to the quantum numbers. Two sets of calculated values are shown in Table 1. The values corresponding to $q=0$ refer to the computations with dipole-dipole interaction only. q is related to the quadrupole moment tensor components by

$$q^2 = \theta_{zz}^2 + \frac{1}{3}(\theta_{yy} - \theta_{xx})^2. \quad (1)$$

A comparison of values in the last two columns of Table 1 indicates that the contribution from quadrupolar interactions to the self-broadened linewidths at low J is about 20%. Clearly,

Table 1. Comparison of experimental and calculated values of the self-broadened linewidths for the pure rotational spectrum of H_2S at 300°K

Transition	$\gamma^\circ_{\text{H}_2\text{S}-\text{H}_2\text{S}} (\text{cm}^{-1} \text{ atm}^{-1})$			
	Exptl		Calc	
	Ref. 2	Ref. 19	q=0	q taken from Ref. 7
$1_{1,0} - 1_{0,1}$	0.197	0.182	0.151	0.205
$2_{0,2} - 2_{1,1}$	0.245	0.230	0.167	0.212
$2_{2,0} - 2_{1,1}$	0.180	0.172	0.164	0.208
$3_{3,0} - 3_{2,1}$	0.215	0.196	0.174	0.213

one cannot neglect dipole-quadrupole, quadrupole-dipole and quadrupole-quadrupole interactions in these calculations. The overall agreement between the experimental and theoretical values is good.

N_2 - and O_2 -broadened linewidths of H_2S at $300^\circ K$ for about 500 transitions have been computed for type A and type B bands. These transitions are in the range of $0 \leq J \leq 12$ and $0 \leq K_a \leq 8$, with the restriction that ΔK_a and $\Delta K_c \leq 1$. Thus very weak transitions are excluded. These results along with self-broadened linewidths at $300^\circ K$ and air-broadened values at $200^\circ K$ are given in Appendices A and B for bands of type A and type B, respectively. Because of C_{2v} symmetry of H_2S molecule only the ν_3 fundamental and its odd overtone or combination bands belong to type A. All other bands are of type B. Self- as well as foreign-gas broadened linewidths show quite appreciable variation with respect to the quantum numbers.

Weighted mean linewidths of H_2S broadened by N_2 , O_2 , air, and H_2S at $300^\circ K$ and by N_2 , O_2 , and air at $200^\circ K$ are given in Table 2. Averaging has been performed over all the transitions in Appendices A and B, for type A and type B bands, respectively. Weighting has been done with respect to the relative intensity of the transition. The temperature dependence of N_2 -, O_2 -, and air-broadened linewidths of H_2S transitions can be obtained by the use of Eqs. (8) and (9) of Ref. 9.

Table 2. Intensity weighted average linewidths of H_2S .
Units of linewidth are $\text{cm}^{-1}\text{atm}^{-1}$

Band type	Broadener	Average linewidth	
		at 300°K	at 200°K
A	N_2	0.0818	0.1099
	O_2	0.0436	0.0582
	Air	0.0737	0.0990
	H_2S	0.2029	
B	N_2	0.0815	0.1096
	O_2	0.0434	0.0581
	Air	0.0735	0.0988
	H_2S	0.2025	

Rotational energy level of the lower state for each transition along with its approximate line position and relative line intensity have also been tabulated in Appendices. Line positions in Appendix A (type A band) refer to ν_3 fundamental and in Appendix B (type B band) refer to ν_2 fundamental. Much more accurate values of line positions in ν_3 fundamental band are available in Ref. 18. However, no such data exists for ν_2 fundamental. ν_2 band of H_2S is expected to be useful in detection and monitoring of this gas in the atmosphere.²⁰ We are under process to look at this band under very high resolution so as to be able to determine very accurate values of line positions and relative line intensities.

IV. ACKNOWLEDGEMENTS

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VI. APPENDIX A

LISTING OF LINEWIDTHS FOR TYPE A BAND

Linewidths and other spectral parameters for transitions in a type A band of H_2S are listed in this Appendix. First three columns in the tabulation refer to the lower state quantum numbers J , K_a , and K_c , respectively; while column numbers 4 to 6 give these quantum numbers for the upper state of the transition. Column number 7 shows the line position in cm^{-1} for the transition in the ν_3 fundamental of H_2S . Rotational energy level in cm^{-1} for the lower state is given in the column 8 and the relative line intensity for the transition in the ν_3 band is shown in the column 9. Next four columns, i.e., columns 10 through 13 list self-, N_2 -, O_2 -, and air-broadened linewidths of H_2S given in the units of $10^{-4} \text{ cm}^{-1} \text{ atm}^{-1}$. $\gamma_{\text{H}_2\text{S}-\text{air}}^\circ$ is at 200°K , all other linewidth values reported here are at 300°K . All the linewidth results in this Appendix should be applicable to any type A band.

Listing of Linewidth Parameters for Type A Band of H₂S

Lower State			Upper State			Approximate Line Position in the ν_3 Band (cm ⁻¹)	Rotational Energy of the Lower State (cm ⁻¹)	Relative Line Intensity (ν_3 Band) at 300°K	γ° (in 10 ⁻⁴ cm ⁻¹ atm ⁻¹) of H ₂ S			
J	K _a	K _c	J	K _a	K _c				H ₂ S	N ₂	O ₂	Air
									300°K	300°K		200°K
0	0	0	1	0	1	2641.2	0.0	1.01	2052	933	503	1115
1	1	1	1	1	0	2631.8	15.090	1.40	2107	934	505	1124
1	1	1	2	1	2	2650.7	15.090	1.41	2157	905	498	1077
2	0	2	1	0	1	2603.2	38.062	1.39	2107	903	487	1086
2	0	2	3	0	3	2660.9	38.062	2.18	2157	876	481	1044
2	1	1	1	1	0	2595.7	51.140	1.16	2071	958	506	1153
2	1	1	2	1	2	2614.6	51.140	0.65	2134	921	494	1097
2	1	1	3	1	2	2671.6	51.140	1.79	2105	923	487	1096
2	2	0	2	2	1	2624.3	58.323	2.12	2150	899	485	1084
2	2	0	3	2	1	2676.4	58.323	1.44	2119	933	495	1121
3	1	3	2	1	2	2594.3	71.475	1.80	2163	879	483	1045
3	1	3	3	1	2	2651.2	71.475	0.53	2147	887	479	1051
3	1	3	4	1	4	2670.1	71.475	2.58	2121	852	461	1019
3	2	2	2	2	1	2586.2	96.392	1.03	2170	885	483	1058
3	2	2	3	2	1	2638.4	96.392	1.03	2152	900	482	1072
3	2	2	4	2	3	2679.7	96.392	1.82	2151	864	471	1025
3	3	1	3	3	0	2629.4	115.331	2.59	2152	869	464	1034
3	3	1	4	3	2	2686.0	115.331	1.07	2179	855	465	1016
4	0	4	3	0	3	2584.9	114.081	2.04	2122	850	460	1020
4	0	4	5	0	5	2679.3	114.081	2.71	2099	838	443	995
4	1	3	3	1	2	2574.2	148.503	1.40	2148	887	476	1044
4	1	3	4	1	4	2593.1	148.503	0.36	2128	853	459	1012
4	1	3	5	1	4	2689.8	148.503	1.94	2147	845	454	998
4	2	2	3	2	1	2564.2	170.502	1.26	2130	900	472	1066
4	2	2	4	2	3	2605.6	170.502	0.57	2156	871	466	1030
4	2	2	5	2	3	2700.9	170.502	1.56	2136	861	460	1011
4	3	1	3	3	0	2562.5	182.286	0.83	2120	922	486	1093
4	3	1	4	3	2	2619.0	182.286	1.09	2150	879	467	1041
4	3	1	5	3	2	2708.8	182.286	1.52	2082	885	460	1038

4	4	0	4	4	1	2626.5	196.726	2.52	2093	825	437	952
4	4	0	5	4	1	2707.3	196.726	0.82	2069	890	474	1035
5	1	5	4	1	4	2575.7	165.875	2.03	2093	834	441	993
5	1	5	5	1	4	2672.4	165.875	0.35	2112	827	437	979
5	1	5	6	1	6	2688.3	165.875	2.58	2084	813	422	955
5	2	4	4	2	3	2565.3	210.764	1.37	2146	839	450	996
5	2	4	5	2	3	2660.7	210.764	0.49	2142	831	446	978
5	2	4	6	2	5	2699.0	210.764	1.81	2115	818	432	962
5	3	3	4	3	2	2556.8	244.519	0.95	2156	833	452	984
5	3	3	5	3	2	2646.6	244.519	0.59	2119	850	452	998
5	3	3	6	3	4	2708.8	244.519	1.34	2101	811	438	950
5	4	2	4	4	1	2552.6	270.606	0.51	2080	827	442	965
5	4	2	5	4	1	2633.4	270.606	1.08	2051	851	450	988
5	4	2	6	4	3	2715.9	270.606	0.96	2054	808	432	939
5	5	1	5	5	0	2627.9	296.441	2.06	1943	769	409	863
5	5	1	6	5	2	2718.0	296.441	0.50	1948	793	424	910
6	0	6	5	0	5	2566.7	226.662	1.84	2081	814	423	956
6	0	6	7	0	7	2697.0	226.662	2.28	2049	781	401	902
6	1	5	5	1	4	2556.0	282.314	1.22	2110	814	430	954
6	1	5	6	1	6	2571.8	282.314	0.19	2084	799	414	929
6	1	5	7	1	6	2708.1	282.314	1.55	2043	781	407	906
6	2	4	5	2	3	2545.5	325.927	0.86	2107	817	442	958
6	2	4	6	2	5	2583.9	325.927	0.28	2087	805	429	943
6	2	4	7	2	5	2718.4	325.927	1.12	2039	789	424	921
6	3	3	5	3	2	2534.0	357.128	0.72	2077	850	449	993
6	3	3	6	3	4	2596.2	357.128	0.32	2086	817	438	955
6	3	3	7	3	4	2729.4	357.128	0.88	2054	810	435	945
6	4	2	5	4	1	2529.3	374.665	0.63	2014	862	451	995
6	4	2	6	4	3	2611.8	374.665	0.43	2045	834	441	968
6	4	2	7	4	3	2740.2	374.665	0.86	2014	841	445	975
6	5	1	5	5	0	2533.8	390.552	0.30	1934	839	450	958
6	5	1	6	5	2	2623.9	390.552	0.88	1930	808	429	923
6	5	1	7	5	2	2740.8	390.552	0.65	1934	826	438	944
6	6	0	6	6	1	2627.3	417.866	1.43	1781	710	384	794
6	6	0	7	6	1	2734.8	417.866	0.29	1794	779	423	889
7	1	7	6	1	6	2557.9	296.196	1.55	2063	821	427	964
7	1	7	7	1	6	2694.3	296.196	0.19	2018	802	419	939
7	1	7	8	1	8	2705.5	296.196	1.89	1978	740	382	848
7	2	6	6	2	5	2546.8	362.974	0.99	2045	784	408	909
7	2	6	7	2	5	2681.4	362.974	0.25	2005	770	405	889
7	2	6	8	2	7	2717.0	362.974	1.24	1959	749	390	851
7	3	5	6	3	4	2536.5	416.810	0.68	2034	791	424	920
7	3	5	7	3	4	2669.7	416.810	0.26	2011	782	420	909
7	3	5	8	3	6	2727.6	416.810	0.87	1966	763	404	879
7	4	4	6	4	3	2527.5	458.950	0.49	2019	788	422	915
7	4	4	7	4	3	2655.9	458.950	0.25	2021	808	430	940
7	4	4	8	4	5	2737.4	458.950	0.64	1947	769	412	889
7	5	3	6	5	2	2522.4	492.056	0.33	1940	779	416	893
7	5	3	7	5	2	2639.3	492.056	0.34	1964	809	430	935
7	5	3	8	5	4	2745.2	492.056	0.49	1917	768	411	887
7	6	2	6	6	1	2521.7	523.430	0.16	1785	745	398	847
7	6	2	7	6	1	2629.3	523.430	0.64	1784	750	400	849
7	6	2	8	6	3	2748.1	523.430	0.32	1813	743	396	848
7	7	1	7	7	0	2627.5	559.651	0.86	1672	676	371	768

7	7	1	8	7	2	2748.3	559.651	0.15	1672	705	382	811
8	0	8	7	0	7	2549.5	374.199	1.23	2023	833	436	977
8	0	8	9	0	9	2713.6	374.199	1.48	1943	700	370	791
8	1	7	7	1	6	2537.9	452.522	0.75	1962	751	391	855
8	1	7	8	1	8	2549.2	452.522	0.08	1921	747	387	847
8	1	7	9	1	8	2725.6	452.522	0.93	1889	760	397	865
8	2	6	7	2	5	2527.5	516.915	0.50	1970	768	408	888
8	2	6	8	2	7	2563.1	516.915	0.12	1942	750	394	858
8	2	6	9	2	7	2736.3	516.915	0.62	1876	733	387	837
8	3	5	7	3	4	2517.3	569.188	0.35	1963	772	416	896
8	3	5	8	3	6	2575.2	569.188	0.13	1915	753	399	867
8	3	5	9	3	6	2746.3	569.188	0.44	1862	751	401	858
8	4	4	7	4	3	2505.3	609.559	0.27	1996	812	436	942
8	4	4	8	4	5	2586.8	609.559	0.12	1938	775	417	897
8	4	4	9	4	5	2756.8	609.559	0.34	1905	769	413	891
8	5	3	7	5	2	2497.1	634.283	0.26	1963	823	438	951
8	5	3	8	5	4	2603.0	634.283	0.13	1954	793	422	921
8	5	3	9	5	4	2769.7	634.283	0.31	1977	818	439	951
8	6	2	7	6	1	2500.7	652.011	0.17	1851	783	421	896
8	6	2	8	6	3	2619.6	652.011	0.22	1889	785	420	908
8	6	2	9	6	3	2773.6	652.011	0.28	1921	802	431	931
8	7	1	7	7	0	2505.9	681.261	0.07	1686	729	398	847
8	7	1	8	7	2	2626.7	681.261	0.38	1667	697	378	798
8	7	1	9	7	2	2766.5	681.261	0.16	1767	745	404	861
8	8	0	8	8	1	2627.5	722.575	0.46	1597	661	367	758
8	8	0	9	8	1	2764.2	722.575	0.07	1618	701	383	820
9	1	9	8	1	8	2541.3	460.354	0.92	1946	770	399	887
9	1	9	9	1	8	2717.8	460.354	0.08	1912	749	392	854
9	1	9	10	1	10	2721.4	460.354	1.09	1908	687	367	770
9	2	8	8	2	7	2529.4	550.632	0.54	1874	720	379	807
9	2	8	9	2	7	2702.6	550.632	0.11	1829	702	372	789
9	2	8	10	2	9	2733.8	550.632	0.66	1843	808	431	934
9	3	7	8	3	6	2518.6	625.731	0.34	1881	740	391	844
9	3	7	9	3	6	2689.7	625.731	0.10	1833	741	393	840
9	3	7	10	3	8	2744.7	625.731	0.42	1775	710	377	801
9	4	6	8	4	5	2508.5	687.853	0.23	1859	744	397	848
9	4	6	9	4	5	2678.5	687.853	0.09	1831	737	393	844
9	4	6	10	4	7	2754.8	687.853	0.29	1707	736	392	828
9	5	5	8	5	4	2499.1	738.115	0.17	1875	758	405	874
9	5	5	9	5	4	2665.9	738.115	0.08	1928	785	420	908
9	5	5	10	5	6	2764.7	738.115	0.21	1811	733	392	832
9	6	4	8	6	3	2493.2	778.354	0.12	1841	751	399	866
9	6	4	9	6	3	2647.2	778.354	0.08	1907	775	412	903
9	6	4	10	6	5	2773.2	778.354	0.16	1852	762	406	879
9	7	3	8	7	2	2492.1	815.838	0.07	1724	715	383	818
9	7	3	9	7	2	2632.0	815.838	0.14	1824	764	412	888
9	7	3	10	7	4	2776.9	815.838	0.11	1776	737	392	850
9	8	2	8	8	1	2491.0	858.993	0.03	1588	681	373	787
9	8	2	9	8	1	2627.8	858.993	0.20	1588	663	364	764
9	8	2	10	8	3	2776.8	858.993	0.07	1658	698	376	798
10	0	10	9	0	9	2533.5	554.323	0.65	1895	692	368	773
10	0	10	11	0	11	2728.9	554.323	0.77	1862	681	365	755
10	1	9	9	1	8	2521.2	656.933	0.36	1776	703	373	780
10	1	9	10	1	10	2524.9	656.933	0.03	1784	718	380	806

10	1	9	11	1	10	2741.6	656.933	0.44	1748	761	406	869
10	2	8	9	2	7	2510.3	742.915	0.22	1784	732	386	829
10	2	8	10	2	9	2541.5	742.915	0.04	1818	767	406	876
10	2	8	11	2	9	2752.5	742.915	0.27	1692	697	373	780
10	3	7	9	3	6	2500.3	815.166	0.14	1768	718	383	802
10	3	7	10	3	8	2555.2	815.166	0.04	1711	686	368	770
10	3	7	11	3	8	2762.5	815.166	0.18	1745	757	400	862
10	4	6	9	4	5	2490.6	875.760	0.10	1840	758	405	864
10	4	6	10	4	7	2566.9	875.760	0.04	1802	738	396	816
10	4	6	11	4	7	2772.0	875.760	0.12	1772	718	387	796
10	5	5	9	5	4	2478.6	925.467	0.07	1904	779	419	905
10	5	5	10	5	6	2577.3	925.467	0.03	1798	729	388	834
10	5	5	11	5	6	2782.0	925.467	0.09	1872	794	422	914
10	6	4	9	6	3	2466.5	959.116	0.07	1989	833	450	977
10	6	4	10	6	5	2592.5	959.116	0.03	1966	804	428	929
10	6	4	11	6	5	2796.6	959.116	0.08	1962	804	433	939
10	7	3	9	7	2	2468.0	979.798	0.05	1872	782	425	916
10	7	3	10	7	4	2613.0	979.798	0.04	1848	758	405	889
10	7	3	11	7	4	2804.9	979.798	0.08	2015	850	464	1004
10	8	2	9	8	1	2476.3	1010.500	0.03	1705	722	392	845
10	8	2	10	8	3	2625.3	1010.500	0.07	1768	752	404	876
10	8	2	11	8	3	2797.8	1010.500	0.05	1812	765	418	907
11	1	11	10	1	10	2526.1	655.746	0.44	1855	671	362	742
11	1	11	11	1	10	2742.7	655.746	0.03	1811	661	360	729
11	1	11	12	1	12	2736.0	655.746	0.52	1784	661	360	732
11	2	10	10	2	9	2513.4	771.013	0.23	1756	702	376	781
11	2	10	11	2	9	2724.4	771.013	0.04	1649	700	376	787
11	2	10	12	2	11	2748.9	771.013	0.28	1683	699	377	787
11	3	9	10	3	8	2502.4	867.956	0.14	1755	790	421	911
11	3	9	11	3	8	2709.7	867.956	0.03	1788	718	383	799
11	3	9	12	3	10	2759.8	867.956	0.16	1705	706	380	792
11	4	8	10	4	7	2492.5	950.168	0.08	1708	705	377	779
11	4	8	11	4	7	2697.6	950.168	0.03	1675	680	368	752
11	4	8	12	4	9	2769.5	950.168	0.10	1735	772	412	889
11	5	7	10	5	6	2482.7	1020.127	0.06	1810	764	404	861
11	5	7	11	5	6	2687.4	1020.127	0.02	1877	759	406	829
11	5	7	12	5	8	2778.8	1020.127	0.07	1760	722	386	793
11	6	6	10	6	5	2472.8	1078.755	0.04	1811	744	396	848
11	6	6	11	6	5	2676.9	1078.755	0.02	1821	740	393	851
11	6	6	12	6	7	2788.8	1078.755	0.05	1861	792	417	899
11	7	5	10	7	4	2465.8	1126.930	0.03	1841	778	415	902
11	7	5	11	7	4	2657.7	1126.930	0.02	2032	822	439	949
11	7	5	12	7	6	2798.4	1126.930	0.04	1849	768	406	881
11	8	4	10	8	3	2464.3	1171.534	0.02	1726	728	388	840
11	8	4	11	8	3	2636.7	1171.534	0.02	1786	740	398	874
11	8	4	12	8	5	2803.1	1171.534	0.03	1838	790	420	924
12	0	12	11	0	11	2519.0	764.254	0.29	1782	665	362	735
12	0	12	13	0	13	2742.7	764.254	0.34	1707	648	357	722
12	1	11	11	1	10	2506.1	892.416	0.14	1700	692	375	771
12	1	11	12	1	12	2499.3	892.416	0.01	1681	681	370	757
12	1	11	13	1	12	2755.7	892.416	0.17	1633	683	373	764
12	2	10	11	2	9	2495.2	1000.249	0.08	1692	771	413	888
12	2	10	12	2	11	2519.6	1000.249	0.01	1718	695	375	784
12	2	10	13	2	11	2766.3	1000.249	0.10	1689	694	376	782

12	3	9	11	3	8	2485.5	1092.144	0.05	1708	697	376	772
12	3	9	12	3	10	2535.6	1092.144	0.01	1638	681	370	766
12	3	9	13	3	10	2775.5	1092.144	0.06	1697	725	391	829
12	4	8	11	4	7	2476.3	1171.478	0.03	1770	772	408	875
12	4	8	12	4	9	2548.2	1171.478	0.01	1806	681	373	735
12	4	8	13	4	9	2784.1	1171.478	0.04	1744	704	378	771
12	5	7	11	5	6	2466.9	1240.547	0.02	1829	753	401	841
12	5	7	12	5	8	2558.4	1240.547	0.01	1704	694	373	771
12	5	7	13	5	8	2793.0	1240.547	0.02	1813	768	405	863
12	6	6	11	6	5	2455.2	1300.469	0.01	1942	828	443	962
12	6	6	12	6	7	2567.1	1300.469	0.01	1962	792	422	879
12	6	6	13	6	7	2802.8	1300.469	0.02	1890	783	414	887
12	7	5	11	7	4	2438.9	1345.797	0.01	2029	825	446	965
12	7	5	12	7	6	2579.5	1345.797	0.00	1870	758	402	877
12	7	5	13	7	6	2818.4	1345.797	0.01	1997	840	453	984
12	8	4	11	8	3	2436.7	1371.548	0.01	1984	846	465	1007
12	8	4	12	8	5	2603.1	1371.548	0.01	2041	825	441	955
12	8	4	13	8	5	2833.4	1371.548	0.01	2057	829	450	974

VII. APPENDIX B

LISTING OF LINEWIDTHS FOR TYPE B BAND

The format of this listing is the same as that used for the tabulation in the Appendix A. The line position and the relative line intensity values refer to the ν_2 fundamental band of H_2S . All other spectral parameters listed can be applied to any type B vibrational-rotational band of hydrogen sulfide. Pure rotational band of H_2S is also a type B band, and the linewidth results given here are very much valid for that band.

Listing of Linewidth Parameters for Type B Band of H₂S

Lower State			Upper State			Approximate Line Position in the ν_2 Band (cm ⁻¹)	Rotational Energy of the Lower State (cm ⁻¹)	Relative Line Intensity (ν_2 Band) at 300°K	γ° (in 10 ⁻⁴ cm ⁻¹ atm ⁻¹) of H ₂ S Lines Broadened by H ₂ S N ₂ O ₂ Air			
J	K _a	K _c	J	K _a	K _c				H ₂ S	300°K	200°K	
0	0	0	1	1	1	1197.7	0.0	1.01	2105	915	503	1082
1	1	0	1	0	1	1177.0	19.366	1.36	2047	938	497	1139
1	1	0	2	2	1	1218.4	19.366	1.40	2134	922	493	1112
2	0	2	1	1	1	1159.6	38.062	1.05	2142	909	500	1085
2	0	2	2	1	1	1195.7	38.062	1.00	2115	918	491	1095
2	0	2	3	1	3	1216.0	38.062	2.06	2148	877	482	1043
2	1	2	1	0	1	1158.1	38.302	1.22	2108	909	490	1091
2	1	2	2	2	1	1199.5	38.302	0.70	2179	904	493	1080
2	1	2	3	0	3	1215.8	38.302	2.04	2157	879	483	1047
2	1	2	3	2	1	1251.6	38.302	0.24	2153	908	486	1080
2	2	0	1	1	1	1139.4	58.323	0.52	2116	900	490	1078
2	2	0	2	1	1	1175.4	58.323	1.60	2083	941	501	1133
2	2	0	3	3	1	1239.6	58.323	1.69	2117	883	477	1059
3	1	2	2	2	1	1142.6	95.219	0.61	2160	924	498	1104
3	1	2	3	0	3	1158.9	95.219	0.65	2142	887	478	1053
3	1	2	3	2	1	1194.7	95.219	1.55	2127	915	481	1084
3	1	2	4	2	3	1236.0	95.219	1.55	2141	883	473	1044
3	2	2	2	1	1	1137.4	96.392	1.01	2111	911	488	1086
3	2	2	3	1	3	1157.7	96.392	0.63	2137	869	477	1033
3	2	2	3	3	1	1201.6	96.392	0.84	2161	879	480	1044
3	2	2	4	1	3	1234.7	96.392	1.47	2145	868	474	1025
3	2	2	4	3	1	1268.5	96.392	0.51	2132	891	476	1053
3	3	0	2	2	1	1120.5	117.292	0.89	2164	878	469	1051
3	3	0	3	2	1	1172.6	117.292	1.31	2129	933	493	1113
3	3	0	4	4	1	1261.0	117.292	1.79	2165	853	450	1003
4	0	4	3	1	3	1140.0	114.081	1.89	2115	853	461	1020
4	0	4	4	1	3	1217.0	114.081	0.64	2121	853	459	1013
4	0	4	5	1	5	1234.4	114.081	2.65	2095	841	444	997
4	1	4	3	0	3	1140.0	114.078	1.89	2118	853	461	1021

4	1	4	4	2	3	1217.2	114.078	0.64	2118	849	456	1011
4	1	4	5	0	5	1234.4	114.078	2.65	2093	839	443	994
4	1	4	5	2	3	1312.5	114.078	0.08	2131	842	453	995
4	2	2	3	1	3	1083.6	170.502	0.06	2147	871	469	1032
4	2	2	3	3	1	1127.4	170.502	0.29	2153	913	492	1087
4	2	2	4	1	3	1160.6	170.502	0.88	2143	873	467	1029
4	2	2	4	3	1	1194.4	170.502	1.62	2106	894	467	1053
4	2	2	5	3	3	1256.6	170.502	1.10	2134	857	458	1011
4	3	2	3	2	1	1116.1	173.804	0.80	2153	890	475	1060
4	3	2	4	2	3	1157.4	173.804	0.78	2159	849	461	1007
4	3	2	4	4	1	1204.5	173.804	0.70	2142	850	459	1002
4	3	2	5	2	3	1252.8	173.804	0.91	2155	845	460	998
4	3	2	5	4	1	1285.3	173.804	0.70	2119	866	462	1015
4	4	0	3	3	1	1101.2	196.726	0.99	2146	837	444	975
4	4	0	4	3	1	1168.2	196.726	0.84	2095	912	483	1072
4	4	0	5	5	1	1282.3	196.726	1.66	2030	799	420	909
5	1	4	4	2	3	1120.5	210.786	1.13	2138	839	450	996
5	1	4	5	0	5	1137.7	210.786	0.38	2110	831	439	981
5	1	4	5	2	3	1215.8	210.786	0.75	2139	834	448	981
5	1	4	6	2	5	1254.1	210.786	1.64	2103	815	431	956
5	2	4	4	1	3	1120.4	210.764	1.13	2139	842	452	995
5	2	4	5	1	5	1137.7	210.764	0.38	2111	831	438	980
5	2	4	5	3	3	1216.4	210.764	0.75	2131	824	442	971
5	2	4	6	1	5	1254.2	210.764	1.64	2106	817	431	960
5	2	4	6	3	3	1329.0	210.764	0.12	2118	825	439	969
5	3	2	4	2	3	1067.6	263.639	0.10	2125	860	456	1016
5	3	2	4	4	1	1114.7	263.639	0.11	2092	904	484	1068
5	3	2	5	2	3	1162.9	263.639	0.89	2108	853	452	998
5	3	2	5	4	1	1195.5	263.639	1.27	2049	877	458	1019
5	3	2	6	4	3	1278.0	263.639	0.74	2068	843	443	982
5	4	2	4	3	1	1094.3	270.606	0.60	2084	873	461	1026
5	4	2	5	3	3	1156.5	270.606	0.67	2096	825	445	966
5	4	2	5	5	1	1208.5	270.606	0.48	2012	817	437	948
5	4	2	6	3	3	1269.1	270.606	0.46	2071	837	448	979
5	4	2	6	5	1	1302.6	270.606	0.75	2009	827	439	950
5	5	0	4	4	1	1081.4	296.890	0.85	2030	779	412	882
5	5	0	5	4	1	1162.2	296.890	0.46	1991	873	465	1007
5	5	0	6	6	1	1303.4	296.890	1.32	1869	723	386	799
6	0	6	5	1	5	1121.8	226.662	1.72	2087	817	423	954
6	0	6	6	1	5	1238.3	226.662	0.40	2084	805	418	938
6	0	6	7	1	7	1252.2	226.662	2.27	2065	785	402	901
6	1	6	5	0	5	1121.8	226.662	1.72	2089	818	424	955
6	1	6	6	2	5	1238.3	226.662	0.40	2083	803	416	932
6	1	6	7	0	7	1252.2	226.662	2.27	2073	791	405	910
6	1	6	7	2	5	1372.8	226.662	0.04	2066	799	418	926
6	2	4	5	1	5	1022.6	325.927	0.02	2099	821	437	964
6	2	4	5	3	3	1101.2	325.927	0.61	2104	813	440	955
6	2	4	6	1	5	1139.0	325.927	0.42	2086	807	431	945
6	2	4	6	3	3	1213.8	325.927	0.63	2087	817	438	956
6	2	4	7	3	5	1273.5	325.927	0.93	2045	799	430	932
6	3	4	5	2	3	1100.7	325.853	0.62	2105	821	444	963
6	3	4	6	2	5	1139.1	325.853	0.42	2076	801	425	936
6	3	4	6	4	3	1215.7	325.853	0.62	2059	802	430	935
6	3	4	7	2	5	1273.7	325.853	0.94	2038	797	427	927

6	3	4	7	4	3	1344.1	325.853	0.12	2075	831	446	970
6	4	2	5	3	3	1052.5	374.665	0.11	2093	851	453	997
6	4	2	5	5	1	1104.4	374.665	0.04	1994	895	479	1045
6	4	2	6	3	3	1165.1	374.665	0.76	2046	848	447	985
6	4	2	6	5	1	1198.5	374.665	0.76	1974	863	456	992
6	4	2	7	5	3	1300.0	374.665	0.49	1994	839	444	971
6	5	2	5	4	1	1072.1	387.010	0.43	2000	847	447	975
6	5	2	6	4	3	1154.6	387.010	0.45	2000	802	428	925
6	5	2	6	6	1	1213.3	387.010	0.28	1869	776	412	883
6	5	2	7	4	3	1283.0	387.010	0.18	2005	848	456	982
6	5	2	7	6	1	1320.8	387.010	0.65	1893	776	412	876
6	6	0	5	5	1	1061.2	417.866	0.60	1873	711	381	788
6	6	0	6	5	1	1155.3	417.866	0.24	1856	808	434	921
6	6	0	7	7	1	1324.4	417.866	0.91	1714	644	360	712
7	1	6	6	2	5	1101.9	362.977	0.85	2040	783	408	909
7	1	6	7	0	7	1115.8	362.977	0.19	2026	776	400	894
7	1	6	7	2	5	1236.5	362.977	0.39	2012	781	411	904
7	1	6	8	2	7	1272.2	362.977	1.17	1960	750	390	853
7	2	6	6	1	5	1102.0	362.974	0.85	2039	783	408	908
7	2	6	7	1	7	1115.8	362.974	0.19	2018	767	395	876
7	2	6	7	3	5	1236.5	362.974	0.39	2008	776	410	897
7	2	6	8	1	7	1272.2	362.974	1.17	1956	745	388	846
7	2	6	8	3	5	1388.8	362.974	0.05	1968	760	400	875
7	3	4	6	2	5	1005.9	459.056	0.03	2061	788	418	919
7	3	4	6	4	3	1082.5	459.056	0.30	2028	791	425	920
7	3	4	7	2	5	1140.5	459.056	0.32	2013	784	420	911
7	3	4	7	4	3	1210.9	459.056	0.45	2036	819	440	953
7	3	4	8	4	5	1292.5	459.056	0.48	1960	770	414	894
7	4	4	6	3	3	1080.8	458.950	0.31	2037	804	429	938
7	4	4	7	3	5	1140.5	458.950	0.32	2000	784	420	911
7	4	4	7	5	3	1215.7	458.950	0.42	1964	782	419	907
7	4	4	8	3	5	1292.9	458.950	0.49	1948	769	412	890
7	4	4	8	5	3	1358.0	458.950	0.10	2001	808	430	937
7	5	2	6	4	3	1037.7	503.888	0.10	2013	816	432	942
7	5	2	6	6	1	1096.4	503.888	0.01	1870	850	458	988
7	5	2	7	4	3	1166.1	503.888	0.54	1992	833	443	957
7	5	2	7	6	1	1204.0	503.888	0.37	1886	817	435	932
7	5	2	8	6	3	1322.8	503.888	0.31	1898	791	416	905
7	6	2	6	5	1	1049.7	523.430	0.28	1874	791	419	895
7	6	2	7	5	3	1151.2	523.430	0.26	1871	774	413	885
7	6	2	7	7	1	1218.8	523.430	0.15	1726	719	388	818
7	6	2	8	5	3	1293.5	523.430	0.06	1902	825	443	955
7	6	2	8	7	1	1340.5	523.430	0.46	1758	714	383	803
7	7	0	6	6	1	1040.6	559.716	0.36	1712	641	359	710
7	7	0	7	6	1	1148.1	559.716	0.12	1733	735	397	833
7	7	0	8	8	1	1345.5	559.716	0.55	1584	579	345	650
8	0	8	7	1	7	1104.6	374.199	1.14	2023	773	397	885
8	0	8	8	1	7	1260.9	374.199	0.21	1963	762	395	870
8	0	8	9	1	9	1268.8	374.199	1.49	1948	736	382	830
8	1	8	7	0	7	1104.6	374.199	1.14	2006	752	366	852
8	1	8	8	2	7	1260.9	374.199	0.21	1939	735	381	825
8	1	8	9	0	9	1268.8	374.199	1.49	1956	751	389	845
8	1	8	9	2	7	1434.2	374.199	0.02	1919	740	385	835
8	2	6	7	1	7	961.9	516.915	0.01	2015	770	400	882

8	2	6	7	3	5	1082.5	516.915	0.39	1978	776	413	897
8	2	6	8	1	7	1118.2	516.915	0.17	1943	749	393	854
8	2	6	8	3	5	1234.9	516.915	0.27	1925	761	405	877
8	2	6	9	3	7	1291.4	516.915	0.56	1889	744	393	849
8	3	6	7	2	5	1082.6	516.891	0.39	1979	777	413	896
8	3	6	8	2	7	1118.3	516.891	0.17	1945	748	393	854
8	3	6	8	4	5	1234.6	516.891	0.27	1926	763	405	879
8	3	6	9	2	7	1291.5	516.891	0.56	1896	750	397	856
8	3	6	9	4	5	1404.6	516.891	0.04	1922	763	406	878
8	4	4	7	3	5	989.9	609.559	0.02	2004	793	428	924
8	4	4	7	5	3	1065.1	609.559	0.12	1960	795	428	926
8	4	4	8	3	5	1142.2	609.559	0.20	1949	780	419	908
8	4	4	8	5	3	1207.3	609.559	0.29	1983	808	433	936
8	4	4	9	5	5	1311.2	609.559	0.23	1929	781	419	908
8	5	4	7	4	3	1060.2	609.783	0.14	1996	821	440	954
8	5	4	8	4	5	1141.7	609.783	0.20	1913	769	411	894
8	5	4	8	6	3	1216.9	609.783	0.24	1868	761	405	880
8	5	4	9	4	5	1311.7	609.783	0.23	1894	770	412	894
8	5	4	9	6	3	1371.0	609.783	0.07	1942	786	418	913
8	6	2	7	5	3	1022.7	652.011	0.08	1916	784	415	898
8	6	2	7	7	1	1090.3	652.011	0.01	1768	798	433	927
8	6	2	8	5	3	1164.9	652.011	0.30	1925	805	426	921
8	6	2	8	7	1	1211.9	652.011	0.16	1797	766	410	876
8	6	2	9	7	3	1346.4	652.011	0.19	1809	746	395	852
8	7	2	7	6	1	1027.4	680.486	0.17	1758	728	389	816
8	7	2	8	6	3	1146.2	680.486	0.12	1751	727	388	829
8	7	2	8	8	1	1224.7	680.486	0.07	1610	668	368	766
8	7	2	9	6	3	1300.3	680.486	0.02	1824	795	428	924
8	7	2	9	8	1	1361.4	680.486	0.27	1649	661	364	749
8	8	0	7	7	1	1019.7	722.575	0.19	1586	580	345	651
8	8	0	8	7	1	1141.3	722.575	0.05	1623	668	370	763
8	8	0	9	9	1	1366.8	722.575	0.29	1497	527	336	606
9	1	8	8	2	7	1084.5	550.631	0.47	1880	713	376	797
9	1	8	9	0	9	1092.3	550.631	0.08	1901	739	388	832
9	1	8	9	2	7	1257.7	550.631	0.17	1853	720	380	810
9	1	8	10	2	9	1288.9	550.631	0.63	1775	680	366	748
9	2	8	8	1	7	1084.5	550.632	0.47	1877	713	376	796
9	2	8	9	1	9	1092.3	550.632	0.08	1867	712	375	794
9	2	8	9	3	7	1257.7	550.632	0.17	1845	712	376	800
9	2	8	10	1	9	1288.9	550.632	0.63	1804	712	377	791
9	2	8	10	3	7	1447.2	550.632	0.02	1827	706	376	789
9	3	6	8	2	7	947.2	687.974	0.01	1898	734	387	831
9	3	6	8	4	5	1063.6	687.974	0.17	1866	749	400	858
9	3	6	9	2	7	1120.4	687.974	0.11	1836	737	391	836
9	3	6	9	4	5	1233.5	687.974	0.15	1855	748	400	856
9	3	6	10	4	7	1309.8	687.974	0.24	1783	722	386	809
9	4	6	8	3	5	1064.0	687.853	0.17	1865	748	400	856
9	4	6	9	3	7	1120.5	687.853	0.11	1832	732	388	830
9	4	6	9	5	5	1232.9	687.853	0.15	1852	748	400	857
9	4	6	10	3	7	1309.9	687.853	0.25	1789	726	388	816
9	4	6	10	5	5	1420.2	687.853	0.03	1857	755	404	873
9	5	4	8	4	5	975.0	776.540	0.01	1946	788	421	924
9	5	4	8	6	3	1050.2	776.540	0.04	1891	787	421	916
9	5	4	9	4	5	1144.9	776.540	0.11	1926	785	419	920

9	5	4	9	6	3	1204.2	776.540	0.18	1942	790	421	916
9	5	4	10	6	5	1330.2	776.540	0.10	1893	778	416	908
9	6	4	8	5	3	1038.5	778.394	0.06	1925	791	419	913
9	6	4	9	5	5	1142.3	778.394	0.11	1854	752	399	871
9	6	4	9	7	3	1220.1	778.394	0.12	1776	724	386	836
9	6	4	10	5	5	1329.7	778.394	0.10	1845	758	405	881
9	6	4	10	7	3	1384.0	778.394	0.05	1868	749	397	866
9	7	2	8	6	3	1006.4	820.330	0.06	1803	732	389	833
9	7	2	8	8	1	1084.8	820.330	0.00	1668	732	400	852
9	7	2	9	6	3	1160.4	820.330	0.13	1859	772	413	889
9	7	2	9	8	1	1221.6	820.330	0.07	1706	706	381	808
9	7	2	10	8	3	1370.7	820.330	0.11	1718	697	375	798
9	8	2	8	7	1	1004.9	858.993	0.08	1656	666	366	751
9	8	2	9	7	3	1139.5	858.993	0.05	1658	684	371	785
9	8	2	9	9	1	1230.3	858.993	0.03	1536	623	355	722
9	8	2	10	7	3	1303.4	858.993	0.01	1756	755	408	882
9	8	2	10	9	1	1383.8	858.993	0.14	1563	617	351	704
10	0	10	9	1	9	1088.7	554.323	0.60	1893	705	373	783
10	0	10	10	1	9	1285.2	554.323	0.09	1836	698	372	775
10	0	10	11	1	11	1284.0	554.323	0.79	1840	674	365	738
10	1	10	9	0	9	1088.7	554.323	0.60	1903	715	378	798
10	1	10	10	2	9	1285.2	554.323	0.09	1787	686	368	760
10	1	10	11	0	11	1284.0	554.323	0.79	1832	668	362	731
10	1	10	11	2	9	1496.3	554.323	0.01	1787	705	374	791
10	2	8	9	1	9	900.1	742.915	0.00	1835	717	377	804
10	2	8	9	3	7	1065.4	742.915	0.18	1789	716	379	808
10	2	8	10	1	9	1096.6	742.915	0.06	1772	716	380	805
10	2	8	10	3	7	1254.9	742.915	0.10	1751	711	379	798
10	2	8	11	3	9	1307.7	742.915	0.25	1686	683	368	769
10	3	8	9	2	7	1065.4	742.919	0.18	1784	712	377	803
10	3	8	10	2	9	1096.6	742.919	0.06	1729	677	364	755
10	3	8	10	4	7	1254.8	742.919	0.10	1736	697	372	783
10	3	8	11	2	9	1307.7	742.919	0.25	1711	706	376	801
10	3	8	11	4	7	1460.0	742.919	0.01	1748	696	373	776
10	4	6	9	3	7	932.6	875.760	0.00	1829	728	387	821
10	4	6	9	5	5	1045.0	875.760	0.06	1841	746	399	849
10	4	6	10	3	7	1122.0	875.760	0.06	1782	720	386	804
10	4	6	10	5	5	1232.3	875.760	0.07	1844	751	402	863
10	4	6	11	5	7	1327.0	875.760	0.10	1765	703	380	778
10	5	6	9	4	5	1046.2	875.313	0.06	1838	742	397	846
10	5	6	10	4	7	1122.5	875.313	0.06	1775	715	383	799
10	5	6	10	6	5	1231.4	875.313	0.08	1807	740	393	848
10	5	6	11	4	7	1327.6	875.313	0.10	1779	715	384	798
10	5	6	11	6	5	1435.5	875.313	0.01	1868	761	402	882
10	6	4	9	5	5	961.6	959.116	0.01	1930	782	416	909
10	6	4	9	7	3	1039.3	959.116	0.01	1851	775	415	902
10	6	4	10	5	5	1149.0	959.116	0.06	1917	774	416	899
10	6	4	10	7	3	1203.3	959.116	0.09	1917	771	411	893
10	6	4	11	7	5	1350.4	959.116	0.04	1873	760	404	888
10	7	4	9	6	3	1015.5	965.298	0.03	1855	754	400	873
10	7	4	10	6	5	1141.4	965.298	0.05	1769	727	387	840
10	7	4	10	8	3	1225.7	965.298	0.05	1681	689	372	798
10	7	4	11	6	5	1345.5	965.298	0.03	1824	755	401	885
10	7	4	11	8	3	1398.1	965.298	0.03	1769	704	378	814

10	8	2	9	7	3	988.0	1010.500	0.03	1709	679	369	780
10	8	2	9	9	1	1078.8	1010.500	0.00	1598	672	374	790
10	8	2	10	7	3	1151.9	1010.500	0.04	1799	733	394	851
10	8	2	10	9	1	1232.2	1010.500	0.03	1621	647	360	748
10	8	2	11	9	3	1395.1	1010.500	0.06	1649	646	358	744
11	1	10	10	2	9	1068.5	771.013	0.20	1716	706	377	791
11	1	10	11	0	11	1067.4	771.013	0.03	1763	672	363	742
11	1	10	11	2	9	1279.6	771.013	0.06	1707	716	381	813
11	1	10	12	2	11	1304.0	771.013	0.28	1648	684	371	767
11	2	10	10	1	9	1068.5	771.013	0.20	1703	682	367	752
11	2	10	11	1	11	1067.4	771.013	0.03	1710	667	363	732
11	2	10	11	3	9	1279.6	771.013	0.06	1630	662	361	740
11	2	10	12	1	11	1304.0	771.013	0.28	1637	682	370	763
11	2	10	12	3	9	1503.8	771.013	0.01	1679	666	363	736
11	3	8	10	2	9	889.4	950.157	0.00	1739	678	366	749
11	3	8	10	4	7	1047.6	950.157	0.06	1715	699	376	776
11	3	8	11	2	9	1100.4	950.157	0.03	1705	702	376	792
11	3	8	11	4	7	1252.7	950.157	0.04	1720	691	374	758
11	3	8	12	4	9	1324.6	950.157	0.09	1643	663	364	730
11	4	8	10	3	7	1047.6	950.168	0.06	1703	690	373	763
11	4	8	11	3	9	1100.4	950.168	0.03	1652	665	362	747
11	4	8	11	5	7	1252.6	950.168	0.04	1687	672	366	738
11	4	8	12	3	9	1324.6	950.168	0.09	1668	684	370	762
11	4	8	12	5	7	1473.0	950.168	0.01	1733	700	376	774
11	5	6	10	4	7	917.8	1080.007	0.00	1784	728	388	824
11	5	6	10	6	5	1026.7	1080.007	0.02	1810	750	399	865
11	5	6	11	4	7	1122.9	1080.007	0.03	1786	722	386	810
11	5	6	11	6	5	1230.8	1080.007	0.03	1870	761	404	885
11	5	6	12	6	7	1342.7	1080.007	0.04	1779	722	385	816
11	6	6	10	5	5	1029.3	1078.755	0.02	1824	750	401	871
11	6	6	11	5	7	1124.0	1078.755	0.03	1755	712	379	805
11	6	6	11	7	5	1230.8	1078.755	0.03	1761	728	386	845
11	6	6	12	5	7	1344.4	1078.755	0.04	1793	735	390	835
11	6	6	12	7	5	1449.7	1078.755	0.01	1875	755	402	876
11	7	4	10	6	5	949.6	1157.172	0.00	1904	762	405	882
11	7	4	10	8	3	1033.8	1157.172	0.00	1823	761	409	890
11	7	4	11	6	5	1153.6	1157.172	0.03	1937	771	409	897
11	7	4	11	8	3	1206.2	1157.172	0.04	1883	754	403	876
11	7	4	12	8	5	1372.6	1157.172	0.02	1866	739	393	862
11	8	4	10	7	3	990.9	1171.534	0.01	1797	722	385	839
11	8	4	11	7	5	1138.0	1171.534	0.02	1705	698	374	817
11	8	4	11	9	3	1234.0	1171.534	0.02	1626	656	360	763
11	8	4	12	7	5	1356.9	1171.534	0.01	1819	749	400	879
11	8	4	12	9	3	1414.6	1171.534	0.02	1701	656	361	769
12	0	12	11	1	11	1074.1	764.254	0.26	1744	647	357	700
12	0	12	12	1	11	1310.8	764.254	0.04	1680	648	359	714
12	0	12	13	1	13	1297.8	764.254	0.35	1659	628	353	688
12	1	12	11	0	11	1074.1	764.254	0.26	1743	643	356	696
12	1	12	12	2	11	1310.8	764.254	0.04	1640	659	362	726
12	1	12	13	0	13	1297.8	764.254	0.35	1667	647	358	714
12	1	12	13	2	11	1557.5	764.254	0.00	1700	725	387	829
12	2	10	11	1	11	838.1	1000.249	0.00	1751	715	382	803
12	2	10	11	3	9	1050.3	1000.249	0.07	1665	723	389	828
12	2	10	12	1	11	1074.8	1000.249	0.02	1672	712	385	808

12	2	10	12	3	9	1274.5	1000.249	0.03	1697	714	384	811
12	2	10	13	3	11	1321.5	1000.249	0.09	1650	724	392	833
12	3	10	11	2	9	1050.3	1000.250	0.07	1632	687	371	776
12	3	10	12	2	11	1074.8	1000.250	0.02	1581	666	366	745
12	3	10	12	4	9	1274.5	1000.250	0.03	1591	655	360	737
12	3	10	13	2	11	1321.5	1000.250	0.09	1639	735	397	851
12	3	10	13	4	9	1510.5	1000.250	0.00	1634	663	364	738
12	4	8	11	3	9	879.1	1171.478	0.00	1671	672	365	747
12	4	8	11	5	7	1031.3	1171.478	0.02	1702	684	371	751
12	4	8	12	3	9	1103.3	1171.478	0.01	1681	665	366	723
12	4	8	12	5	7	1251.7	1171.478	0.02	1741	688	375	747
12	4	8	13	5	9	1339.3	1171.478	0.03	1631	642	359	691
12	5	8	11	4	7	1031.4	1171.492	0.02	1688	669	367	724
12	5	8	12	4	9	1103.3	1171.492	0.01	1610	640	357	699
12	5	8	12	6	7	1251.2	1171.492	0.02	1690	670	366	734
12	5	8	13	4	9	1339.2	1171.492	0.03	1649	666	364	731
12	5	8	13	6	7	1486.9	1171.492	0.00	1737	710	380	799
12	6	6	11	5	7	902.3	1300.469	0.00	1787	740	390	848
12	6	6	11	7	5	1009.1	1300.469	0.01	1791	755	399	884
12	6	6	12	5	7	1122.7	1300.469	0.01	1821	749	396	855
12	6	6	12	7	5	1227.9	1300.469	0.01	1896	767	407	891
12	6	6	13	7	7	1356.5	1300.469	0.01	1800	750	397	871
12	7	6	11	6	5	1013.0	1297.820	0.01	1848	764	404	898
12	7	6	12	6	7	1124.8	1297.820	0.01	1759	727	384	838
12	7	6	12	8	5	1232.0	1297.820	0.01	1727	717	381	841
12	7	6	13	6	7	1360.6	1297.820	0.01	1802	757	400	878
12	7	6	13	8	5	1462.3	1297.820	0.00	1897	759	402	889
12	8	4	11	7	5	938.0	1371.548	0.00	1847	725	387	847
12	8	4	11	9	3	1034.0	1371.548	0.00	1778	723	390	848
12	8	4	12	7	5	1156.9	1371.548	0.01	1925	751	403	874
12	8	4	12	9	3	1214.6	1371.548	0.01	1825	708	385	832
12	8	4	13	9	5	1397.0	1371.548	0.01	1833	709	381	832