

1 Rate constants for a reactive system of astrophysical interest:  
2 A statistical study of  $\text{CH}_2^+$ . Supplementary Information Part  
3 A

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15 **1 The  $\text{C}^+ + \text{H}_2(v, j) \rightarrow \text{CH}^+(v', j') + \text{H}$  reaction**

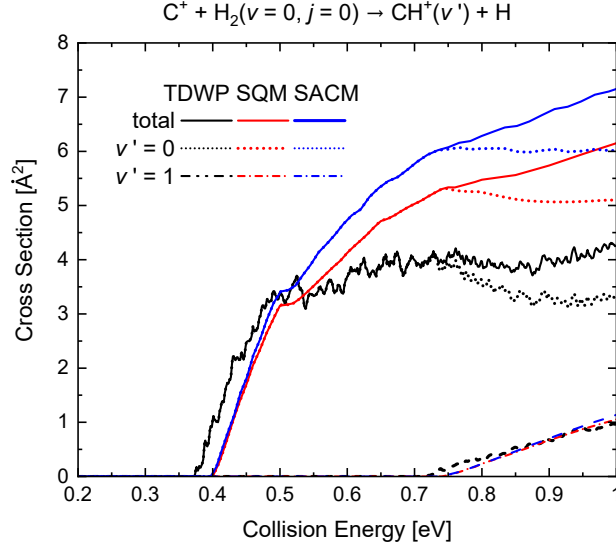


Figure 1: Integral cross sections for the  $\text{C}^+ + \text{H}_2(v=0, j=0) \rightarrow \text{H} + \text{CH}^+(v'=0,1)$  reaction. TDWP results (black lines) from Zanchet *et al. Astrophys. J.* **766** 80 (2013) are compared with present cross sections obtained with the SQM (red lines) and SACM (blue lines) approaches. As opposed to the figure included in the main manuscript where a comparison with the experiment is carried out, here ICSs are not affected by the corresponding electronic partition function.

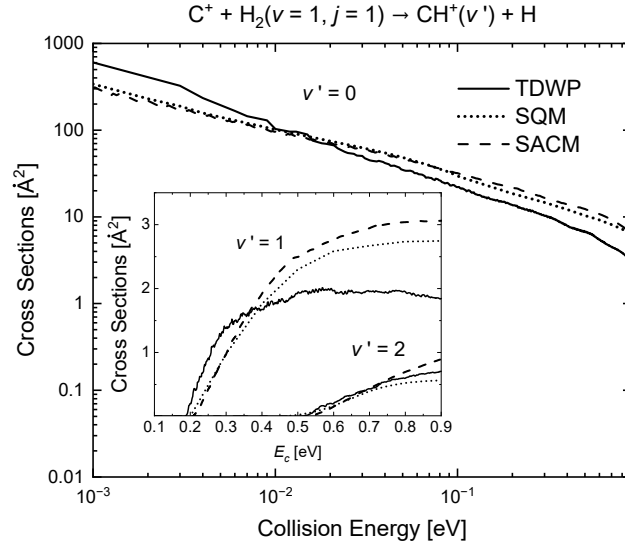


Figure 2: Integral cross sections for the  $\text{C}^+ + \text{H}_2(v=1, j=1) \rightarrow \text{H} + \text{CH}^+(v'=0-2)$  reaction. TDWP results (black lines) from Zanchet *et al. Astrophys. J.* **766** 80 (2013) are compared with present cross sections obtained with the SQM (red lines) and SACM (blue lines) approaches.

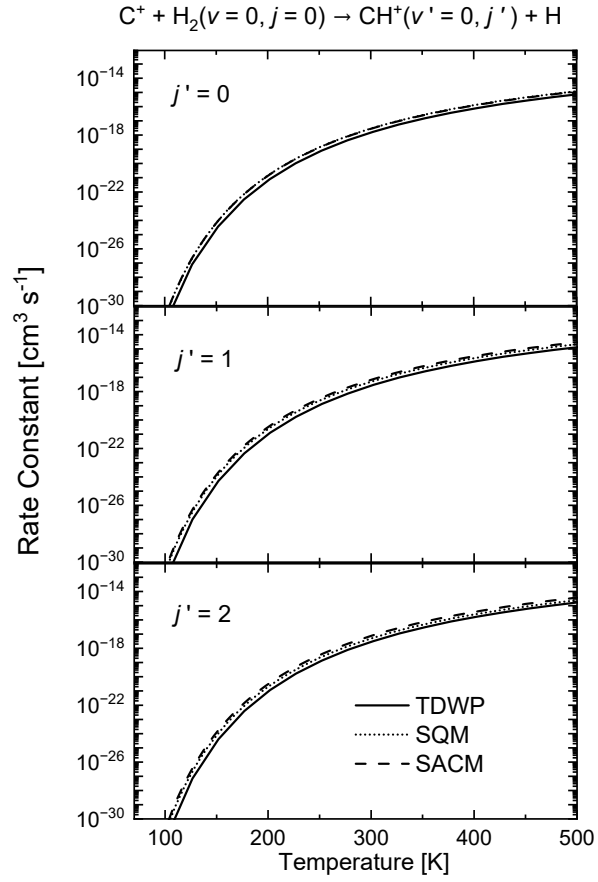


Figure 3: Rate constants for the  $\text{C}^+ + \text{H}_2(v=0, j=0) \rightarrow \text{H} + \text{CH}^+(v'=0, j'=0-2)$  reaction. TDWP results (solid lines) from Zanchet *et al. Astrophys. J.* **766** 80 (2013) are compared with rates obtained with the SQM (dotted lines) and SACM (dashed lines) approaches.

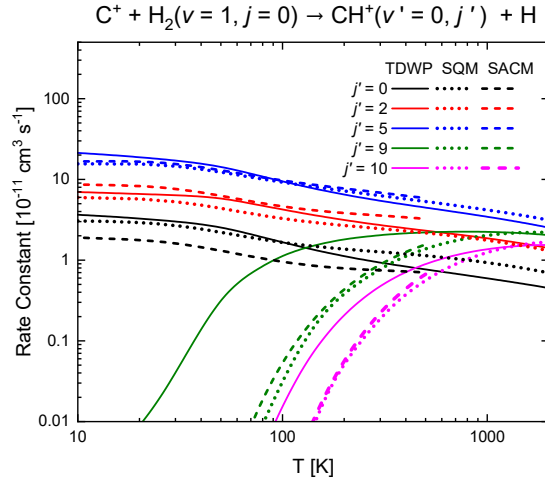


Figure 4: State-to-states rate coefficients for the  $\text{C}^+ + \text{H}_2(v = 1, j = 0) \rightarrow \text{H} + \text{CH}^+(v' = 0, j' = 0, 2, 5, 9, 10)$  reaction. Present SQM results (dotted lines) are compared with TDWP rates (solid lines) from Zanchet *et al. Astrophys. J.* **766** 80 (2013).

Table 1: Rate constants for the  $\text{C}^+ + \text{H}_2(v=0, j=0) \rightarrow \text{H} + \text{CH}(v', j')$  transitions. Units are K for  $T$  and  $10^{-x} \text{ cm}^3 \text{ s}^{-1}$ , where  $x$  is the number in parenthesis.

| $T$ [K]<br>$(v', j')$ | 50        | 100      | 500      | 1000     | 1500     |
|-----------------------|-----------|----------|----------|----------|----------|
| (0, 0)                | 9.66(52)  | 1.35(31) | 1.20(15) | 9.61(14) | 3.76(13) |
| (0, 1)                | 1.41(51)  | 2.10(31) | 2.12(15) | 1.75(13) | 6.89(13) |
| (0, 2)                | 2.70(52)  | 1.08(31) | 2.44(15) | 2.23(13) | 9.15(13) |
| (0, 3)                | 2.88(53)  | 3.76(32) | 2.25(15) | 2.36(13) | 1.02(12) |
| (0, 4)                | 2.08(54)  | 9.63(33) | 1.78(15) | 2.21(13) | 1.02(12) |
| (0, 5)                | 2.54(56)  | 1.12(33) | 1.18(15) | 1.85(13) | 9.25(13) |
| (0, 6)                | 2.19(58)  | 1.01(34) | 7.04(16) | 1.44(13) | 7.93(13) |
| (0, 7)                | 1.01(60)  | 5.63(36) | 3.73(16) | 1.06(13) | 6.46(13) |
| (0, 8)                | 1.24(63)  | 2.02(37) | 1.89(16) | 7.49(14) | 5.12(13) |
| (0, 9)                | 9.08(67)  | 5.12(39) | 8.81(17) | 5.04(14) | 3.87(13) |
| (0,10)                | 1.69(70)  | 7.26(41) | 3.72(17) | 3.21(14) | 2.80(13) |
| (0,11)                | 3.79(74)  | 9.48(43) | 1.46(17) | 1.94(14) | 1.93(13) |
| (0,12)                | 2.46(78)  | 7.26(45) | 5.22(18) | 1.10(14) | 1.26(13) |
| (0,13)                | 6.47(83)  | 3.94(47) | 1.68(18) | 5.80(15) | 7.72(14) |
| (0,14)                | 1.26(87)  | 1.38(49) | 4.71(19) | 2.79(15) | 4.36(14) |
| (0,15)                | 2.54(92)  | 5.53(52) | 1.31(19) | 1.29(15) | 2.32(14) |
| (0,16)                | 1.92(97)  | 1.38(54) | 3.37(20) | 5.38(16) | 1.10(14) |
| (0,17)                | 1.33(102) | 3.17(57) | 7.30(21) | 1.78(16) | 4.07(15) |
| (0,18)                | 7.10(108) | 5.60(60) | 8.89(22) | 3.00(17) | 7.54(16) |
| (1, 0)                | 9.67(87)  | 1.65(49) | 7.69(20) | 3.39(16) | 4.83(15) |
| (1, 1)                | 1.56(86)  | 2.75(49) | 1.42(19) | 6.37(16) | 9.12(15) |
| (1, 2)                | 2.54(87)  | 1.39(49) | 1.70(19) | 8.44(16) | 1.24(14) |
| (1, 3)                | 3.05(88)  | 5.36(50) | 1.70(19) | 9.47(16) | 1.44(14) |
| (1, 4)                | 2.86(89)  | 1.67(50) | 1.49(19) | 9.51(16) | 1.51(14) |
| (1, 5)                | 3.63(91)  | 2.03(51) | 1.07(19) | 8.39(16) | 1.41(14) |
| (1, 6)                | 1.50(92)  | 3.27(52) | 7.35(20) | 7.02(16) | 1.24(14) |
| (1, 7)                | 9.96(93)  | 2.17(52) | 5.72(20) | 5.96(16) | 1.09(14) |
| (1, 8)                | 1.49(97)  | 1.07(54) | 2.42(20) | 3.73(16) | 7.52(15) |
| (1, 9)                | 6.97(98)  | 5.04(55) | 1.51(20) | 2.61(16) | 5.48(15) |
| (1,10)                | 1.10(101) | 2.63(57) | 5.75(21) | 1.37(16) | 3.12(15) |
| (1,11)                | 1.25(106) | 9.84(60) | 1.44(21) | 4.76(17) | 1.19(15) |
| (1,12)                | 1.00(107) | 7.50(61) | 2.11(22) | 7.95(18) | 2.07(16) |

Table 2: Same as Table 1 for  $C^+ + H_2(v = 0, j = 1) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50        | 100      | 500      | 1000     | 1500     |
|-------------------------|-----------|----------|----------|----------|----------|
| ( 0, 0)                 | 2.21(50)  | 4.76(31) | 1.00(15) | 7.08(14) | 2.68(13) |
| ( 0, 1)                 | 1.71(50)  | 6.65(31) | 2.30(15) | 1.71(13) | 6.58(13) |
| ( 0, 2)                 | 1.45(50)  | 6.39(31) | 3.04(15) | 2.43(13) | 9.60(13) |
| ( 0, 3)                 | 1.75(51)  | 2.51(31) | 3.02(15) | 2.73(13) | 1.13(12) |
| ( 0, 4)                 | 2.13(53)  | 3.10(32) | 2.27(15) | 2.55(13) | 1.13(12) |
| ( 0, 5)                 | 5.33(54)  | 9.88(33) | 1.69(15) | 2.27(13) | 1.07(12) |
| ( 0, 6)                 | 3.27(56)  | 7.20(34) | 1.02(15) | 1.79(13) | 9.28(13) |
| ( 0, 7)                 | 1.75(59)  | 2.68(35) | 5.52(16) | 1.32(13) | 7.56(13) |
| ( 0, 8)                 | 9.45(62)  | 1.57(36) | 2.86(16) | 9.32(14) | 5.96(13) |
| ( 0, 9)                 | 3.64(62)  | 6.08(37) | 1.62(16) | 6.61(14) | 4.64(13) |
| ( 0,10)                 | 5.63(67)  | 3.10(39) | 6.48(17) | 4.15(14) | 3.33(13) |
| ( 0,11)                 | 5.82(72)  | 1.06(41) | 2.19(17) | 2.38(14) | 2.23(13) |
| ( 0,12)                 | 5.84(77)  | 3.51(44) | 7.10(18) | 1.31(14) | 1.43(13) |
| ( 0,13)                 | 4.34(78)  | 2.70(45) | 2.42(18) | 7.01(15) | 8.83(14) |
| ( 0,14)                 | 6.55(83)  | 1.32(47) | 7.56(19) | 3.52(15) | 5.09(14) |
| ( 0,15)                 | 4.73(88)  | 3.17(50) | 2.00(19) | 1.57(15) | 2.63(14) |
| ( 0,16)                 | 2.06(93)  | 4.64(53) | 4.50(20) | 6.03(16) | 1.16(14) |
| ( 0,17)                 | 1.84(102) | 4.39(57) | 8.39(21) | 1.81(16) | 3.96(15) |
| ( 0,18)                 | 1.25(107) | 9.61(60) | 9.72(22) | 2.84(17) | 6.78(16) |
| ( 1, 0)                 | 2.05(83)  | 4.08(48) | 8.82(20) | 2.91(16) | 3.79(15) |
| ( 1, 1)                 | 4.82(83)  | 9.60(48) | 2.15(19) | 7.20(16) | 9.43(15) |
| ( 1, 2)                 | 6.34(83)  | 1.26(47) | 3.04(19) | 1.06(15) | 1.41(14) |
| ( 1, 3)                 | 4.85(83)  | 9.68(48) | 3.05(19) | 1.20(15) | 1.65(14) |
| ( 1, 4)                 | 1.44(87)  | 9.46(50) | 2.02(19) | 1.10(15) | 1.63(14) |
| ( 1, 5)                 | 1.26(87)  | 8.30(50) | 1.93(19) | 1.10(15) | 1.67(14) |
| ( 1, 6)                 | 5.78(88)  | 3.83(50) | 1.33(19) | 9.05(16) | 1.45(14) |
| ( 1, 7)                 | 1.48(92)  | 3.23(52) | 7.23(20) | 6.68(16) | 1.16(14) |
| ( 1, 8)                 | 5.33(93)  | 1.17(52) | 4.16(20) | 4.65(16) | 8.56(15) |
| ( 1, 9)                 | 1.15(97)  | 8.27(55) | 1.94(20) | 2.92(16) | 5.78(15) |
| ( 1,10)                 | 1.40(102) | 3.34(57) | 6.25(21) | 1.34(16) | 2.92(15) |
| ( 1,11)                 | 1.00(103) | 9.40(58) | 2.50(21) | 5.96(17) | 1.34(15) |
| ( 1,12)                 | 1.00(104) | 5.32(60) | 5.43(22) | 1.59(17) | 3.80(16) |

Table 3: Same as Table 1 for  $C^+ + H_2(v = 0, j = 2) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>$(v', j')$ | 50        | 100      | 500      | 1000     | 1500     |
|-----------------------|-----------|----------|----------|----------|----------|
| ( 0, 0)               | 8.84(48)  | 1.29(29) | 4.35(15) | 2.38(13) | 8.17(13) |
| ( 0, 1)               | 1.97(47)  | 1.34(29) | 1.91(15) | 9.39(14) | 3.13(13) |
| ( 0, 2)               | 1.23(47)  | 1.79(29) | 6.32(15) | 3.54(13) | 1.23(12) |
| ( 0, 3)               | 1.27(47)  | 1.86(29) | 7.10(15) | 4.18(13) | 1.49(12) |
| ( 0, 4)               | 8.74(48)  | 1.29(29) | 6.24(15) | 4.11(13) | 1.54(12) |
| ( 0, 5)               | 1.95(51)  | 2.85(31) | 3.56(15) | 3.26(13) | 1.36(12) |
| ( 0, 6)               | 1.73(53)  | 2.57(32) | 2.12(15) | 2.54(13) | 1.17(12) |
| ( 0, 7)               | 1.05(55)  | 1.66(33) | 1.13(15) | 1.86(13) | 9.54(13) |
| ( 0, 8)               | 1.01(59)  | 1.65(35) | 4.69(16) | 1.22(13) | 7.20(13) |
| ( 0, 9)               | 5.46(60)  | 8.95(36) | 3.13(16) | 9.41(14) | 5.94(13) |
| ( 0,10)               | 7.10(65)  | 3.83(38) | 1.19(16) | 5.77(14) | 4.21(13) |
| ( 0,11)               | 7.10(70)  | 1.27(40) | 3.92(17) | 3.25(14) | 2.80(13) |
| ( 0,12)               | 1.45(70)  | 2.63(41) | 1.70(17) | 1.97(14) | 1.91(13) |
| ( 0,13)               | 2.17(75)  | 1.29(43) | 5.92(18) | 1.08(14) | 1.21(13) |
| ( 0,14)               | 1.86(80)  | 3.65(46) | 1.70(18) | 5.40(15) | 7.05(14) |
| ( 0,15)               | 1.86(80)  | 3.65(46) | 1.70(18) | 5.40(15) | 7.04(14) |
| ( 0,16)               | 5.84(86)  | 3.98(49) | 3.94(19) | 2.38(15) | 3.70(14) |
| ( 0,17)               | 2.18(91)  | 5.20(52) | 9.38(20) | 9.90(16) | 1.78(14) |
| ( 0,18)               | 1.48(99)  | 1.21(55) | 1.94(20) | 3.40(16) | 7.00(15) |
| ( 1, 0)               | 2.21(81)  | 4.31(47) | 1.38(19) | 3.55(16) | 4.31(15) |
| ( 1, 1)               | 5.69(81)  | 1.11(46) | 3.66(19) | 9.53(16) | 1.16(14) |
| ( 1, 2)               | 7.90(81)  | 1.54(46) | 5.35(19) | 1.44(15) | 1.77(14) |
| ( 1, 3)               | 8.20(81)  | 1.60(46) | 6.12(19) | 1.75(15) | 2.20(14) |
| ( 1, 4)               | 1.48(81)  | 2.99(47) | 4.03(19) | 1.58(15) | 2.16(14) |
| ( 1, 5)               | 1.55(85)  | 1.00(48) | 3.39(19) | 1.53(15) | 2.18(14) |
| ( 1, 6)               | 7.21(86)  | 4.74(49) | 2.53(19) | 1.34(15) | 2.00(14) |
| ( 1, 7)               | 1.85(90)  | 3.95(51) | 1.32(19) | 9.80(16) | 1.60(14) |
| ( 1, 8)               | 6.06(91)  | 1.33(51) | 8.26(20) | 7.38(16) | 1.27(14) |
| ( 1, 9)               | 1.55(95)  | 1.10(53) | 3.86(20) | 4.72(16) | 8.82(15) |
| ( 1,10)               | 6.43(100) | 6.72(56) | 1.36(20) | 2.40(16) | 4.96(15) |
| ( 1,11)               | 4.84(101) | 1.15(56) | 5.88(21) | 1.23(16) | 2.66(15) |
| ( 1,12)               | 7.13(105) | 1.73(58) | 1.91(21) | 4.81(17) | 1.10(15) |

Table 4: Same as Table 1 for  $\text{C}^+ + \text{H}_2(v = 0, j = 3) \rightarrow \text{H}^+ + \text{CH}(v', j')$  transitions.

| $T \text{ [K]}$<br>$(v', j')$ | 50        | 100      | 500      | 1000     | 1500     |
|-------------------------------|-----------|----------|----------|----------|----------|
| (0, 0)                        | 4.20(43)  | 1.93(27) | 4.71(15) | 1.43(13) | 4.08(13) |
| (0, 1)                        | 7.20(43)  | 4.01(27) | 1.26(14) | 3.97(13) | 1.15(12) |
| (0, 2)                        | 1.81(43)  | 2.40(27) | 1.62(14) | 5.62(13) | 1.68(12) |
| (0, 3)                        | 1.36(43)  | 1.90(27) | 1.71(14) | 6.49(13) | 2.01(12) |
| (0, 4)                        | 2.05(45)  | 2.81(28) | 1.35(14) | 6.20(13) | 2.05(12) |
| (0, 5)                        | 2.21(47)  | 3.07(29) | 9.17(15) | 5.32(13) | 1.91(12) |
| (0, 6)                        | 2.02(49)  | 2.84(30) | 5.61(15) | 4.22(13) | 1.66(12) |
| (0, 7)                        | 1.18(51)  | 1.80(31) | 3.08(15) | 3.12(13) | 1.36(12) |
| (0, 8)                        | 5.93(52)  | 9.06(32) | 2.00(15) | 2.40(13) | 1.13(12) |
| (0, 9)                        | 8.99(57)  | 4.53(34) | 8.07(16) | 1.53(13) | 8.28(13) |
| (0,10)                        | 8.47(62)  | 1.41(36) | 2.60(16) | 8.69(14) | 5.63(13) |
| (0,11)                        | 2.94(62)  | 4.92(37) | 1.40(16) | 5.94(14) | 4.22(13) |
| (0,12)                        | 2.95(67)  | 1.64(39) | 4.63(17) | 3.33(14) | 2.77(13) |
| (0,13)                        | 2.71(71)  | 1.55(41) | 1.64(17) | 1.86(14) | 1.79(13) |
| (0,14)                        | 2.40(76)  | 4.54(44) | 4.80(18) | 9.38(15) | 1.06(13) |
| (0,15)                        | 2.40(76)  | 4.54(44) | 4.80(18) | 9.38(15) | 1.06(13) |
| (0,16)                        | 1.13(86)  | 2.33(49) | 3.07(19) | 1.91(15) | 3.02(14) |
| (0,17)                        | 4.37(92)  | 3.02(52) | 6.46(20) | 7.33(16) | 1.36(14) |
| (0,18)                        | 8.84(98)  | 2.12(55) | 1.18(20) | 2.26(16) | 4.77(15) |
| (1, 0)                        | 2.38(77)  | 4.48(45) | 3.53(19) | 5.75(16) | 6.08(15) |
| (1, 1)                        | 6.52(77)  | 1.23(44) | 9.81(19) | 1.61(15) | 1.71(14) |
| (1, 2)                        | 9.24(77)  | 1.74(44) | 1.45(18) | 2.45(15) | 2.63(14) |
| (1, 3)                        | 9.88(77)  | 1.86(44) | 1.68(18) | 3.00(15) | 3.28(14) |
| (1, 4)                        | 5.93(77)  | 1.12(44) | 1.43(18) | 3.00(15) | 3.45(14) |
| (1, 5)                        | 1.74(81)  | 1.08(46) | 9.04(19) | 2.61(15) | 3.26(14) |
| (1, 6)                        | 1.30(81)  | 8.10(47) | 7.70(19) | 2.42(15) | 3.13(14) |
| (1, 7)                        | 1.99(86)  | 4.09(49) | 3.41(19) | 1.67(15) | 2.43(14) |
| (1, 8)                        | 1.26(86)  | 2.61(49) | 2.55(19) | 1.38(15) | 2.09(14) |
| (1, 9)                        | 1.63(91)  | 1.11(51) | 1.00(19) | 8.49(16) | 1.44(14) |
| (1,10)                        | 4.70(92)  | 3.23(52) | 5.19(20) | 5.50(16) | 9.97(15) |
| (1,11)                        | 9.68(97)  | 2.19(54) | 2.24(20) | 3.19(16) | 6.24(15) |
| (1,12)                        | 9.99(98)  | 8.40(57) | 6.88(21) | 1.40(16) | 3.00(15) |
| (1,13)                        | 9.99(99)  | 2.67(59) | 1.34(21) | 3.75(17) | 8.80(16) |
| (1,14)                        | 6.53(108) | 1.60(60) | 7.97(23) | 2.22(18) | 5.20(17) |
| (2, 0)                        | 4.35(108) | 1.07(60) | 5.31(23) | 1.48(18) | 3.47(17) |
| (2, 1)                        | 1.14(107) | 2.79(60) | 1.39(22) | 3.86(18) | 9.07(17) |
| (2, 2)                        | 1.52(107) | 3.74(60) | 1.86(22) | 5.17(18) | 1.21(16) |
| (2, 3)                        | 1.17(107) | 2.88(60) | 1.43(22) | 3.98(18) | 9.33(17) |

Table 5: Same as Table 1 for  $C^+ + H_2(v = 0, j = 4) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50        | 100      | 500      | 1000     | 1500     |
|-------------------------|-----------|----------|----------|----------|----------|
| (0, 0)                  | 3.20(37)  | 1.80(24) | 2.01(14) | 2.98(13) | 6.64(13) |
| (0, 1)                  | 3.98(37)  | 3.16(24) | 5.36(14) | 8.36(13) | 1.90(12) |
| (0, 2)                  | 2.29(37)  | 2.89(24) | 7.23(14) | 1.20(12) | 2.81(12) |
| (0, 3)                  | 1.31(37)  | 1.82(24) | 7.13(14) | 1.33(12) | 3.26(12) |
| (0, 4)                  | 2.34(39)  | 3.03(25) | 5.52(14) | 1.25(12) | 3.27(12) |
| (0, 5)                  | 1.67(41)  | 2.33(26) | 3.40(14) | 1.02(12) | 2.94(12) |
| (0, 6)                  | 1.21(41)  | 1.70(26) | 2.75(14) | 9.05(13) | 2.75(12) |
| (0, 7)                  | 1.33(46)  | 6.13(29) | 9.92(15) | 5.65(13) | 2.04(12) |
| (0, 8)                  | 8.13(47)  | 3.75(29) | 7.15(15) | 4.60(13) | 1.76(12) |
| (0, 9)                  | 1.01(51)  | 1.55(31) | 2.72(15) | 2.88(13) | 1.29(12) |
| (0,10)                  | 2.51(52)  | 3.87(32) | 1.32(15) | 1.91(13) | 9.56(13) |
| (0,11)                  | 5.01(57)  | 2.53(34) | 5.59(16) | 1.20(13) | 6.86(13) |
| (0,12)                  | 5.01(57)  | 2.53(34) | 5.59(16) | 1.20(13) | 6.86(13) |
| (0,13)                  | 5.01(57)  | 2.53(34) | 5.59(16) | 1.20(13) | 6.86(13) |
| (0,14)                  | 5.01(57)  | 2.53(34) | 5.59(16) | 1.20(13) | 6.86(13) |
| (0,15)                  | 5.01(57)  | 2.53(34) | 5.59(16) | 1.20(13) | 6.86(13) |
| (0,16)                  | 3.21(77)  | 1.93(44) | 4.34(18) | 8.71(15) | 9.91(14) |
| (0,17)                  | 2.39(82)  | 4.76(47) | 1.15(18) | 4.11(15) | 5.51(14) |
| (0,18)                  | 1.58(87)  | 1.04(49) | 2.84(19) | 1.79(15) | 2.81(14) |
| (0,19)                  | 7.14(93)  | 1.56(52) | 5.71(20) | 6.48(16) | 1.20(14) |
| (0,20)                  | 2.13(98)  | 1.56(55) | 9.59(21) | 1.84(16) | 3.90(15) |
| (1, 0)                  | 1.36(68)  | 7.46(41) | 1.79(18) | 1.24(15) | 1.03(14) |
| (1, 1)                  | 2.69(68)  | 1.48(40) | 4.45(18) | 3.36(15) | 2.86(14) |
| (1, 2)                  | 1.26(72)  | 2.29(42) | 4.28(18) | 4.37(15) | 4.01(14) |
| (1, 3)                  | 1.47(72)  | 2.66(42) | 5.20(18) | 5.49(15) | 5.11(14) |
| (1, 4)                  | 1.40(72)  | 2.55(42) | 5.39(18) | 6.03(15) | 5.76(14) |
| (1, 5)                  | 7.89(73)  | 1.44(42) | 4.20(18) | 5.59(15) | 5.66(14) |
| (1, 6)                  | 1.89(77)  | 1.14(44) | 2.38(18) | 4.54(15) | 5.06(14) |
| (1, 7)                  | 1.15(77)  | 6.92(45) | 1.80(18) | 3.91(15) | 4.57(14) |
| (1, 8)                  | 1.89(82)  | 3.75(47) | 8.21(19) | 2.73(15) | 3.57(14) |
| (1, 9)                  | 6.58(83)  | 1.32(47) | 4.71(19) | 1.97(15) | 2.78(14) |
| (1,10)                  | 1.35(87)  | 8.90(50) | 2.20(19) | 1.31(15) | 2.02(14) |
| (1,11)                  | 1.61(92)  | 3.49(52) | 7.89(20) | 7.31(16) | 1.27(14) |
| (1,12)                  | 1.58(97)  | 1.14(54) | 2.45(20) | 3.54(16) | 6.90(15) |
| (1,13)                  | 2.21(98)  | 1.62(55) | 8.78(21) | 1.64(16) | 3.46(15) |
| (1,14)                  | 3.92(103) | 9.39(58) | 2.39(21) | 5.63(17) | 1.27(15) |
| (2, 0)                  | 7.20(103) | 1.72(57) | 4.34(21) | 1.02(16) | 2.30(15) |
| (2, 1)                  | 6.02(104) | 1.43(58) | 2.66(22) | 5.70(18) | 1.24(16) |
| (2, 2)                  | 1.70(103) | 4.05(58) | 7.55(22) | 1.62(17) | 3.53(16) |
| (2, 3)                  | 2.39(103) | 5.68(58) | 1.09(21) | 2.35(17) | 5.14(16) |
| (2, 4)                  | 2.49(103) | 5.93(58) | 1.19(21) | 2.63(17) | 5.79(16) |
| (2, 5)                  | 4.89(108) | 3.78(60) | 3.88(22) | 1.14(17) | 2.72(16) |

Table 6: Same as Table 1 for  $C^+ + H_2(v = 0, j = 5) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 3.42(30) | 5.49(21) | 9.23(14) | 6.26(13) | 1.09(12) |
| (0, 1)                  | 5.51(30) | 1.18(20) | 2.59(13) | 1.82(12) | 3.19(12) |
| (0, 2)                  | 5.52(30) | 1.26(20) | 3.53(13) | 2.64(12) | 4.76(12) |
| (0, 3)                  | 2.81(31) | 3.37(21) | 3.35(13) | 2.92(12) | 5.54(12) |
| (0, 4)                  | 3.27(33) | 3.98(22) | 2.49(13) | 2.71(12) | 5.56(12) |
| (0, 5)                  | 1.21(33) | 1.69(22) | 1.94(13) | 2.46(12) | 5.35(12) |
| (0, 6)                  | 9.28(36) | 1.39(23) | 1.18(13) | 1.95(12) | 4.65(12) |
| (0, 7)                  | 2.74(39) | 3.51(25) | 6.07(14) | 1.41(12) | 3.76(12) |
| (0, 8)                  | 1.38(41) | 1.93(26) | 3.08(14) | 9.88(13) | 2.96(12) |
| (0, 9)                  | 5.80(42) | 8.15(27) | 1.81(14) | 7.15(13) | 2.35(12) |
| (0,10)                  | 8.48(47) | 3.92(29) | 7.09(15) | 4.45(13) | 1.70(12) |
| (0,11)                  | 8.66(52) | 1.32(31) | 2.37(15) | 2.56(13) | 1.16(12) |
| (0,12)                  | 8.65(57) | 4.35(34) | 7.65(16) | 1.42(13) | 7.63(13) |
| (0,13)                  | 8.51(58) | 4.39(35) | 2.71(16) | 7.90(14) | 4.96(13) |
| (0,14)                  | 1.16(62) | 1.95(37) | 8.52(17) | 4.14(14) | 3.08(13) |
| (0,15)                  | 8.03(68) | 4.49(40) | 2.26(17) | 2.01(14) | 1.81(13) |
| (0,16)                  | 3.75(73) | 7.01(43) | 5.40(18) | 9.27(15) | 1.01(13) |
| (0,17)                  | 1.91(79) | 1.69(46) | 1.24(18) | 4.17(15) | 5.49(14) |
| (0,18)                  | 1.89(87) | 1.25(49) | 3.05(19) | 1.81(15) | 2.81(14) |
| (0,19)                  | 1.01(92) | 2.20(52) | 6.41(20) | 6.72(16) | 1.21(14) |
| (0,20)                  | 3.05(98) | 2.22(55) | 9.99(21) | 1.81(16) | 3.80(15) |
| (1, 0)                  | 2.70(63) | 4.49(38) | 8.29(18) | 2.79(15) | 1.82(14) |
| (1, 1)                  | 7.57(63) | 1.26(37) | 2.38(17) | 8.12(15) | 5.32(14) |
| (1, 2)                  | 1.03(62) | 1.71(37) | 3.44(17) | 1.22(14) | 8.15(14) |
| (1, 3)                  | 8.90(63) | 1.48(37) | 3.61(17) | 1.43(14) | 9.90(14) |
| (1, 4)                  | 2.17(67) | 1.19(39) | 2.22(17) | 1.29(14) | 9.92(14) |
| (1, 5)                  | 1.94(67) | 1.07(39) | 2.13(17) | 1.32(14) | 1.04(13) |
| (1, 6)                  | 1.04(67) | 5.73(40) | 1.56(17) | 1.15(14) | 9.72(14) |
| (1, 7)                  | 2.24(72) | 4.07(42) | 8.09(18) | 8.74(15) | 8.24(14) |
| (1, 8)                  | 9.59(73) | 1.75(42) | 5.07(18) | 6.79(15) | 6.92(14) |
| (1, 9)                  | 1.76(77) | 1.06(44) | 2.36(18) | 4.74(15) | 5.40(14) |
| (1,10)                  | 2.10(82) | 4.17(47) | 8.93(19) | 2.93(15) | 3.82(14) |
| (1,11)                  | 7.05(83) | 1.41(47) | 4.82(19) | 2.00(15) | 2.82(14) |
| (1,12)                  | 1.08(87) | 7.12(50) | 1.91(19) | 1.19(15) | 1.86(14) |
| (1,13)                  | 1.19(92) | 2.58(52) | 6.34(20) | 6.15(16) | 1.08(14) |
| (1,14)                  | 1.08(97) | 7.76(55) | 1.81(20) | 2.71(16) | 5.36(15) |
| (1,15)                  | 9.32(99) | 2.22(57) | 4.29(21) | 9.32(17) | 2.04(15) |
| (2, 0)                  | 2.66(94) | 5.82(54) | 1.97(21) | 2.16(17) | 3.93(16) |
| (2, 1)                  | 2.41(98) | 1.73(55) | 3.55(21) | 4.99(17) | 9.66(16) |
| (2, 2)                  | 3.57(98) | 2.56(55) | 5.36(21) | 7.59(17) | 1.47(15) |
| (2, 3)                  | 4.19(98) | 3.01(55) | 6.50(21) | 9.36(17) | 1.83(15) |
| (2, 4)                  | 4.10(98) | 2.95(55) | 6.76(21) | 1.00(16) | 1.97(15) |
| (2, 5)                  | 2.10(98) | 1.52(55) | 4.90(21) | 8.18(17) | 1.67(15) |

Table 7: Same as Table 1 for  $C^+ + H_2(v = 0, j = 6) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 1.07(21) | 1.03(16) | 7.25(13) | 1.78(12) | 2.19(12) |
| (0, 1)                  | 1.60(21) | 2.18(16) | 2.08(12) | 5.29(12) | 6.56(12) |
| (0, 2)                  | 1.89(21) | 2.64(16) | 2.89(12) | 7.73(12) | 9.79(12) |
| (0, 3)                  | 3.92(23) | 4.41(17) | 2.48(12) | 8.07(12) | 1.10(11) |
| (0, 4)                  | 2.05(23) | 2.52(17) | 2.16(12) | 7.94(12) | 1.13(11) |
| (0, 5)                  | 2.55(25) | 3.07(18) | 1.47(12) | 6.75(12) | 1.05(11) |
| (0, 6)                  | 2.19(27) | 2.71(19) | 8.72(13) | 5.25(12) | 8.99(12) |
| (0, 7)                  | 9.11(30) | 1.21(20) | 4.03(13) | 3.59(12) | 7.05(12) |
| (0, 8)                  | 1.17(31) | 1.51(21) | 2.55(13) | 2.79(12) | 5.94(12) |
| (0, 9)                  | 1.38(36) | 5.84(24) | 9.33(14) | 1.72(12) | 4.29(12) |
| (0,10)                  | 5.34(37) | 2.28(24) | 5.29(14) | 1.21(12) | 3.33(12) |
| (0,11)                  | 7.65(42) | 1.07(26) | 2.02(14) | 7.36(13) | 2.35(12) |
| (0,12)                  | 7.99(47) | 3.69(29) | 6.68(15) | 4.12(13) | 1.56(12) |
| (0,13)                  | 7.61(52) | 1.16(31) | 2.03(15) | 2.18(13) | 9.89(13) |
| (0,14)                  | 6.03(57) | 3.04(34) | 5.58(16) | 1.09(13) | 6.03(13) |
| (0,15)                  | 6.03(57) | 3.04(34) | 5.58(16) | 1.09(13) | 6.03(13) |
| (0,16)                  | 4.65(62) | 7.73(37) | 1.52(16) | 5.42(14) | 3.63(13) |
| (0,17)                  | 3.52(67) | 1.94(39) | 4.08(17) | 2.64(14) | 2.14(13) |
| (0,18)                  | 2.46(72) | 4.48(42) | 1.04(17) | 1.24(14) | 1.21(13) |
| (0,19)                  | 1.32(77) | 7.98(45) | 2.30(18) | 5.31(15) | 6.36(14) |
| (0,20)                  | 4.04(83) | 8.17(48) | 4.39(19) | 2.09(15) | 3.06(14) |
| (1, 0)                  | 2.42(53) | 3.69(33) | 6.97(17) | 7.90(15) | 3.68(14) |
| (1, 1)                  | 6.42(53) | 9.80(33) | 1.97(16) | 2.30(14) | 1.08(13) |
| (1, 2)                  | 1.79(57) | 9.01(35) | 1.50(16) | 2.69(14) | 1.42(13) |
| (1, 3)                  | 2.12(57) | 1.07(34) | 1.84(16) | 3.40(14) | 1.82(13) |
| (1, 4)                  | 2.11(57) | 1.06(34) | 1.95(16) | 3.77(14) | 2.07(13) |
| (1, 5)                  | 1.54(57) | 7.76(35) | 1.69(16) | 3.67(14) | 2.12(13) |
| (1, 6)                  | 2.71(62) | 4.51(37) | 8.35(17) | 2.82(14) | 1.85(13) |
| (1, 7)                  | 1.86(62) | 3.10(37) | 6.66(17) | 2.51(14) | 1.72(13) |
| (1, 8)                  | 2.70(67) | 1.48(39) | 2.87(17) | 1.74(14) | 1.37(13) |
| (1, 9)                  | 1.32(67) | 7.28(40) | 1.87(17) | 1.36(14) | 1.14(13) |
| (1,10)                  | 2.03(72) | 3.69(42) | 7.90(18) | 8.92(15) | 8.55(14) |
| (1,11)                  | 2.28(77) | 1.37(44) | 2.81(18) | 5.31(15) | 5.90(14) |
| (1,12)                  | 1.26(78) | 7.97(46) | 1.01(18) | 3.06(15) | 3.92(14) |
| (1,13)                  | 1.26(78) | 7.97(46) | 1.01(18) | 3.06(15) | 3.91(14) |
| (1,14)                  | 7.05(83) | 1.41(47) | 4.63(19) | 1.90(15) | 2.67(14) |
| (1,15)                  | 7.58(88) | 5.01(50) | 1.51(19) | 9.94(16) | 1.59(14) |
| (2, 0)                  | 1.35(87) | 8.94(50) | 3.04(19) | 2.29(15) | 3.86(14) |
| (2, 1)                  | 8.85(89) | 5.83(51) | 1.23(20) | 6.65(17) | 9.93(16) |
| (2, 2)                  | 2.54(88) | 1.67(50) | 3.56(20) | 1.94(16) | 2.91(15) |
| (2, 3)                  | 3.63(88) | 2.39(50) | 5.27(20) | 2.94(16) | 4.44(15) |
| (2, 4)                  | 3.99(88) | 2.63(50) | 6.19(20) | 3.60(16) | 5.51(15) |
| (2, 5)                  | 2.45(88) | 1.62(50) | 5.26(20) | 3.54(16) | 5.67(15) |

Table 8: Same as Table 1 for  $C^+ + H_2(v = 0, j = 7) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 6.03(12) | 8.40(12) | 7.02(12) | 5.58(12) | 4.71(12) |
| (0, 1)                  | 8.90(12) | 1.49(11) | 1.77(11) | 1.53(11) | 1.34(11) |
| (0, 2)                  | 9.09(13) | 4.27(12) | 1.91(11) | 2.00(11) | 1.86(11) |
| (0, 3)                  | 9.76(13) | 4.59(12) | 2.20(11) | 2.41(11) | 2.28(11) |
| (0, 4)                  | 7.58(13) | 3.58(12) | 2.02(11) | 2.43(11) | 2.41(11) |
| (0, 5)                  | 1.68(16) | 6.56(14) | 1.07(11) | 1.87(11) | 2.09(11) |
| (0, 6)                  | 1.26(16) | 4.93(14) | 8.93(12) | 1.69(11) | 1.97(11) |
| (0, 7)                  | 1.89(21) | 2.31(16) | 3.50(12) | 1.09(11) | 1.48(11) |
| (0, 8)                  | 1.18(21) | 1.45(16) | 2.54(12) | 8.82(12) | 1.28(11) |
| (0, 9)                  | 1.59(26) | 6.30(19) | 9.42(13) | 5.39(12) | 9.19(12) |
| (0,10)                  | 4.53(27) | 1.80(19) | 4.60(13) | 3.55(12) | 6.83(12) |
| (0,11)                  | 7.31(32) | 9.47(22) | 1.84(13) | 2.21(12) | 4.91(12) |
| (0,12)                  | 8.39(37) | 3.57(24) | 6.31(14) | 1.27(12) | 3.32(12) |
| (0,13)                  | 7.98(42) | 1.12(26) | 1.95(14) | 6.79(13) | 2.13(12) |
| (0,14)                  | 6.77(47) | 3.13(29) | 5.57(15) | 3.46(13) | 1.32(12) |
| (0,15)                  | 5.39(52) | 8.22(32) | 1.52(15) | 1.70(13) | 7.94(13) |
| (0,16)                  | 3.83(57) | 1.93(34) | 3.88(16) | 8.16(14) | 4.68(13) |
| (0,17)                  | 2.52(62) | 4.20(37) | 9.70(17) | 3.86(14) | 2.71(13) |
| (0,18)                  | 1.13(67) | 6.25(40) | 2.07(17) | 1.68(14) | 1.47(13) |
| (0,19)                  | 3.44(73) | 6.39(43) | 4.17(18) | 7.00(15) | 7.64(14) |
| (0,20)                  | 1.63(82) | 3.24(47) | 7.74(19) | 2.76(15) | 3.71(14) |
| (1, 0)                  | 2.41(43) | 3.37(28) | 6.58(16) | 2.45(14) | 7.92(14) |
| (1, 1)                  | 5.72(43) | 8.03(28) | 1.78(15) | 7.03(14) | 2.31(13) |
| (1, 2)                  | 2.12(47) | 9.79(30) | 1.56(15) | 8.75(14) | 3.17(13) |
| (1, 3)                  | 2.48(47) | 1.14(29) | 1.89(15) | 1.10(13) | 4.04(13) |
| (1, 4)                  | 2.41(47) | 1.11(29) | 1.97(15) | 1.21(13) | 4.57(13) |
| (1, 5)                  | 1.50(47) | 6.94(30) | 1.59(15) | 1.13(13) | 4.57(13) |
| (1, 6)                  | 3.25(52) | 4.96(32) | 8.52(16) | 9.02(14) | 4.08(13) |
| (1, 7)                  | 2.07(52) | 3.16(32) | 6.50(16) | 7.84(14) | 3.76(13) |
| (1, 8)                  | 3.03(57) | 1.52(34) | 2.79(16) | 5.42(14) | 3.00(13) |
| (1, 9)                  | 1.17(57) | 5.92(35) | 1.66(16) | 4.09(14) | 2.47(13) |
| (1,10)                  | 2.17(62) | 3.61(37) | 7.55(17) | 2.81(14) | 1.92(13) |
| (1,11)                  | 2.56(67) | 1.41(39) | 2.79(17) | 1.73(14) | 1.38(13) |
| (1,12)                  | 2.64(72) | 4.80(42) | 9.42(18) | 9.98(15) | 9.32(14) |
| (1,13)                  | 4.02(73) | 7.42(43) | 3.81(18) | 5.95(15) | 6.32(14) |
| (1,14)                  | 4.02(73) | 7.42(43) | 3.81(18) | 5.95(15) | 6.32(14) |
| (1,15)                  | 7.18(78) | 4.33(45) | 1.40(18) | 3.39(15) | 4.11(14) |
| (2, 0)                  | 1.07(78) | 6.42(46) | 1.27(19) | 2.32(16) | 2.55(15) |
| (2, 1)                  | 3.11(78) | 1.87(45) | 3.72(19) | 6.83(16) | 7.51(15) |
| (2, 2)                  | 4.42(78) | 2.65(45) | 5.49(19) | 1.04(15) | 1.15(14) |
| (2, 3)                  | 4.73(78) | 2.84(45) | 6.35(19) | 1.26(15) | 1.43(14) |
| (2, 4)                  | 8.29(83) | 1.65(47) | 3.34(19) | 1.05(15) | 1.34(14) |
| (2, 5)                  | 7.99(83) | 1.59(47) | 3.38(19) | 1.10(15) | 1.43(14) |

Table 9: Same as Table 1 for  $C^+ + H_2(v = 0, j = 8) \rightarrow H^+ + CH(v', j')$  transitions.

| $T [K]$<br>$(v', j')$ | 50       | 100      | 500      | 1000     | 1500     |
|-----------------------|----------|----------|----------|----------|----------|
| (0, 0)                | 1.59(11) | 1.13(11) | 6.69(12) | 5.26(12) | 4.43(12) |
| (0, 1)                | 5.08(11) | 3.61(11) | 2.10(11) | 1.64(11) | 1.38(11) |
| (0, 2)                | 8.06(11) | 5.78(11) | 3.36(11) | 2.61(11) | 2.19(11) |
| (0, 3)                | 1.08(10) | 7.77(11) | 4.43(11) | 3.44(11) | 2.89(11) |
| (0, 4)                | 1.32(10) | 9.55(11) | 5.28(11) | 4.07(11) | 3.42(11) |
| (0, 5)                | 1.54(10) | 1.10(10) | 5.79(11) | 4.45(11) | 3.75(11) |
| (0, 6)                | 1.67(10) | 1.16(10) | 5.77(11) | 4.49(11) | 3.84(11) |
| (0, 7)                | 1.30(10) | 8.91(11) | 4.87(11) | 4.05(11) | 3.59(11) |
| (0, 8)                | 4.70(13) | 4.67(12) | 2.54(11) | 2.90(11) | 2.87(11) |
| (0, 9)                | 3.94(16) | 1.26(13) | 1.18(11) | 1.95(11) | 2.18(11) |
| (0,10)                | 1.47(19) | 2.07(15) | 4.80(12) | 1.21(11) | 1.57(11) |
| (0,11)                | 1.04(21) | 1.27(16) | 2.23(12) | 7.86(12) | 1.15(11) |
| (0,12)                | 1.13(26) | 4.48(19) | 7.28(13) | 4.37(12) | 7.62(12) |
| (0,13)                | 1.08(31) | 1.39(21) | 2.18(13) | 2.29(12) | 4.84(12) |
| (0,14)                | 8.76(37) | 3.72(24) | 6.04(14) | 1.15(12) | 2.98(12) |
| (0,15)                | 6.97(42) | 9.76(27) | 1.66(14) | 5.78(13) | 1.82(12) |
| (0,16)                | 6.97(42) | 9.76(27) | 1.66(14) | 5.78(13) | 1.82(12) |
| (0,17)                | 5.43(47) | 2.50(29) | 4.50(15) | 2.84(13) | 1.09(12) |
| (0,18)                | 3.88(52) | 5.93(32) | 1.16(15) | 1.35(13) | 6.37(13) |
| (0,19)                | 2.26(57) | 1.15(34) | 2.65(16) | 6.03(14) | 3.54(13) |
| (0,20)                | 6.99(63) | 1.17(37) | 4.97(17) | 2.47(14) | 1.84(13) |
| (1, 0)                | 3.80(33) | 4.92(23) | 7.98(15) | 8.63(14) | 1.84(13) |
| (1, 1)                | 1.08(32) | 1.40(22) | 2.35(14) | 2.59(13) | 5.55(13) |
| (1, 2)                | 1.12(32) | 1.45(22) | 2.98(14) | 3.65(13) | 8.17(13) |
| (1, 3)                | 3.15(37) | 1.34(24) | 2.04(14) | 3.67(13) | 9.14(13) |
| (1, 4)                | 3.18(37) | 1.35(24) | 2.18(14) | 4.10(13) | 1.04(12) |
| (1, 5)                | 2.54(37) | 1.08(24) | 1.97(14) | 4.07(13) | 1.08(12) |
| (1, 6)                | 4.09(42) | 5.74(27) | 9.25(15) | 3.05(13) | 9.32(13) |
| (1, 7)                | 3.00(42) | 4.21(27) | 7.64(15) | 2.76(13) | 8.82(13) |
| (1, 8)                | 4.08(47) | 1.88(29) | 3.16(15) | 1.87(13) | 6.95(13) |
| (1, 9)                | 2.29(47) | 1.06(29) | 2.20(15) | 1.51(13) | 5.98(13) |
| (1,10)                | 3.18(52) | 4.84(32) | 8.82(16) | 9.76(14) | 4.48(13) |
| (1,11)                | 3.17(52) | 4.83(32) | 8.82(16) | 9.76(14) | 4.48(13) |
| (1,12)                | 3.44(57) | 1.73(34) | 3.07(16) | 5.83(14) | 3.16(13) |
| (1,13)                | 6.89(58) | 3.51(35) | 1.36(16) | 3.70(14) | 2.28(13) |
| (1,14)                | 1.33(62) | 2.21(37) | 5.55(17) | 2.28(14) | 1.60(13) |
| (1,15)                | 1.33(67) | 7.33(40) | 1.78(17) | 1.25(14) | 1.03(13) |
| (2, 0)                | 2.36(67) | 1.30(39) | 3.68(17) | 3.25(14) | 3.01(13) |
| (2, 1)                | 1.38(68) | 7.58(41) | 1.38(18) | 7.93(16) | 6.02(15) |
| (2, 2)                | 4.12(68) | 2.26(40) | 4.13(18) | 2.38(15) | 1.80(14) |
| (2, 3)                | 5.96(68) | 3.27(40) | 6.14(18) | 3.62(15) | 2.78(14) |
| (2, 4)                | 6.74(68) | 3.70(40) | 7.32(18) | 4.49(15) | 3.51(14) |
| (2, 5)                | 5.45(68) | 3.00(40) | 6.98(18) | 4.74(15) | 3.85(14) |

Table 10: Same as Table 1 for  $C^+ + H_2(v = 0, j = 9) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 9.67(12) | 6.83(12) | 4.57(12) | 4.03(12) | 3.58(12) |
| (0, 1)                  | 3.06(11) | 2.16(11) | 1.43(11) | 1.25(11) | 1.11(11) |
| (0, 2)                  | 4.83(11) | 3.44(11) | 2.32(11) | 2.03(11) | 1.80(11) |
| (0, 3)                  | 6.41(11) | 4.60(11) | 3.14(11) | 2.75(11) | 2.43(11) |
| (0, 4)                  | 7.83(11) | 5.67(11) | 3.90(11) | 3.39(11) | 2.98(11) |
| (0, 5)                  | 9.11(11) | 6.66(11) | 4.57(11) | 3.93(11) | 3.44(11) |
| (0, 6)                  | 1.03(10) | 7.58(11) | 5.13(11) | 4.35(11) | 3.80(11) |
| (0, 7)                  | 1.13(10) | 8.42(11) | 5.55(11) | 4.63(11) | 4.02(11) |
| (0, 8)                  | 1.23(10) | 9.16(11) | 5.76(11) | 4.72(11) | 4.09(11) |
| (0, 9)                  | 1.31(10) | 9.67(11) | 5.66(11) | 4.58(11) | 3.98(11) |
| (0,10)                  | 1.30(10) | 9.25(11) | 5.04(11) | 4.13(11) | 3.63(11) |
| (0,11)                  | 7.45(12) | 1.67(11) | 2.94(11) | 2.98(11) | 2.84(11) |
| (0,12)                  | 1.89(15) | 2.20(13) | 1.10(11) | 1.74(11) | 1.93(11) |
| (0,13)                  | 2.60(20) | 7.76(16) | 2.83(12) | 8.22(12) | 1.14(11) |
| (0,14)                  | 4.60(22) | 5.65(17) | 1.24(12) | 5.01(12) | 7.87(12) |
| (0,15)                  | 1.11(22) | 1.36(17) | 3.96(13) | 2.42(12) | 4.61(12) |
| (0,16)                  | 4.89(36) | 1.11(23) | 6.68(14) | 1.10(12) | 2.70(12) |
| (0,17)                  | 2.37(37) | 5.43(25) | 1.41(14) | 4.67(13) | 1.48(12) |
| (0,18)                  | 2.08(42) | 2.91(27) | 6.35(15) | 2.77(13) | 9.78(13) |
| (0,19)                  | 2.45(52) | 3.76(32) | 8.10(16) | 1.01(13) | 4.83(13) |
| (0,20)                  | 3.80(53) | 5.84(33) | 1.92(16) | 4.10(14) | 2.45(13) |
| (1, 0)                  | 2.61(23) | 3.21(18) | 6.84(14) | 2.62(13) | 3.94(13) |
| (1, 1)                  | 8.11(23) | 9.95(18) | 2.12(13) | 8.06(13) | 1.21(12) |
| (1, 2)                  | 1.26(22) | 1.55(17) | 3.31(13) | 1.27(12) | 1.90(12) |
| (1, 3)                  | 1.58(22) | 1.93(17) | 4.15(13) | 1.61(12) | 2.45(12) |
| (1, 4)                  | 1.70(22) | 2.08(17) | 4.52(13) | 1.80(12) | 2.80(12) |
| (1, 5)                  | 1.59(22) | 1.95(17) | 4.34(13) | 1.82(12) | 2.91(12) |
| (1, 6)                  | 1.12(22) | 1.37(17) | 3.29(13) | 1.57(12) | 2.69(12) |
| (1, 7)                  | 2.76(32) | 3.59(22) | 7.19(14) | 8.67(13) | 1.92(12) |
| (1, 8)                  | 2.44(32) | 3.17(22) | 6.45(14) | 8.07(13) | 1.84(12) |
| (1, 9)                  | 1.80(32) | 2.34(22) | 4.97(14) | 6.74(13) | 1.61(12) |
| (1,10)                  | 2.87(42) | 4.02(27) | 8.14(15) | 3.06(13) | 9.82(13) |
| (1,11)                  | 2.88(42) | 4.02(27) | 8.14(15) | 3.06(13) | 9.82(13) |
| (1,12)                  | 2.29(42) | 3.20(27) | 6.62(15) | 2.60(13) | 8.61(13) |
| (1,13)                  | 1.30(42) | 1.81(27) | 4.05(15) | 1.84(13) | 6.59(13) |
| (1,14)                  | 2.08(52) | 3.20(32) | 6.82(16) | 8.26(14) | 3.90(13) |
| (1,15)                  | 1.24(52) | 1.90(32) | 4.29(16) | 5.82(14) | 2.93(13) |
| (2, 0)                  | 9.35(54) | 1.42(33) | 3.01(17) | 3.84(15) | 2.00(14) |
| (2, 1)                  | 2.85(53) | 4.34(33) | 9.17(17) | 1.09(14) | 5.10(14) |
| (2, 2)                  | 4.28(53) | 6.51(33) | 1.38(16) | 1.67(14) | 7.88(14) |
| (2, 3)                  | 5.12(53) | 7.79(33) | 1.68(16) | 2.08(14) | 9.94(14) |
| (2, 4)                  | 5.23(53) | 7.97(33) | 1.75(16) | 2.27(14) | 1.12(13) |
| (2, 5)                  | 4.07(53) | 6.19(33) | 1.46(16) | 2.12(14) | 1.10(13) |

Table 11: Same as Table 1 for  $C^+ + H_2(v = 0, j = 10) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 6.66(12) | 4.79(12) | 3.13(12) | 2.90(12) | 2.68(12) |
| (0, 1)                  | 2.11(11) | 1.52(11) | 9.81(12) | 9.02(12) | 8.31(12) |
| (0, 2)                  | 3.35(11) | 2.42(11) | 1.60(11) | 1.47(11) | 1.36(11) |
| (0, 3)                  | 4.45(11) | 3.23(11) | 2.18(11) | 2.01(11) | 1.85(11) |
| (0, 4)                  | 5.46(11) | 3.98(11) | 2.73(11) | 2.51(11) | 2.31(11) |
| (0, 5)                  | 6.36(11) | 4.67(11) | 3.25(11) | 2.98(11) | 2.72(11) |
| (0, 6)                  | 7.18(11) | 5.31(11) | 3.74(11) | 3.39(11) | 3.08(11) |
| (0, 7)                  | 7.91(11) | 5.90(11) | 4.18(11) | 3.74(11) | 3.38(11) |
| (0, 8)                  | 8.57(11) | 6.44(11) | 4.56(11) | 4.02(11) | 3.60(11) |
| (0, 9)                  | 9.16(11) | 6.94(11) | 4.87(11) | 4.21(11) | 3.74(11) |
| (0,10)                  | 9.68(11) | 7.39(11) | 5.06(11) | 4.28(11) | 3.76(11) |
| (0,11)                  | 1.01(10) | 7.78(11) | 5.07(11) | 4.19(11) | 3.66(11) |
| (0,12)                  | 1.05(10) | 7.97(11) | 4.81(11) | 3.90(11) | 3.41(11) |
| (0,13)                  | 1.00(10) | 7.34(11) | 4.06(11) | 3.32(11) | 2.95(11) |
| (0,14)                  | 2.26(12) | 7.60(12) | 1.94(11) | 2.10(11) | 2.09(11) |
| (0,15)                  | 1.85(17) | 1.76(14) | 5.12(12) | 1.03(11) | 1.26(11) |
| (0,16)                  | 1.85(17) | 1.76(14) | 3.54(12) | 4.04(12) | 3.29(12) |
| (0,17)                  | 6.65(22) | 8.13(17) | 9.32(13) | 1.82(12) | 1.77(12) |
| (0,18)                  | 5.06(27) | 1.88(19) | 8.35(14) | 2.13(13) | 2.25(13) |
| (0,19)                  | 2.65(32) | 3.44(22) | 7.90(14) | 1.06(12) | 2.51(12) |
| (0,20)                  | 7.46(38) | 3.23(25) | 1.51(14) | 4.45(13) | 1.36(12) |
| (1, 0)                  | 5.53(12) | 3.77(12) | 1.74(12) | 1.37(12) | 1.20(12) |
| (1, 1)                  | 1.65(11) | 1.14(11) | 5.37(12) | 4.22(12) | 3.68(12) |
| (1, 2)                  | 1.65(11) | 1.36(11) | 7.72(12) | 6.35(12) | 5.65(12) |
| (1, 3)                  | 1.45(12) | 4.33(12) | 7.56(12) | 7.24(12) | 6.80(12) |
| (1, 4)                  | 1.45(13) | 1.40(12) | 6.72(12) | 7.47(12) | 7.40(12) |
| (1, 5)                  | 1.87(15) | 1.72(13) | 4.89(12) | 6.82(12) | 7.29(12) |
| (1, 6)                  | 1.84(17) | 1.73(14) | 3.26(12) | 5.83(12) | 6.78(12) |
| (1, 7)                  | 1.47(19) | 1.46(15) | 1.99(12) | 4.67(12) | 5.98(12) |
| (1, 8)                  | 5.28(22) | 6.45(17) | 1.03(12) | 3.43(12) | 4.94(12) |
| (1, 9)                  | 2.71(22) | 3.32(17) | 6.86(13) | 2.71(12) | 4.21(12) |
| (1,10)                  | 4.33(27) | 1.71(19) | 2.86(13) | 1.79(12) | 3.21(12) |
| (1,11)                  | 4.36(27) | 1.71(19) | 2.86(13) | 1.79(12) | 3.21(12) |
| (1,12)                  | 5.01(32) | 6.47(22) | 1.01(13) | 1.07(12) | 2.29(12) |
| (1,13)                  | 7.90(34) | 1.22(23) | 3.39(14) | 6.20(13) | 1.59(12) |
| (1,14)                  | 1.51(37) | 6.53(25) | 1.65(14) | 4.06(13) | 1.17(12) |
| (1,15)                  | 1.73(42) | 2.46(27) | 5.53(15) | 2.30(13) | 7.87(13) |
| (2, 0)                  | 3.43(42) | 4.82(27) | 1.22(14) | 6.45(13) | 2.63(12) |
| (2, 1)                  | 2.17(43) | 3.04(28) | 4.72(16) | 1.52(14) | 4.64(14) |
| (2, 2)                  | 6.54(43) | 9.15(28) | 1.43(15) | 4.62(14) | 1.41(13) |
| (2, 3)                  | 9.41(43) | 1.32(27) | 2.12(15) | 7.03(14) | 2.17(13) |
| (2, 4)                  | 1.05(42) | 1.47(27) | 2.51(15) | 8.69(14) | 2.75(13) |
| (2, 5)                  | 5.68(43) | 7.99(28) | 2.01(15) | 8.48(14) | 2.89(13) |

Table 12: Same as Table 1 for  $C^+ + H_2(v = 0, j = 11) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 4.08(12) | 3.05(12) | 2.10(12) | 2.05(12) | 1.96(12) |
| (0, 1)                  | 1.27(11) | 9.59(12) | 6.55(12) | 6.34(12) | 6.06(12) |
| (0, 2)                  | 2.02(11) | 1.52(11) | 1.06(11) | 1.04(11) | 9.92(12) |
| (0, 3)                  | 2.69(11) | 2.03(11) | 1.45(11) | 1.42(11) | 1.36(11) |
| (0, 4)                  | 3.32(11) | 2.50(11) | 1.81(11) | 1.78(11) | 1.71(11) |
| (0, 5)                  | 3.90(11) | 2.93(11) | 2.17(11) | 2.13(11) | 2.04(11) |
| (0, 6)                  | 4.44(11) | 3.34(11) | 2.50(11) | 2.46(11) | 2.34(11) |
| (0, 7)                  | 4.92(11) | 3.72(11) | 2.82(11) | 2.76(11) | 2.62(11) |
| (0, 8)                  | 5.34(11) | 4.06(11) | 3.12(11) | 3.03(11) | 2.87(11) |
| (0, 9)                  | 5.72(11) | 4.37(11) | 3.41(11) | 3.27(11) | 3.07(11) |
| (0,10)                  | 6.05(11) | 4.66(11) | 3.66(11) | 3.46(11) | 3.22(11) |
| (0,11)                  | 6.34(11) | 4.93(11) | 3.86(11) | 3.59(11) | 3.30(11) |
| (0,12)                  | 6.60(11) | 5.16(11) | 3.99(11) | 3.63(11) | 3.30(11) |
| (0,13)                  | 6.81(11) | 5.37(11) | 4.01(11) | 3.55(11) | 3.20(11) |
| (0,14)                  | 6.98(11) | 5.50(11) | 3.86(11) | 3.34(11) | 2.99(11) |
| (0,15)                  | 6.99(11) | 5.40(11) | 3.46(11) | 2.94(11) | 2.65(11) |
| (0,16)                  | 5.17(11) | 3.92(11) | 2.06(11) | 1.18(11) | 7.71(12) |
| (0,17)                  | 6.05(15) | 1.61(13) | 5.04(13) | 2.79(13) | 1.77(13) |
| (0,18)                  | 7.51(21) | 1.86(16) | 2.37(13) | 2.91(13) | 2.40(13) |
| (0,19)                  | 2.05(22) | 2.51(17) | 3.19(13) | 6.40(13) | 6.31(13) |
| (0,20)                  | 2.72(32) | 3.53(22) | 7.23(14) | 9.23(13) | 2.16(12) |
| (1, 0)                  | 4.09(12) | 3.05(12) | 1.85(12) | 1.55(12) | 1.37(12) |
| (1, 1)                  | 1.28(11) | 9.59(12) | 5.77(12) | 4.79(12) | 4.21(12) |
| (1, 2)                  | 2.02(11) | 1.52(11) | 9.22(12) | 7.67(12) | 6.75(12) |
| (1, 3)                  | 2.70(11) | 2.03(11) | 1.23(11) | 1.02(11) | 9.00(12) |
| (1, 4)                  | 3.32(11) | 2.49(11) | 1.50(11) | 1.24(11) | 1.09(11) |
| (1, 5)                  | 3.90(11) | 2.91(11) | 1.72(11) | 1.42(11) | 1.25(11) |
| (1, 6)                  | 4.43(11) | 3.28(11) | 1.88(11) | 1.54(11) | 1.36(11) |
| (1, 7)                  | 4.86(11) | 3.55(11) | 1.94(11) | 1.59(11) | 1.41(11) |
| (1, 8)                  | 4.93(11) | 3.50(11) | 1.85(11) | 1.53(11) | 1.38(11) |
| (1, 9)                  | 8.81(12) | 1.26(11) | 1.33(11) | 1.28(11) | 1.22(11) |
| (1,10)                  | 4.95(15) | 2.53(13) | 6.03(12) | 8.60(12) | 9.36(12) |
| (1,11)                  | 4.95(15) | 2.53(13) | 6.03(12) | 8.60(12) | 9.36(12) |
| (1,12)                  | 2.80(22) | 3.44(17) | 7.39(13) | 2.90(12) | 4.47(12) |
| (1,13)                  | 1.95(22) | 2.39(17) | 5.25(13) | 2.19(12) | 3.55(12) |
| (1,14)                  | 1.18(24) | 1.45(19) | 4.43(14) | 6.28(13) | 1.56(12) |
| (1,15)                  | 1.19(32) | 1.54(22) | 3.49(14) | 5.30(13) | 1.35(12) |
| (2, 0)                  | 9.15(24) | 1.12(18) | 2.48(14) | 1.02(13) | 1.63(13) |
| (2, 1)                  | 2.77(23) | 3.40(18) | 7.52(14) | 3.11(13) | 4.96(13) |
| (2, 2)                  | 3.82(23) | 4.68(18) | 1.06(13) | 4.55(13) | 7.43(13) |
| (2, 3)                  | 7.39(24) | 9.07(19) | 4.10(14) | 3.30(13) | 6.76(13) |
| (2, 4)                  | 1.10(32) | 1.42(22) | 2.82(14) | 3.35(13) | 7.41(13) |
| (2, 5)                  | 1.17(32) | 1.51(22) | 3.02(14) | 3.65(13) | 8.17(13) |

Table 13: Same as Table C<sup>+</sup> + H<sub>2</sub>( $v = 0, j = 12$ ) → H<sup>+</sup> + CH( $v', j'$ ) transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| ( 0, 0)                 | 2.96(12) | 2.30(12) | 1.53(12) | 1.48(12) | 1.42(12) |
| ( 0, 1)                 | 9.33(12) | 7.29(12) | 4.81(12) | 4.61(12) | 4.43(12) |
| ( 0, 2)                 | 1.48(11) | 1.15(11) | 7.76(12) | 7.52(12) | 7.26(12) |
| ( 0, 3)                 | 1.98(11) | 1.53(11) | 1.05(11) | 1.03(11) | 9.98(12) |
| ( 0, 4)                 | 2.43(11) | 1.88(11) | 1.32(11) | 1.30(11) | 1.26(11) |
| ( 0, 5)                 | 2.85(11) | 2.20(11) | 1.57(11) | 1.56(11) | 1.51(11) |
| ( 0, 6)                 | 3.22(11) | 2.49(11) | 1.81(11) | 1.80(11) | 1.75(11) |
| ( 0, 7)                 | 3.56(11) | 2.76(11) | 2.04(11) | 2.04(11) | 1.98(11) |
| ( 0, 8)                 | 3.86(11) | 3.00(11) | 2.27(11) | 2.26(11) | 2.20(11) |
| ( 0, 9)                 | 4.12(11) | 3.22(11) | 2.48(11) | 2.47(11) | 2.39(11) |
| ( 0,10)                 | 4.35(11) | 3.42(11) | 2.68(11) | 2.66(11) | 2.56(11) |
| ( 0,11)                 | 4.56(11) | 3.61(11) | 2.87(11) | 2.82(11) | 2.69(11) |
| ( 0,12)                 | 4.73(11) | 3.77(11) | 3.03(11) | 2.95(11) | 2.79(11) |
| ( 0,13)                 | 4.89(11) | 3.92(11) | 3.17(11) | 3.03(11) | 2.84(11) |
| ( 0,14)                 | 5.02(11) | 4.06(11) | 3.27(11) | 3.06(11) | 2.83(11) |
| ( 0,15)                 | 5.13(11) | 4.17(11) | 3.30(11) | 3.01(11) | 2.75(11) |
| ( 0,16)                 | 5.21(11) | 4.25(11) | 3.22(11) | 2.85(11) | 2.58(11) |
| ( 0,17)                 | 5.23(11) | 4.22(11) | 2.96(11) | 2.56(11) | 2.32(11) |
| ( 0,18)                 | 4.71(11) | 3.67(11) | 2.39(11) | 2.09(11) | 1.92(11) |
| ( 0,19)                 | 7.72(13) | 2.49(12) | 9.90(12) | 1.20(11) | 1.26(11) |
| ( 0,20)                 | 2.72(32) | 3.53(22) | 7.23(14) | 9.23(13) | 2.16(12) |
| ( 1, 0)                 | 2.97(12) | 2.31(12) | 1.49(12) | 1.31(12) | 1.19(12) |
| ( 1, 1)                 | 9.36(12) | 7.31(12) | 4.66(12) | 4.09(12) | 3.70(12) |
| ( 1, 2)                 | 1.48(11) | 1.16(11) | 7.50(12) | 6.62(12) | 6.00(12) |
| ( 1, 3)                 | 1.98(11) | 1.54(11) | 1.01(11) | 8.97(12) | 8.12(12) |
| ( 1, 4)                 | 2.44(11) | 1.88(11) | 1.26(11) | 1.11(11) | 1.01(11) |
| ( 1, 5)                 | 2.86(11) | 2.20(11) | 1.49(11) | 1.31(11) | 1.18(11) |
| ( 1, 6)                 | 3.23(11) | 2.49(11) | 1.69(11) | 1.49(11) | 1.34(11) |
| ( 1, 7)                 | 3.57(11) | 2.76(11) | 1.88(11) | 1.63(11) | 1.46(11) |
| ( 1, 8)                 | 3.87(11) | 3.00(11) | 2.03(11) | 1.75(11) | 1.56(11) |
| ( 1, 9)                 | 4.13(11) | 3.22(11) | 2.13(11) | 1.81(11) | 1.61(11) |
| ( 1,10)                 | 4.36(11) | 3.39(11) | 2.16(11) | 1.81(11) | 1.61(11) |
| ( 1,11)                 | 4.95(15) | 2.53(13) | 6.03(12) | 8.60(12) | 9.36(12) |
| ( 1,12)                 | 2.80(22) | 3.44(17) | 7.39(13) | 2.90(12) | 4.47(12) |
| ( 1,13)                 | 1.95(22) | 2.39(17) | 5.25(13) | 2.19(12) | 3.55(12) |
| ( 1,14)                 | 1.18(24) | 1.45(19) | 4.43(14) | 6.28(13) | 1.56(12) |
| ( 1,15)                 | 1.19(32) | 1.54(22) | 3.49(14) | 5.30(13) | 1.35(12) |
| ( 2, 0)                 | 9.15(24) | 1.12(18) | 2.48(14) | 1.02(13) | 1.63(13) |
| ( 2, 1)                 | 2.77(23) | 3.40(18) | 7.52(14) | 3.11(13) | 4.96(13) |
| ( 2, 2)                 | 3.82(23) | 4.68(18) | 1.06(13) | 4.55(13) | 7.43(13) |
| ( 2, 3)                 | 7.39(24) | 9.07(19) | 4.10(14) | 3.30(13) | 6.76(13) |
| ( 2, 4)                 | 1.10(32) | 1.42(22) | 2.82(14) | 3.35(13) | 7.41(13) |
| ( 2, 5)                 | 1.17(32) | 1.51(22) | 3.02(14) | 3.65(13) | 8.17(13) |

Table 14: Same as Table C<sup>+</sup>+ H<sub>2</sub>( $v = 0, j = 13$ )  $\rightarrow$  H<sup>+</sup>+CH( $v', j'$ ) transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| ( 0, 0)                 | 1.93(12) | 1.60(12) | 1.12(12) | 1.07(12) | 1.04(12) |
| ( 0, 1)                 | 5.98(12) | 5.01(12) | 3.50(12) | 3.33(12) | 3.21(12) |
| ( 0, 2)                 | 9.57(12) | 7.95(12) | 5.64(12) | 5.43(12) | 5.24(12) |
| ( 0, 3)                 | 1.29(11) | 1.06(11) | 7.64(12) | 7.43(12) | 7.20(12) |
| ( 0, 4)                 | 1.60(11) | 1.31(11) | 9.54(12) | 9.36(12) | 9.10(12) |
| ( 0, 5)                 | 1.90(11) | 1.54(11) | 1.14(11) | 1.12(11) | 1.10(11) |
| ( 0, 6)                 | 2.18(11) | 1.76(11) | 1.31(11) | 1.30(11) | 1.28(11) |
| ( 0, 7)                 | 2.43(11) | 1.96(11) | 1.48(11) | 1.48(11) | 1.45(11) |
| ( 0, 8)                 | 2.66(11) | 2.14(11) | 1.64(11) | 1.65(11) | 1.62(11) |
| ( 0, 9)                 | 2.87(11) | 2.30(11) | 1.80(11) | 1.81(11) | 1.78(11) |
| ( 0,10)                 | 3.05(11) | 2.45(11) | 1.95(11) | 1.97(11) | 1.93(11) |
| ( 0,11)                 | 3.20(11) | 2.59(11) | 2.09(11) | 2.12(11) | 2.07(11) |
| ( 0,12)                 | 3.34(11) | 2.71(11) | 2.22(11) | 2.25(11) | 2.19(11) |
| ( 0,13)                 | 3.45(11) | 2.82(11) | 2.35(11) | 2.36(11) | 2.29(11) |
| ( 0,14)                 | 3.55(11) | 2.92(11) | 2.46(11) | 2.46(11) | 2.36(11) |
| ( 0,15)                 | 3.63(11) | 3.00(11) | 2.56(11) | 2.52(11) | 2.40(11) |
| ( 0,16)                 | 3.70(11) | 3.08(11) | 2.63(11) | 2.53(11) | 2.39(11) |
| ( 0,17)                 | 3.75(11) | 3.14(11) | 2.65(11) | 2.49(11) | 2.32(11) |
| ( 0,18)                 | 3.80(11) | 3.19(11) | 2.58(11) | 2.37(11) | 2.18(11) |
| ( 0,19)                 | 3.80(11) | 3.16(11) | 2.39(11) | 2.14(11) | 1.96(11) |
| ( 0,20)                 | 3.55(11) | 2.85(11) | 1.98(11) | 1.76(11) | 1.58(11) |
| ( 1, 0)                 | 1.98(12) | 1.62(12) | 1.11(12) | 1.04(12) | 9.85(13) |
| ( 1, 1)                 | 6.08(12) | 5.06(12) | 3.48(12) | 3.24(12) | 3.05(12) |
| ( 1, 2)                 | 9.69(12) | 8.02(12) | 5.60(12) | 5.26(12) | 4.96(12) |
| ( 1, 3)                 | 1.30(11) | 1.07(11) | 7.58(12) | 7.15(12) | 6.77(12) |
| ( 1, 4)                 | 1.61(11) | 1.32(11) | 9.45(12) | 8.95(12) | 8.47(12) |
| ( 1, 5)                 | 1.91(11) | 1.55(11) | 1.12(11) | 1.06(11) | 1.01(11) |
| ( 1, 6)                 | 2.19(11) | 1.76(11) | 1.29(11) | 1.22(11) | 1.15(11) |
| ( 1, 7)                 | 2.45(11) | 1.97(11) | 1.45(11) | 1.37(11) | 1.29(11) |
| ( 1, 8)                 | 2.71(11) | 2.16(11) | 1.60(11) | 1.50(11) | 1.41(11) |
| ( 1, 9)                 | 2.94(11) | 2.34(11) | 1.74(11) | 1.62(11) | 1.50(11) |
| ( 1,10)                 | 3.14(11) | 2.50(11) | 1.85(11) | 1.71(11) | 1.58(11) |
| ( 1,11)                 | 3.32(11) | 2.64(11) | 1.95(11) | 1.76(11) | 1.62(11) |
| ( 1,12)                 | 3.46(11) | 2.76(11) | 2.00(11) | 1.78(11) | 1.62(11) |
| 5 ( 1,13)               | 3.58(11) | 2.86(11) | 1.99(11) | 1.73(11) | 1.57(11) |
| ( 1,14)                 | 3.66(11) | 2.89(11) | 1.89(11) | 1.62(11) | 1.47(11) |
| ( 1,15)                 | 3.51(11) | 2.69(11) | 1.63(11) | 1.40(11) | 1.29(11) |
| ( 2, 0)                 | 1.91(12) | 1.58(12) | 9.77(13) | 8.00(13) | 7.01(13) |
| ( 2, 1)                 | 5.89(12) | 4.94(12) | 3.05(12) | 2.48(12) | 2.17(12) |
| ( 2, 2)                 | 9.45(12) | 7.86(12) | 4.83(12) | 3.94(12) | 3.45(12) |
| ( 2, 3)                 | 1.28(11) | 1.05(11) | 6.39(12) | 5.21(12) | 4.57(12) |
| ( 2, 4)                 | 1.59(11) | 1.29(11) | 7.72(12) | 6.29(12) | 5.53(12) |
| ( 2, 5)                 | 1.88(11) | 1.51(11) | 8.78(12) | 7.14(12) | 6.29(12) |

Table 15: Same as Table 15 for  $C^+ + H_2(v = 1, j = 0) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 2.21(11) | 1.66(11) | 1.14(11) | 9.26(12) | 7.73(12) |
| (0, 1)                  | 4.38(11) | 3.28(11) | 2.18(11) | 1.75(11) | 1.46(11) |
| (0, 2)                  | 6.48(11) | 4.87(11) | 3.19(11) | 2.57(11) | 2.14(11) |
| (0, 3)                  | 8.51(11) | 6.41(11) | 4.10(11) | 3.27(11) | 2.72(11) |
| (0, 4)                  | 1.04(10) | 7.88(11) | 4.83(11) | 3.81(11) | 3.16(11) |
| (0, 5)                  | 1.23(10) | 9.22(11) | 5.32(11) | 4.16(11) | 3.45(11) |
| (0, 6)                  | 1.39(10) | 1.02(10) | 5.42(11) | 4.23(11) | 3.53(11) |
| (0, 7)                  | 1.44(10) | 9.85(11) | 4.91(11) | 3.95(11) | 3.36(11) |
| (0, 8)                  | 5.55(12) | 1.50(11) | 2.97(11) | 3.00(11) | 2.76(11) |
| (0, 9)                  | 5.08(15) | 4.08(13) | 1.38(11) | 2.00(11) | 2.06(11) |
| (0,10)                  | 2.47(18) | 8.34(15) | 5.60(12) | 1.21(11) | 1.42(11) |
| (0,11)                  | 6.80(22) | 8.34(17) | 1.79(12) | 6.60(12) | 9.08(12) |
| (0,12)                  | 4.61(22) | 5.66(17) | 1.27(12) | 5.00(12) | 7.10(12) |
| (0,13)                  | 4.94(23) | 6.07(18) | 3.27(13) | 2.25(12) | 3.80(12) |
| (0,14)                  | 5.24(34) | 6.90(23) | 8.21(14) | 1.04(12) | 2.05(12) |
| (0,15)                  | 6.92(35) | 9.12(24) | 2.07(14) | 3.98(13) | 8.91(13) |
| (0,16)                  | 2.79(42) | 3.91(27) | 7.19(15) | 1.93(13) | 4.62(13) |
| (0,17)                  | 2.43(44) | 3.41(29) | 3.86(16) | 1.77(14) | 4.96(14) |
| (0,18)                  | 1.44(52) | 2.15(32) | 1.48(16) | 7.35(15) | 2.09(14) |
| (0,19)                  | 1.82(62) | 3.03(37) | 6.97(17) | 2.75(14) | 1.88(13) |
| (0,20)                  | 2.44(63) | 4.06(38) | 1.55(17) | 1.08(14) | 9.06(14) |
| (1, 0)                  | 5.50(35) | 7.24(24) | 8.49(15) | 1.21(13) | 2.82(13) |
| (1, 1)                  | 1.07(34) | 1.41(23) | 1.65(14) | 2.33(13) | 5.42(13) |
| (1, 2)                  | 1.53(34) | 2.01(23) | 2.36(14) | 3.37(13) | 7.87(13) |
| (1, 3)                  | 1.81(34) | 2.38(23) | 2.83(14) | 4.13(13) | 9.75(13) |
| (1, 4)                  | 1.86(34) | 2.44(23) | 2.97(14) | 4.51(13) | 1.09(12) |
| (1, 5)                  | 1.62(34) | 2.14(23) | 2.73(14) | 4.45(13) | 1.12(12) |
| (1, 6)                  | 8.27(35) | 1.09(23) | 1.74(14) | 3.58(13) | 9.90(13) |
| (1, 7)                  | 2.31(42) | 3.24(27) | 6.61(15) | 2.52(13) | 8.17(13) |
| (1, 8)                  | 1.98(42) | 2.77(27) | 5.77(15) | 2.30(13) | 7.65(13) |
| (1, 9)                  | 1.33(42) | 1.86(27) | 4.11(15) | 1.82(13) | 6.47(13) |
| (1,10)                  | 2.25(52) | 3.43(32) | 7.26(16) | 8.66(14) | 4.04(13) |
| (1,11)                  | 1.72(52) | 2.62(32) | 5.69(16) | 7.17(14) | 3.47(13) |
| (1,12)                  | 8.12(53) | 1.24(32) | 3.04(16) | 4.69(14) | 2.51(13) |
| (1,13)                  | 1.57(62) | 2.62(37) | 5.93(17) | 2.28(14) | 1.54(13) |
| (1,14)                  | 8.41(63) | 1.40(37) | 3.44(17) | 1.52(14) | 1.10(13) |
| (1,15)                  | 8.41(63) | 1.40(37) | 3.44(17) | 1.52(14) | 1.10(13) |
| (2, 0)                  | 1.15(63) | 1.91(38) | 4.35(18) | 1.69(15) | 1.15(14) |
| (2, 1)                  | 2.20(63) | 3.66(38) | 8.34(18) | 3.24(15) | 2.20(14) |
| (2, 2)                  | 2.99(63) | 4.99(38) | 1.15(17) | 4.55(15) | 3.12(14) |
| (2, 3)                  | 3.39(63) | 5.65(38) | 1.32(17) | 5.41(15) | 3.77(14) |
| (2, 4)                  | 3.22(63) | 5.37(38) | 1.31(17) | 5.69(15) | 4.09(14) |
| (2, 5)                  | 1.53(63) | 2.55(38) | 7.84(18) | 4.54(15) | 3.61(14) |

Table 16: Same as Table 15 for  $C^+ + H_2(v = 1, j = 1) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| ( 0, 0)                 | 1.35(11) | 1.03(11) | 7.61(12) | 6.34(12) | 5.42(12) |
| ( 0, 1)                 | 3.72(11) | 2.80(11) | 2.01(11) | 1.64(11) | 1.39(11) |
| ( 0, 2)                 | 6.00(11) | 4.54(11) | 3.18(11) | 2.58(11) | 2.19(11) |
| ( 0, 3)                 | 8.20(11) | 6.21(11) | 4.23(11) | 3.40(11) | 2.87(11) |
| ( 0, 4)                 | 1.03(10) | 7.82(11) | 5.11(11) | 4.05(11) | 3.42(11) |
| ( 0, 5)                 | 1.23(10) | 9.33(11) | 5.76(11) | 4.51(11) | 3.80(11) |
| ( 0, 6)                 | 1.42(10) | 1.06(10) | 6.04(11) | 4.69(11) | 3.97(11) |
| ( 0, 7)                 | 1.56(10) | 1.12(10) | 5.80(11) | 4.53(11) | 3.88(11) |
| ( 0, 8)                 | 1.11(10) | 7.67(11) | 4.53(11) | 3.84(11) | 3.44(11) |
| ( 0, 9)                 | 2.52(13) | 2.92(12) | 2.13(11) | 2.56(11) | 2.59(11) |
| ( 0,10)                 | 5.05(17) | 4.09(14) | 8.34(12) | 1.55(11) | 1.83(11) |
| ( 0,11)                 | 7.96(21) | 2.88(16) | 2.22(12) | 7.77(12) | 1.14(11) |
| ( 0,12)                 | 5.31(22) | 6.52(17) | 1.43(12) | 5.80(12) | 9.06(12) |
| ( 0,13)                 | 5.31(22) | 6.52(17) | 1.43(12) | 5.80(12) | 9.06(12) |
| ( 0,14)                 | 5.31(22) | 6.52(17) | 1.43(12) | 5.80(12) | 9.06(12) |
| ( 0,15)                 | 5.31(22) | 6.52(17) | 1.43(12) | 5.80(12) | 9.06(12) |
| ( 0,16)                 | 5.31(22) | 6.52(17) | 1.43(12) | 5.80(12) | 9.06(12) |
| ( 0,17)                 | 5.31(22) | 6.52(17) | 1.43(12) | 5.80(12) | 9.06(12) |
| ( 0,18)                 | 5.31(22) | 6.52(17) | 1.43(12) | 5.80(12) | 9.06(12) |
| ( 0,19)                 | 5.31(22) | 6.52(17) | 1.43(12) | 5.80(12) | 9.06(12) |
| ( 0,20)                 | 5.46(63) | 9.11(38) | 2.60(17) | 1.46(14) | 1.22(13) |
| ( 1, 0)                 | 5.95(25) | 7.32(20) | 1.24(14) | 1.13(13) | 2.32(13) |
| ( 1, 1)                 | 1.19(23) | 1.46(18) | 5.34(14) | 3.42(13) | 6.49(13) |
| ( 1, 2)                 | 5.35(23) | 6.57(18) | 1.70(13) | 7.80(13) | 1.30(12) |
| ( 1, 3)                 | 5.95(24) | 7.30(19) | 4.97(14) | 5.00(13) | 1.09(12) |
| ( 1, 4)                 | 1.68(32) | 2.18(22) | 4.40(14) | 5.42(13) | 1.23(12) |
| ( 1, 5)                 | 1.60(32) | 2.08(22) | 4.29(14) | 5.53(13) | 1.29(12) |
| ( 1, 6)                 | 1.23(32) | 1.60(22) | 3.48(14) | 4.95(13) | 1.23(12) |
| ( 1, 7)                 | 2.42(42) | 3.40(27) | 6.91(15) | 2.62(13) | 8.55(13) |
| ( 1, 8)                 | 2.16(42) | 3.03(27) | 6.25(15) | 2.46(13) | 8.21(13) |
| ( 1, 9)                 | 1.65(42) | 2.32(27) | 4.96(15) | 2.09(13) | 7.30(13) |
| ( 1,10)                 | 6.08(43) | 8.53(28) | 2.29(15) | 1.33(13) | 5.37(13) |
| ( 1,11)                 | 6.08(43) | 8.53(28) | 2.29(15) | 1.33(13) | 5.37(13) |
| ( 1,12)                 | 6.08(43) | 8.53(28) | 2.29(15) | 1.33(13) | 5.37(13) |
| ( 1,13)                 | 6.08(43) | 8.53(28) | 2.29(15) | 1.33(13) | 5.37(13) |
| ( 1,14)                 | 6.08(43) | 8.53(28) | 2.29(15) | 1.33(13) | 5.37(13) |
| ( 1,15)                 | 6.08(43) | 8.53(28) | 2.29(15) | 1.33(13) | 5.37(13) |
| ( 2, 0)                 | 8.56(64) | 1.43(38) | 3.21(18) | 1.26(15) | 8.92(15) |
| ( 2, 1)                 | 2.13(63) | 3.56(38) | 8.01(18) | 3.10(15) | 2.16(14) |
| ( 2, 2)                 | 3.20(63) | 5.33(38) | 1.20(17) | 4.71(15) | 3.31(14) |
| ( 2, 3)                 | 3.90(63) | 6.49(38) | 1.48(17) | 5.92(15) | 4.21(14) |
| ( 2, 4)                 | 4.06(63) | 6.77(38) | 1.58(17) | 6.58(15) | 4.78(14) |
| ( 2, 5)                 | 3.49(63) | 5.81(38) | 1.42(17) | 6.45(15) | 4.90(14) |

Table 17: Same as Table 15 for  $C^+ + H_2(v = 1, j = 2) \rightarrow H^+ + CH(v', j')$  transitions.

| $T [K]$<br>$(v', j')$ | 50       | 100      | 500      | 1000     | 1500     |
|-----------------------|----------|----------|----------|----------|----------|
| (0, 0)                | 1.04(11) | 7.74(12) | 5.81(12) | 5.06(12) | 4.43(12) |
| (0, 1)                | 3.03(11) | 2.24(11) | 1.66(11) | 1.43(11) | 1.24(11) |
| (0, 2)                | 4.89(11) | 3.65(11) | 2.68(11) | 2.29(11) | 1.99(11) |
| (0, 3)                | 6.67(11) | 5.01(11) | 3.62(11) | 3.06(11) | 2.65(11) |
| (0, 4)                | 8.38(11) | 6.32(11) | 4.45(11) | 3.72(11) | 3.21(11) |
| (0, 5)                | 9.99(11) | 7.56(11) | 5.13(11) | 4.22(11) | 3.63(11) |
| (0, 6)                | 1.15(10) | 8.73(11) | 5.60(11) | 4.53(11) | 3.89(11) |
| (0, 7)                | 1.29(10) | 9.68(11) | 5.74(11) | 4.60(11) | 3.96(11) |
| (0, 8)                | 1.39(10) | 9.96(11) | 5.37(11) | 4.34(11) | 3.78(11) |
| (0, 9)                | 7.37(11) | 5.60(11) | 3.93(11) | 3.54(11) | 3.25(11) |
| (0,10)                | 3.29(14) | 1.07(12) | 1.68(11) | 2.25(11) | 2.37(11) |
| (0,11)                | 5.33(18) | 1.22(14) | 6.16(12) | 1.30(11) | 1.61(11) |
| (0,12)                | 6.65(22) | 8.16(17) | 1.74(12) | 6.68(12) | 1.01(11) |
| (0,13)                | 4.18(22) | 5.13(17) | 1.14(12) | 4.80(12) | 7.72(12) |
| (0,14)                | 2.84(24) | 3.49(19) | 1.53(13) | 1.80(12) | 4.00(12) |
| (0,15)                | 3.35(32) | 4.34(22) | 9.16(14) | 1.23(12) | 2.93(12) |
| (0,16)                | 3.35(32) | 4.34(22) | 9.16(14) | 1.23(12) | 2.93(12) |
| (0,17)                | 4.23(42) | 5.90(27) | 1.20(14) | 4.59(13) | 1.51(12) |
| (0,18)                | 2.08(42) | 2.90(27) | 6.36(15) | 2.84(13) | 1.02(12) |
| (0,19)                | 2.56(52) | 3.92(32) | 8.48(16) | 1.07(13) | 5.27(13) |
| (0,20)                | 5.11(53) | 7.81(33) | 2.37(16) | 4.76(14) | 2.88(13) |
| (1, 0)                | 1.42(23) | 1.75(18) | 4.03(14) | 1.81(13) | 3.01(13) |
| (1, 1)                | 3.55(23) | 4.36(18) | 1.02(13) | 4.71(13) | 7.97(13) |
| (1, 2)                | 4.26(23) | 5.22(18) | 1.30(13) | 6.59(13) | 1.16(12) |
| (1, 3)                | 1.67(32) | 2.18(22) | 4.34(14) | 5.17(13) | 1.14(12) |
| (1, 4)                | 1.92(32) | 2.50(22) | 5.02(14) | 6.05(13) | 1.34(12) |
| (1, 5)                | 1.99(32) | 2.59(22) | 5.25(14) | 6.48(13) | 1.46(12) |
| (1, 6)                | 1.84(32) | 2.39(22) | 4.96(14) | 6.38(13) | 1.48(12) |
| (1, 7)                | 1.38(32) | 1.80(22) | 3.93(14) | 5.56(13) | 1.36(12) |
| (1, 8)                | 2.67(42) | 3.74(27) | 7.56(15) | 2.83(13) | 9.16(13) |
| (1, 9)                | 2.28(42) | 3.20(27) | 6.58(15) | 2.56(13) | 8.50(13) |
| (1,10)                | 2.28(42) | 3.20(27) | 6.58(15) | 2.56(13) | 8.50(13) |
| (1,11)                | 1.60(42) | 2.25(27) | 4.83(15) | 2.05(13) | 7.20(13) |
| (1,12)                | 3.16(45) | 4.48(30) | 7.51(16) | 8.96(14) | 4.27(13) |
| (1,13)                | 1.72(52) | 2.63(32) | 5.72(16) | 7.29(14) | 3.61(13) |
| (1,14)                | 7.56(53) | 1.16(32) | 2.88(16) | 4.60(14) | 2.56(13) |
| (1,15)                | 1.49(62) | 2.48(37) | 5.64(17) | 2.24(14) | 1.58(13) |
| (2, 0)                | 2.84(62) | 4.74(37) | 1.19(16) | 5.94(14) | 4.85(13) |
| (2, 1)                | 8.84(64) | 1.47(38) | 3.28(18) | 1.25(15) | 8.55(15) |
| (2, 2)                | 2.40(63) | 3.98(38) | 8.89(18) | 3.36(15) | 2.31(14) |
| (2, 3)                | 3.71(63) | 6.16(38) | 1.38(17) | 5.25(15) | 3.62(14) |
| (2, 4)                | 4.74(63) | 7.87(38) | 1.77(17) | 6.80(15) | 4.72(14) |
| (2, 5)                | 5.33(63) | 8.85(38) | 2.01(17) | 7.87(15) | 5.52(14) |

Table 18: Same as Table 15 for  $C^+ + H_2(v = 1, j = 3) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 9.38(12) | 6.83(12) | 4.97(12) | 4.40(12) | 3.90(12) |
| (0, 1)                  | 2.78(11) | 2.02(11) | 1.46(11) | 1.28(11) | 1.13(11) |
| (0, 2)                  | 4.45(11) | 3.27(11) | 2.38(11) | 2.08(11) | 1.83(11) |
| (0, 3)                  | 6.03(11) | 4.47(11) | 3.24(11) | 2.81(11) | 2.46(11) |
| (0, 4)                  | 7.53(11) | 5.63(11) | 4.02(11) | 3.45(11) | 3.01(11) |
| (0, 5)                  | 8.95(11) | 6.74(11) | 4.71(11) | 3.97(11) | 3.45(11) |
| (0, 6)                  | 1.03(10) | 7.80(11) | 5.26(11) | 4.36(11) | 3.77(11) |
| (0, 7)                  | 1.15(10) | 8.79(11) | 5.63(11) | 4.57(11) | 3.95(11) |
| (0, 8)                  | 1.27(10) | 9.61(11) | 5.71(11) | 4.57(11) | 3.94(11) |
| (0, 9)                  | 1.35(10) | 9.97(11) | 5.35(11) | 4.28(11) | 3.73(11) |
| (0,10)                  | 1.05(10) | 7.23(11) | 4.08(11) | 3.52(11) | 3.20(11) |
| (0,11)                  | 8.12(14) | 1.43(12) | 1.65(11) | 2.17(11) | 2.27(11) |
| (0,12)                  | 6.01(18) | 1.18(14) | 5.68(12) | 1.21(11) | 1.50(11) |
| (0,13)                  | 5.85(22) | 7.17(17) | 1.54(12) | 6.04(12) | 9.24(12) |
| (0,14)                  | 3.33(22) | 4.08(17) | 9.32(13) | 4.09(12) | 6.74(12) |
| (0,15)                  | 4.87(32) | 6.31(22) | 1.27(13) | 1.56(12) | 3.53(12) |
| (0,16)                  | 2.36(32) | 3.06(22) | 6.72(14) | 9.71(13) | 2.42(12) |
| (0,17)                  | 3.35(42) | 4.70(27) | 9.75(15) | 3.87(13) | 1.30(12) |
| (0,18)                  | 9.46(43) | 1.33(27) | 3.44(15) | 1.93(13) | 7.68(13) |
| (0,19)                  | 1.91(52) | 2.92(32) | 6.46(16) | 8.53(14) | 4.33(13) |
| (0,20)                  | 7.39(41) | 5.19(26) | 2.45(14) | 6.94(13) | 2.21(12) |
| (1, 0)                  | 2.20(23) | 2.69(18) | 5.86(14) | 2.34(13) | 3.63(13) |
| (1, 1)                  | 6.31(23) | 7.74(18) | 1.68(13) | 6.67(13) | 1.03(12) |
| (1, 2)                  | 9.51(23) | 1.17(17) | 2.54(13) | 1.03(12) | 1.60(12) |
| (1, 3)                  | 1.12(22) | 1.38(17) | 3.05(13) | 1.27(12) | 2.02(12) |
| (1, 4)                  | 1.10(22) | 1.35(17) | 3.10(13) | 1.36(12) | 2.25(12) |
| (1, 5)                  | 7.68(23) | 9.43(18) | 2.39(13) | 1.23(12) | 2.18(12) |
| (1, 6)                  | 2.47(32) | 3.22(22) | 6.44(14) | 7.75(13) | 1.73(12) |
| (1, 7)                  | 2.25(32) | 2.93(22) | 5.97(14) | 7.45(13) | 1.70(12) |
| (1, 8)                  | 1.77(32) | 2.31(22) | 4.87(14) | 6.52(13) | 1.56(12) |
| (1, 9)                  | 8.08(33) | 1.05(22) | 2.63(14) | 4.53(13) | 1.22(12) |
| (1,10)                  | 2.38(42) | 3.34(27) | 6.87(15) | 2.67(13) | 8.86(13) |
| (1,11)                  | 1.67(42) | 2.35(27) | 5.03(15) | 2.13(13) | 7.42(13) |
| (1,12)                  | 8.86(44) | 1.24(28) | 9.77(16) | 9.61(14) | 4.42(13) |
| (1,13)                  | 1.70(52) | 2.59(32) | 5.62(16) | 7.13(14) | 3.52(13) |
| (1,14)                  | 5.79(53) | 8.85(33) | 2.33(16) | 4.03(14) | 2.31(13) |
| (1,15)                  | 1.30(62) | 2.17(37) | 5.01(17) | 2.03(14) | 1.45(13) |
| (2, 0)                  | 6.98(54) | 1.07(33) | 2.33(17) | 3.08(15) | 1.66(14) |
| (2, 1)                  | 1.88(53) | 2.88(33) | 6.31(17) | 8.18(15) | 4.10(14) |
| (2, 2)                  | 2.68(53) | 4.09(33) | 9.11(17) | 1.22(14) | 6.23(14) |
| (2, 3)                  | 2.90(53) | 4.42(33) | 1.02(16) | 1.46(14) | 7.70(14) |
| (2, 4)                  | 1.54(53) | 2.35(33) | 6.78(17) | 1.29(14) | 7.62(14) |

Table 19: Same as Table 15 for  $C^+ + H_2(v = 1, j = 4) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 7.78(12) | 5.56(12) | 4.11(12) | 3.77(12) | 3.41(12) |
| (0, 1)                  | 2.36(11) | 1.68(11) | 1.24(11) | 1.13(11) | 1.02(11) |
| (0, 2)                  | 3.75(11) | 2.71(11) | 2.02(11) | 1.84(11) | 1.66(11) |
| (0, 3)                  | 5.03(11) | 3.68(11) | 2.78(11) | 2.52(11) | 2.25(11) |
| (0, 4)                  | 6.23(11) | 4.60(11) | 3.49(11) | 3.13(11) | 2.79(11) |
| (0, 5)                  | 7.36(11) | 5.49(11) | 4.15(11) | 3.68(11) | 3.26(11) |
| (0, 6)                  | 8.42(11) | 6.34(11) | 4.74(11) | 4.13(11) | 3.64(11) |
| (0, 7)                  | 9.40(11) | 7.14(11) | 5.22(11) | 4.46(11) | 3.90(11) |
| (0, 8)                  | 1.03(10) | 7.89(11) | 5.55(11) | 4.64(11) | 4.03(11) |
| (0, 9)                  | 1.11(10) | 8.54(11) | 5.65(11) | 4.63(11) | 4.00(11) |
| (0,10)                  | 1.18(10) | 8.96(11) | 5.41(11) | 4.37(11) | 3.79(11) |
| (0,11)                  | 1.15(10) | 8.25(11) | 4.57(11) | 3.77(11) | 3.33(11) |
| (0,12)                  | 1.94(12) | 7.21(12) | 2.22(11) | 2.45(11) | 2.42(11) |
| (0,13)                  | 7.04(17) | 3.89(14) | 6.94(12) | 1.28(11) | 1.52(11) |
| (0,14)                  | 5.24(22) | 6.43(17) | 1.39(12) | 5.51(12) | 8.50(12) |
| (0,15)                  | 3.00(22) | 3.69(17) | 8.45(13) | 3.74(12) | 6.20(12) |
| (0,16)                  | 3.00(22) | 3.69(17) | 8.45(13) | 3.74(12) | 6.20(12) |
| (0,17)                  | 4.49(32) | 5.81(22) | 1.17(13) | 1.44(12) | 3.25(12) |
| (0,18)                  | 2.08(32) | 2.69(22) | 5.93(14) | 8.65(13) | 2.17(12) |
| (0,19)                  | 2.82(42) | 3.99(27) | 8.35(15) | 3.36(13) | 1.14(12) |
| (0,20)                  | 4.50(43) | 6.39(28) | 2.06(15) | 1.43(13) | 6.16(13) |
| (1, 0)                  | 1.43(20) | 1.41(16) | 1.77(13) | 4.12(13) | 5.28(13) |
| (1, 1)                  | 2.04(20) | 2.58(16) | 4.59(13) | 1.13(12) | 1.48(12) |
| (1, 2)                  | 5.74(21) | 1.69(16) | 5.57(13) | 1.57(12) | 2.16(12) |
| (1, 3)                  | 1.58(22) | 1.94(17) | 4.15(13) | 1.61(12) | 2.44(12) |
| (1, 4)                  | 1.81(22) | 2.22(17) | 4.78(13) | 1.88(12) | 2.88(12) |
| (1, 5)                  | 1.86(22) | 2.28(17) | 4.97(13) | 2.00(12) | 3.13(12) |
| (1, 6)                  | 1.70(22) | 2.08(17) | 4.64(13) | 1.96(12) | 3.15(12) |
| (1, 7)                  | 1.22(22) | 1.50(17) | 3.57(13) | 1.68(12) | 2.87(12) |
| (1, 8)                  | 2.86(32) | 3.72(22) | 7.42(14) | 8.90(13) | 1.98(12) |
| (1, 9)                  | 2.43(32) | 3.15(22) | 6.40(14) | 7.99(13) | 1.83(12) |
| (1,10)                  | 1.65(32) | 2.14(22) | 4.58(14) | 6.31(13) | 1.54(12) |
| (1,11)                  | 1.66(32) | 2.14(22) | 4.58(14) | 6.31(13) | 1.54(12) |
| (1,12)                  | 2.55(42) | 3.62(27) | 7.40(15) | 2.83(13) | 9.29(13) |
| (1,13)                  | 1.88(42) | 2.67(27) | 5.62(15) | 2.29(13) | 7.83(13) |
| (1,14)                  | 7.31(43) | 1.04(27) | 2.59(15) | 1.38(13) | 5.43(13) |
| (1,15)                  | 1.71(52) | 2.58(32) | 5.59(16) | 7.08(14) | 3.50(13) |
| (2, 0)                  | 3.07(52) | 4.69(32) | 1.14(15) | 1.86(13) | 1.09(12) |
| (2, 1)                  | 9.65(54) | 1.47(33) | 3.12(17) | 3.75(15) | 1.78(14) |
| (2, 2)                  | 2.78(53) | 4.25(33) | 8.99(17) | 1.08(14) | 5.13(14) |
| (2, 3)                  | 4.32(53) | 6.59(33) | 1.40(16) | 1.69(14) | 8.07(14) |
| (2, 4)                  | 5.49(53) | 8.39(33) | 1.79(16) | 2.18(14) | 1.05(13) |
| (2, 5)                  | 6.12(53) | 9.35(33) | 2.01(16) | 2.51(14) | 1.23(13) |

Table 20: Same as Table 15 for  $C^+ + H_2(v = 1, j = 5) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 1)                  | 2.02(11) | 1.41(11) | 9.84(12) | 9.27(12) | 8.60(12) |
| (0, 2)                  | 3.19(11) | 2.25(11) | 1.61(11) | 1.52(11) | 1.41(11) |
| (0, 3)                  | 4.24(11) | 3.03(11) | 2.21(11) | 2.08(11) | 1.92(11) |
| (0, 4)                  | 5.20(11) | 3.77(11) | 2.80(11) | 2.61(11) | 2.40(11) |
| (0, 5)                  | 6.10(11) | 4.47(11) | 3.35(11) | 3.11(11) | 2.84(11) |
| (0, 6)                  | 6.94(11) | 5.14(11) | 3.88(11) | 3.55(11) | 3.22(11) |
| (0, 7)                  | 7.71(11) | 5.77(11) | 4.36(11) | 3.93(11) | 3.53(11) |
| (0, 8)                  | 8.42(11) | 6.37(11) | 4.76(11) | 4.22(11) | 3.76(11) |
| (0, 9)                  | 9.06(11) | 6.92(11) | 5.06(11) | 4.38(11) | 3.87(11) |
| (0,10)                  | 9.64(11) | 7.43(11) | 5.20(11) | 4.39(11) | 3.85(11) |
| (0,11)                  | 1.01(10) | 7.82(11) | 5.09(11) | 4.20(11) | 3.67(11) |
| (0,12)                  | 1.04(10) | 7.84(11) | 4.60(11) | 3.75(11) | 3.30(11) |
| (0,13)                  | 6.57(11) | 4.85(11) | 3.19(11) | 2.84(11) | 2.62(11) |
| (0,14)                  | 6.36(15) | 3.34(13) | 9.83(12) | 1.47(11) | 1.63(11) |
| (0,15)                  | 4.94(20) | 7.50(16) | 2.13(12) | 6.35(12) | 9.04(12) |
| (0,16)                  | 3.12(22) | 3.83(17) | 8.62(13) | 3.70(12) | 6.04(12) |
| (0,17)                  | 1.90(23) | 2.33(18) | 1.54(13) | 1.48(12) | 3.20(12) |
| (0,18)                  | 2.12(32) | 2.75(22) | 5.97(14) | 8.45(13) | 2.09(12) |
| (0,19)                  | 2.69(42) | 3.78(27) | 7.83(15) | 3.12(13) | 1.06(12) |
| (0,20)                  | 4.55(43) | 6.38(28) | 1.96(15) | 1.32(13) | 5.64(13) |
| (1, 0)                  | 1.02(13) | 3.69(13) | 9.33(13) | 9.71(13) | 9.42(13) |
| (1, 1)                  | 5.69(14) | 5.35(13) | 2.50(12) | 2.75(12) | 2.71(12) |
| (1, 2)                  | 4.58(14) | 5.21(13) | 3.46(12) | 4.08(12) | 4.12(12) |
| (1, 3)                  | 5.46(15) | 2.01(13) | 3.55(12) | 4.76(12) | 5.03(12) |
| (1, 4)                  | 1.24(16) | 3.75(14) | 2.99(12) | 4.79(12) | 5.38(12) |
| (1, 5)                  | 5.69(18) | 7.34(15) | 2.26(12) | 4.40(12) | 5.32(12) |
| (1, 6)                  | 5.38(20) | 7.04(16) | 1.38(12) | 3.57(12) | 4.78(12) |
| (1, 7)                  | 2.44(22) | 3.00(17) | 6.48(13) | 2.56(12) | 3.96(12) |
| (1, 8)                  | 2.14(22) | 2.63(17) | 5.79(13) | 2.38(12) | 3.78(12) |
| (1, 9)                  | 1.54(22) | 1.90(17) | 4.39(13) | 1.97(12) | 3.30(12) |
| (1,10)                  | 2.96(32) | 3.84(22) | 7.69(14) | 9.28(13) | 2.07(12) |
| (1,11)                  | 2.33(32) | 3.02(22) | 6.19(14) | 7.85(13) | 1.82(12) |
| (1,12)                  | 1.27(32) | 1.65(22) | 3.69(14) | 5.47(13) | 1.39(12) |
| (1,13)                  | 2.29(42) | 3.20(27) | 6.54(15) | 2.54(13) | 8.47(13) |
| (1,14)                  | 1.33(42) | 1.86(27) | 4.03(15) | 1.77(13) | 6.39(13) |
| (1,15)                  | 1.79(52) | 2.73(32) | 5.88(16) | 7.33(14) | 3.58(13) |
| (2, 0)                  | 9.49(44) | 1.33(28) | 2.73(16) | 1.06(14) | 3.53(14) |
| (2, 1)                  | 2.76(43) | 3.88(28) | 7.94(16) | 3.09(14) | 1.03(13) |
| (2, 2)                  | 4.15(43) | 5.82(28) | 1.20(15) | 4.73(14) | 1.59(13) |
| (2, 3)                  | 4.94(43) | 6.93(28) | 1.45(15) | 5.89(14) | 2.02(13) |
| (2, 4)                  | 4.98(43) | 6.99(28) | 1.50(15) | 6.44(14) | 2.28(13) |
| (2, 5)                  | 3.67(43) | 5.15(28) | 1.21(15) | 5.96(14) | 2.26(13) |

Table 21: Same as Table 15 for  $C^+ + H_2(v = 1, j = 6) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 5.10(12) | 3.53(12) | 2.47(12) | 2.41(12) | 2.30(12) |
| (0, 1)                  | 1.58(11) | 1.09(11) | 7.55(12) | 7.34(12) | 6.99(12) |
| (0, 2)                  | 2.49(11) | 1.74(11) | 1.23(11) | 1.20(11) | 1.15(11) |
| (0, 3)                  | 3.30(11) | 2.33(11) | 1.70(11) | 1.66(11) | 1.58(11) |
| (0, 4)                  | 4.03(11) | 2.89(11) | 2.14(11) | 2.09(11) | 1.98(11) |
| (0, 5)                  | 4.70(11) | 3.41(11) | 2.57(11) | 2.50(11) | 2.36(11) |
| (0, 6)                  | 5.31(11) | 3.90(11) | 2.99(11) | 2.88(11) | 2.71(11) |
| (0, 7)                  | 5.88(11) | 4.37(11) | 3.39(11) | 3.23(11) | 3.01(11) |
| (0, 8)                  | 6.41(11) | 4.81(11) | 3.76(11) | 3.54(11) | 3.27(11) |
| (0, 9)                  | 6.88(11) | 5.22(11) | 4.08(11) | 3.78(11) | 3.46(11) |
| (0, 10)                 | 7.30(11) | 5.61(11) | 4.34(11) | 3.94(11) | 3.56(11) |
| (0, 11)                 | 7.68(11) | 5.96(11) | 4.50(11) | 3.97(11) | 3.56(11) |
| (0, 12)                 | 8.00(11) | 6.25(11) | 4.48(11) | 3.85(11) | 3.42(11) |
| (0, 13)                 | 8.23(11) | 6.40(11) | 4.20(11) | 3.53(11) | 3.13(11) |
| (0, 14)                 | 8.03(11) | 5.95(11) | 3.49(11) | 2.95(11) | 2.66(11) |
| (0, 15)                 | 2.74(12) | 6.99(12) | 1.66(11) | 1.84(11) | 1.86(11) |
| (0, 16)                 | 1.41(17) | 1.29(14) | 4.07(12) | 8.55(12) | 1.08(11) |
| (0, 17)                 | 3.61(22) | 4.42(17) | 9.66(13) | 3.92(12) | 6.20(12) |
| (0, 18)                 | 1.11(22) | 1.36(17) | 3.62(13) | 2.01(12) | 3.74(12) |
| (0, 19)                 | 2.39(32) | 3.11(22) | 6.52(14) | 8.73(13) | 2.11(12) |
| (0, 20)                 | 2.39(32) | 3.11(22) | 6.52(14) | 8.73(13) | 2.11(12) |
| (1, 0)                  | 5.10(12) | 3.46(12) | 1.79(12) | 1.32(12) | 1.01(12) |
| (1, 1)                  | 1.58(11) | 1.07(11) | 5.44(12) | 4.33(12) | 3.77(12) |
| (1, 2)                  | 2.48(11) | 1.69(11) | 8.60(12) | 6.86(12) | 6.00(12) |
| (1, 3)                  | 3.28(11) | 2.23(11) | 1.12(11) | 8.99(12) | 7.88(12) |
| (1, 4)                  | 3.91(11) | 2.62(11) | 1.30(11) | 1.05(11) | 9.29(12) |
| (1, 5)                  | 4.06(11) | 2.63(11) | 1.32(11) | 1.11(11) | 1.00(11) |
| (1, 6)                  | 1.76(12) | 4.99(12) | 9.63(12) | 9.85(12) | 9.55(12) |
| (1, 7)                  | 1.41(14) | 4.37(13) | 6.04(12) | 8.01(12) | 8.49(12) |
| (1, 8)                  | 2.70(17) | 1.81(14) | 3.24(12) | 5.95(12) | 7.06(12) |
| (1, 9)                  | 2.76(20) | 5.35(16) | 1.46(12) | 3.98(12) | 5.44(12) |
| (1, 10)                 | 2.57(22) | 3.15(17) | 6.82(13) | 2.72(12) | 4.24(12) |
| (1, 11)                 | 1.83(22) | 2.25(17) | 5.05(13) | 2.18(12) | 3.57(12) |
| (1, 12)                 | 1.55(23) | 1.90(18) | 1.11(13) | 1.01(12) | 2.17(12) |
| (1, 13)                 | 2.12(32) | 2.76(22) | 5.67(14) | 7.30(13) | 1.71(12) |
| (1, 14)                 | 8.06(33) | 1.05(22) | 2.55(14) | 4.32(13) | 1.17(12) |
| (1, 15)                 | 1.82(42) | 2.55(27) | 5.31(15) | 2.14(13) | 7.40(13) |
| (2, 0)                  | 8.96(34) | 1.17(23) | 2.39(15) | 3.06(14) | 7.17(14) |
| (2, 1)                  | 2.60(33) | 3.37(23) | 6.96(15) | 8.96(14) | 2.10(13) |
| (2, 2)                  | 3.71(33) | 4.83(23) | 1.01(14) | 1.34(13) | 3.20(13) |
| (2, 3)                  | 4.11(33) | 5.34(23) | 1.15(14) | 1.61(13) | 3.98(13) |
| (2, 4)                  | 2.81(33) | 3.65(23) | 8.99(15) | 1.52(13) | 4.11(13) |
| (2, 5)                  | 1.01(42) | 1.42(27) | 2.88(15) | 1.09(13) | 3.61(13) |

Table 22: Same as Table 15 for  $C^+ + H_2(v = 1, j = 7) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 4.06(12) | 2.79(12) | 1.92(12) | 1.92(12) | 1.87(12) |
| (0, 1)                  | 1.26(11) | 8.63(12) | 5.87(12) | 5.85(12) | 5.70(12) |
| (0, 2)                  | 1.97(11) | 1.37(11) | 9.57(12) | 9.59(12) | 9.36(12) |
| (0, 3)                  | 2.59(11) | 1.82(11) | 1.31(11) | 1.32(11) | 1.29(11) |
| (0, 4)                  | 3.15(11) | 2.24(11) | 1.65(11) | 1.67(11) | 1.62(11) |
| (0, 5)                  | 3.65(11) | 2.63(11) | 1.98(11) | 2.00(11) | 1.94(11) |
| (0, 6)                  | 4.11(11) | 2.99(11) | 2.30(11) | 2.31(11) | 2.24(11) |
| (0, 7)                  | 4.52(11) | 3.34(11) | 2.61(11) | 2.61(11) | 2.51(11) |
| (0, 8)                  | 4.91(11) | 3.66(11) | 2.91(11) | 2.88(11) | 2.75(11) |
| (0, 9)                  | 5.25(11) | 3.96(11) | 3.19(11) | 3.12(11) | 2.96(11) |
| (0,10)                  | 5.57(11) | 4.25(11) | 3.44(11) | 3.32(11) | 3.11(11) |
| (0,11)                  | 5.84(11) | 4.51(11) | 3.66(11) | 3.46(11) | 3.20(11) |
| (0,12)                  | 6.08(11) | 4.74(11) | 3.81(11) | 3.51(11) | 3.21(11) |
| (0,13)                  | 6.28(11) | 4.95(11) | 3.86(11) | 3.46(11) | 3.13(11) |
| (0,14)                  | 6.44(11) | 5.10(11) | 3.74(11) | 3.26(11) | 2.93(11) |
| (0,15)                  | 6.52(11) | 5.08(11) | 3.37(11) | 2.89(11) | 2.60(11) |
| (0,16)                  | 5.44(11) | 4.02(11) | 2.54(11) | 2.26(11) | 2.09(11) |
| (0,17)                  | 4.29(14) | 6.28(13) | 8.29(12) | 1.18(11) | 1.31(11) |
| (0,18)                  | 4.24(20) | 5.17(16) | 1.48(12) | 4.67(12) | 6.80(12) |
| (0,19)                  | 1.68(22) | 2.32(17) | 5.78(13) | 2.59(12) | 4.34(12) |
| (0,20)                  | 2.17(32) | 3.14(22) | 7.04(14) | 9.07(13) | 2.13(12) |
| (1, 0)                  | 4.07(12) | 2.79(12) | 1.72(12) | 1.46(12) | 1.29(12) |
| (1, 1)                  | 1.27(11) | 8.64(12) | 5.23(12) | 4.41(12) | 3.90(12) |
| (1, 2)                  | 1.98(11) | 1.37(11) | 8.40(12) | 7.10(12) | 6.27(12) |
| (1, 3)                  | 2.60(11) | 1.82(11) | 1.13(11) | 9.50(12) | 8.39(12) |
| (1, 4)                  | 3.16(11) | 2.24(11) | 1.38(11) | 1.16(11) | 1.02(11) |
| (1, 5)                  | 3.66(11) | 2.62(11) | 1.60(11) | 1.33(11) | 1.17(11) |
| (1, 6)                  | 4.11(11) | 2.96(11) | 1.76(11) | 1.45(11) | 1.28(11) |
| (1, 7)                  | 4.52(11) | 3.24(11) | 1.83(11) | 1.50(11) | 1.33(11) |
| (1, 8)                  | 4.76(11) | 3.31(11) | 1.76(11) | 1.46(11) | 1.31(11) |
| (1, 9)                  | 2.95(11) | 2.15(11) | 1.39(11) | 1.26(11) | 1.19(11) |
| (1,10)                  | 1.49(14) | 4.57(13) | 6.37(12) | 8.57(12) | 9.18(12) |
| (1,11)                  | 4.94(18) | 7.15(15) | 2.63(12) | 5.42(12) | 6.73(12) |
| (1,12)                  | 2.17(22) | 2.99(17) | 7.05(13) | 2.80(12) | 4.35(12) |
| (1,13)                  | 1.53(22) | 2.11(17) | 5.14(13) | 2.19(12) | 3.56(12) |
| (1,14)                  | 2.67(23) | 3.68(18) | 1.44(13) | 1.06(12) | 2.16(12) |
| (1,15)                  | 1.46(32) | 2.12(22) | 4.82(14) | 6.39(13) | 1.53(12) |
| (2, 0)                  | 6.53(24) | 9.02(19) | 2.19(14) | 9.28(14) | 1.50(13) |
| (2, 1)                  | 1.90(23) | 2.62(18) | 6.40(14) | 2.73(13) | 4.43(13) |
| (2, 2)                  | 2.67(23) | 3.68(18) | 9.16(14) | 4.05(13) | 6.71(13) |
| (2, 3)                  | 2.72(23) | 3.76(18) | 9.81(14) | 4.70(13) | 8.13(13) |
| (2, 4)                  | 7.96(33) | 1.16(22) | 2.53(14) | 3.07(13) | 6.86(13) |
| (2, 5)                  | 8.49(33) | 1.24(22) | 2.72(14) | 3.36(13) | 7.61(13) |

Table 23: Same as Table 15 for  $C^+ + H_2(v = 1, j = 8) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 3.59(12) | 2.43(12) | 1.55(12) | 1.51(12) | 1.46(12) |
| (0, 1)                  | 1.13(11) | 7.61(12) | 4.79(12) | 4.62(12) | 4.46(12) |
| (0, 2)                  | 1.76(11) | 1.20(11) | 7.78(12) | 7.57(12) | 7.34(12) |
| (0, 3)                  | 2.30(11) | 1.59(11) | 1.06(11) | 1.04(11) | 1.01(11) |
| (0, 4)                  | 2.78(11) | 1.94(11) | 1.34(11) | 1.32(11) | 1.28(11) |
| (0, 5)                  | 3.21(11) | 2.26(11) | 1.60(11) | 1.59(11) | 1.55(11) |
| (0, 6)                  | 3.59(11) | 2.57(11) | 1.86(11) | 1.85(11) | 1.80(11) |
| (0, 7)                  | 3.93(11) | 2.85(11) | 2.10(11) | 2.10(11) | 2.04(11) |
| (0, 8)                  | 4.25(11) | 3.11(11) | 2.34(11) | 2.34(11) | 2.26(11) |
| (0, 9)                  | 4.53(11) | 3.35(11) | 2.58(11) | 2.56(11) | 2.47(11) |
| (0,10)                  | 4.78(11) | 3.58(11) | 2.80(11) | 2.76(11) | 2.64(11) |
| (0,11)                  | 5.00(11) | 3.79(11) | 3.00(11) | 2.93(11) | 2.78(11) |
| (0,12)                  | 5.19(11) | 3.98(11) | 3.18(11) | 3.06(11) | 2.87(11) |
| (0,13)                  | 5.35(11) | 4.15(11) | 3.33(11) | 3.13(11) | 2.91(11) |
| (0,14)                  | 5.49(11) | 4.30(11) | 3.41(11) | 3.13(11) | 2.87(11) |
| (0,15)                  | 5.60(11) | 4.42(11) | 3.39(11) | 3.02(11) | 2.74(11) |
| (0,16)                  | 5.68(11) | 4.48(11) | 3.21(11) | 2.79(11) | 2.51(11) |
| (0,17)                  | 5.60(11) | 4.29(11) | 2.78(11) | 2.38(11) | 2.16(11) |
| (0,18)                  | 2.12(11) | 1.99(11) | 1.75(11) | 1.67(11) | 1.61(11) |
| (0,19)                  | 3.84(16) | 4.97(14) | 4.00(12) | 7.37(12) | 8.94(12) |
| (0,20)                  | 2.61(22) | 3.20(17) | 7.04(13) | 2.91(12) | 4.67(12) |
| (1, 0)                  | 3.60(12) | 2.44(12) | 1.50(12) | 1.32(12) | 1.20(12) |
| (1, 1)                  | 1.13(11) | 7.63(12) | 4.61(12) | 4.04(12) | 3.64(12) |
| (1, 2)                  | 1.76(11) | 1.20(11) | 7.46(12) | 6.56(12) | 5.92(12) |
| (1, 3)                  | 2.31(11) | 1.59(11) | 1.01(11) | 8.91(12) | 8.03(12) |
| (1, 4)                  | 2.79(11) | 1.94(11) | 1.26(11) | 1.11(11) | 9.97(12) |
| (1, 5)                  | 3.21(11) | 2.27(11) | 1.49(11) | 1.30(11) | 1.17(11) |
| (1, 6)                  | 3.60(11) | 2.57(11) | 1.70(11) | 1.47(11) | 1.32(11) |
| (1, 7)                  | 3.95(11) | 2.85(11) | 1.88(11) | 1.61(11) | 1.43(11) |
| (1, 8)                  | 4.26(11) | 3.11(11) | 2.01(11) | 1.70(11) | 1.50(11) |
| (1, 9)                  | 4.54(11) | 3.33(11) | 2.07(11) | 1.73(11) | 1.53(11) |
| (1,10)                  | 4.77(11) | 3.49(11) | 2.03(11) | 1.67(11) | 1.49(11) |
| (1,11)                  | 4.80(11) | 3.39(11) | 1.82(11) | 1.52(11) | 1.37(11) |
| (1,12)                  | 5.35(12) | 8.59(12) | 1.12(11) | 1.13(11) | 1.10(11) |
| (1,13)                  | 3.78(16) | 6.04(14) | 3.91(12) | 6.49(12) | 7.51(12) |
| (1,14)                  | 6.83(21) | 2.12(16) | 9.67(13) | 3.12(12) | 4.57(12) |
| (1,15)                  | 1.78(22) | 2.19(17) | 4.87(13) | 2.07(12) | 3.37(12) |
| (2, 0)                  | 1.04(19) | 3.02(16) | 1.29(13) | 2.49(13) | 3.00(13) |
| (2, 1)                  | 2.94(19) | 8.66(16) | 3.81(13) | 7.44(13) | 8.97(13) |
| (2, 2)                  | 4.94(20) | 4.53(16) | 4.80(13) | 1.05(12) | 1.32(12) |
| (2, 3)                  | 6.15(21) | 1.76(16) | 4.75(13) | 1.20(12) | 1.59(12) |
| (2, 4)                  | 9.78(23) | 1.20(17) | 2.56(13) | 9.95(13) | 1.52(12) |
| (2, 5)                  | 1.05(22) | 1.28(17) | 2.76(13) | 1.09(12) | 1.69(12) |

Table 24: Same as Table 15 for  $C^+ + H_2(v = 1, j = 9) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 2.79(12) | 1.93(12) | 1.23(12) | 1.18(12) | 1.15(12) |
| (0, 1)                  | 8.81(12) | 6.07(12) | 3.79(12) | 3.63(12) | 3.52(12) |
| (0, 2)                  | 1.38(11) | 9.56(12) | 6.14(12) | 5.94(12) | 5.78(12) |
| (0, 3)                  | 1.81(11) | 1.27(11) | 8.37(12) | 8.17(12) | 7.97(12) |
| (0, 4)                  | 2.19(11) | 1.55(11) | 1.05(11) | 1.03(11) | 1.01(11) |
| (0, 5)                  | 2.83(11) | 2.04(11) | 1.46(11) | 1.45(11) | 1.42(11) |
| (0, 6)                  | 3.10(11) | 2.26(11) | 1.65(11) | 1.65(11) | 1.62(11) |
| (0, 7)                  | 3.10(11) | 2.26(11) | 1.65(11) | 1.65(11) | 1.62(11) |
| (0, 8)                  | 3.34(11) | 2.46(11) | 1.84(11) | 1.85(11) | 1.81(11) |
| (0, 9)                  | 3.55(11) | 2.64(11) | 2.02(11) | 2.03(11) | 1.99(11) |
| (0,10)                  | 3.74(11) | 2.82(11) | 2.19(11) | 2.21(11) | 2.16(11) |
| (0,11)                  | 3.91(11) | 2.98(11) | 2.36(11) | 2.37(11) | 2.31(11) |
| (0,12)                  | 4.06(11) | 3.12(11) | 2.52(11) | 2.51(11) | 2.43(11) |
| (0,13)                  | 4.19(11) | 3.25(11) | 2.67(11) | 2.63(11) | 2.52(11) |
| (0,14)                  | 4.29(11) | 3.37(11) | 2.79(11) | 2.71(11) | 2.57(11) |
| (0,15)                  | 4.38(11) | 3.47(11) | 2.89(11) | 2.74(11) | 2.56(11) |
| (0,16)                  | 4.45(11) | 3.56(11) | 2.92(11) | 2.70(11) | 2.49(11) |
| (0,17)                  | 4.50(11) | 3.62(11) | 2.86(11) | 2.57(11) | 2.34(11) |
| (0,18)                  | 4.52(11) | 3.61(11) | 2.63(11) | 2.31(11) | 2.10(11) |
| (0,19)                  | 4.22(11) | 3.22(11) | 2.14(11) | 1.88(11) | 1.74(11) |
| (0,20)                  | 2.43(12) | 4.39(12) | 9.95(12) | 1.12(11) | 1.11(11) |
| (1, 0)                  | 2.80(12) | 1.94(12) | 1.21(12) | 1.12(12) | 1.04(12) |
| (1, 1)                  | 8.84(12) | 6.09(12) | 3.75(12) | 3.43(12) | 3.19(12) |
| (1, 2)                  | 1.38(11) | 9.59(12) | 6.06(12) | 5.57(12) | 5.19(12) |
| (1, 3)                  | 1.81(11) | 1.27(11) | 8.23(12) | 7.60(12) | 7.08(12) |
| (1, 4)                  | 2.20(11) | 1.55(11) | 1.03(11) | 9.52(12) | 8.85(12) |
| (1, 5)                  | 2.53(11) | 1.81(11) | 1.23(11) | 1.13(11) | 1.05(11) |
| (1, 6)                  | 2.84(11) | 2.05(11) | 1.41(11) | 1.30(11) | 1.20(11) |
| (1, 7)                  | 3.11(11) | 2.26(11) | 1.59(11) | 1.45(11) | 1.33(11) |
| (1, 8)                  | 3.35(11) | 2.46(11) | 1.75(11) | 1.58(11) | 1.45(11) |
| (1, 9)                  | 3.56(11) | 2.65(11) | 1.89(11) | 1.69(11) | 1.53(11) |
| (1,10)                  | 3.75(11) | 2.82(11) | 1.99(11) | 1.75(11) | 1.58(11) |
| (1,11)                  | 3.92(11) | 2.97(11) | 2.05(11) | 1.76(11) | 1.58(11) |
| (1,12)                  | 4.06(11) | 3.09(11) | 2.02(11) | 1.70(11) | 1.52(11) |
| (1,13)                  | 4.14(11) | 3.10(11) | 1.86(11) | 1.55(11) | 1.40(11) |
| (1,14)                  | 3.41(11) | 2.45(11) | 1.44(11) | 1.26(11) | 1.18(11) |
| (1,15)                  | 1.99(14) | 3.90(13) | 5.19(12) | 7.18(12) | 7.89(12) |
| (2, 0)                  | 2.78(12) | 1.87(12) | 8.84(13) | 6.98(13) | 6.13(13) |
| (2, 1)                  | 8.77(12) | 5.84(12) | 2.71(12) | 2.13(12) | 1.86(12) |
| (2, 2)                  | 1.36(11) | 9.04(12) | 4.21(12) | 3.32(12) | 2.93(12) |
| (2, 3)                  | 1.73(11) | 1.14(11) | 5.35(12) | 4.28(12) | 3.80(12) |
| (2, 4)                  | 1.90(11) | 1.24(11) | 5.95(12) | 4.90(12) | 4.43(12) |
| (2, 5)                  | 2.54(12) | 4.39(12) | 5.09(12) | 4.82(12) | 4.58(12) |

Table 25: Same as Table 15 for  $C^+ + H_2(v = 1, j = 10) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 2.12(12) | 1.53(12) | 9.80(13) | 9.51(13) | 9.33(13) |
| (0, 1)                  | 6.64(12) | 4.82(12) | 3.04(12) | 2.93(12) | 2.87(12) |
| (0, 2)                  | 1.04(11) | 7.59(12) | 4.91(12) | 4.79(12) | 4.71(12) |
| (0, 3)                  | 1.38(11) | 1.01(11) | 6.66(12) | 6.56(12) | 6.49(12) |
| (0, 4)                  | 1.69(11) | 1.23(11) | 8.34(12) | 8.29(12) | 8.22(12) |
| (0, 5)                  | 1.97(11) | 1.44(11) | 9.95(12) | 9.96(12) | 9.91(12) |
| (0, 6)                  | 2.22(11) | 1.63(11) | 1.15(11) | 1.16(11) | 1.16(11) |
| (0, 7)                  | 2.45(11) | 1.80(11) | 1.30(11) | 1.32(11) | 1.32(11) |
| (0, 8)                  | 2.64(11) | 1.96(11) | 1.45(11) | 1.47(11) | 1.47(11) |
| (0, 9)                  | 2.81(11) | 2.11(11) | 1.59(11) | 1.62(11) | 1.62(11) |
| (0,10)                  | 2.96(11) | 2.24(11) | 1.72(11) | 1.77(11) | 1.77(11) |
| (0,11)                  | 3.09(11) | 2.36(11) | 1.85(11) | 1.91(11) | 1.90(11) |
| (0,12)                  | 3.21(11) | 2.47(11) | 1.98(11) | 2.04(11) | 2.02(11) |
| (0,13)                  | 3.30(11) | 2.57(11) | 2.10(11) | 2.15(11) | 2.12(11) |
| (0,14)                  | 3.39(11) | 2.66(11) | 2.21(11) | 2.24(11) | 2.20(11) |
| (0,15)                  | 3.45(11) | 2.74(11) | 2.31(11) | 2.32(11) | 2.24(11) |
| (0,16)                  | 3.50(11) | 2.80(11) | 2.40(11) | 2.36(11) | 2.26(11) |
| (0,17)                  | 3.55(11) | 2.86(11) | 2.45(11) | 2.36(11) | 2.22(11) |
| (0,18)                  | 3.58(11) | 2.91(11) | 2.44(11) | 2.29(11) | 2.13(11) |
| (0,19)                  | 3.60(11) | 2.94(11) | 2.34(11) | 2.13(11) | 1.97(11) |
| (0,20)                  | 3.59(11) | 2.86(11) | 2.09(11) | 1.87(11) | 1.72(11) |
| (1, 0)                  | 2.13(12) | 1.54(12) | 9.78(13) | 9.24(13) | 8.83(13) |
| (1, 1)                  | 6.69(12) | 4.85(12) | 3.03(12) | 2.85(12) | 2.71(12) |
| (1, 2)                  | 1.05(11) | 7.64(12) | 4.89(12) | 4.63(12) | 4.43(12) |
| (1, 3)                  | 1.40(11) | 1.01(11) | 6.64(12) | 6.33(12) | 6.06(12) |
| (1, 4)                  | 1.71(11) | 1.24(11) | 8.29(12) | 7.94(12) | 7.60(12) |
| (1, 5)                  | 1.99(11) | 1.45(11) | 9.88(12) | 9.48(12) | 9.06(12) |
| (1, 6)                  | 2.24(11) | 1.64(11) | 1.14(11) | 1.09(11) | 1.04(11) |
| (1, 7)                  | 2.45(11) | 1.81(11) | 1.28(11) | 1.23(11) | 1.17(11) |
| (1, 8)                  | 2.65(11) | 1.97(11) | 1.42(11) | 1.36(11) | 1.29(11) |
| (1, 9)                  | 2.82(11) | 2.11(11) | 1.55(11) | 1.47(11) | 1.38(11) |
| (1,10)                  | 2.97(11) | 2.24(11) | 1.67(11) | 1.57(11) | 1.47(11) |
| (1,11)                  | 3.10(11) | 2.37(11) | 1.78(11) | 1.65(11) | 1.52(11) |
| (1,12)                  | 3.21(11) | 2.47(11) | 1.86(11) | 1.69(11) | 1.55(11) |
| (1,13)                  | 3.31(11) | 2.57(11) | 1.89(11) | 1.69(11) | 1.54(11) |
| (1,14)                  | 3.39(11) | 2.65(11) | 1.87(11) | 1.63(11) | 1.47(11) |
| (1,15)                  | 3.43(11) | 2.66(11) | 1.74(11) | 1.49(11) | 1.35(11) |
| (2, 0)                  | 2.14(12) | 1.54(12) | 9.08(13) | 7.61(13) | 6.74(13) |
| (2, 1)                  | 6.71(12) | 4.85(12) | 2.81(12) | 2.34(12) | 2.07(12) |
| (2, 2)                  | 1.06(11) | 7.65(12) | 4.49(12) | 3.74(12) | 3.31(12) |
| (2, 3)                  | 1.40(11) | 1.01(11) | 6.00(12) | 5.00(12) | 4.43(12) |
| (2, 4)                  | 1.71(11) | 1.24(11) | 7.35(12) | 6.11(12) | 5.41(12) |
| (2, 5)                  | 1.99(11) | 1.45(11) | 8.51(12) | 7.04(12) | 6.23(12) |

Table 26: Same as Table 1 for  $C^+ + H_2(v = 2, j = 0) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 4.91(12) | 3.52(12) | 2.65(12) | 2.69(12) | 2.64(12) |
| (0, 1)                  | 9.70(12) | 6.98(12) | 5.28(12) | 5.35(12) | 5.24(12) |
| (0, 2)                  | 1.43(11) | 1.03(11) | 7.88(12) | 8.01(12) | 7.85(12) |
| (0, 3)                  | 1.87(11) | 1.36(11) | 1.05(11) | 1.06(11) | 1.04(11) |
| (0, 4)                  | 2.28(11) | 1.67(11) | 1.30(11) | 1.32(11) | 1.29(11) |
| (0, 5)                  | 2.67(11) | 1.97(11) | 1.55(11) | 1.57(11) | 1.54(11) |
| (0, 6)                  | 3.04(11) | 2.25(11) | 1.79(11) | 1.82(11) | 1.78(11) |
| (0, 7)                  | 3.37(11) | 2.52(11) | 2.03(11) | 2.06(11) | 2.00(11) |
| (0, 8)                  | 3.67(11) | 2.78(11) | 2.26(11) | 2.28(11) | 2.21(11) |
| (0, 9)                  | 3.95(11) | 3.02(11) | 2.48(11) | 2.49(11) | 2.41(11) |
| (0,10)                  | 4.19(11) | 3.24(11) | 2.69(11) | 2.68(11) | 2.57(11) |
| (0,11)                  | 4.40(11) | 3.44(11) | 2.88(11) | 2.84(11) | 2.70(11) |
| (0,12)                  | 4.58(11) | 3.62(11) | 3.06(11) | 2.96(11) | 2.78(11) |
| (0,13)                  | 4.73(11) | 3.79(11) | 3.19(11) | 3.02(11) | 2.80(11) |
| (0,14)                  | 4.86(11) | 3.94(11) | 3.27(11) | 3.01(11) | 2.76(11) |
| (0,15)                  | 4.96(11) | 4.06(11) | 3.24(11) | 2.90(11) | 2.63(11) |
| (0,16)                  | 5.02(11) | 4.13(11) | 3.07(11) | 2.67(11) | 2.41(11) |
| (0,17)                  | 5.02(11) | 4.01(11) | 2.66(11) | 2.28(11) | 2.07(11) |
| (0,18)                  | 3.17(11) | 2.50(11) | 1.79(11) | 1.66(11) | 1.57(11) |
| (0,19)                  | 3.63(15) | 1.45(13) | 4.58(12) | 7.63(12) | 8.99(12) |
| (0,20)                  | 1.40(21) | 6.27(17) | 7.37(13) | 2.90(12) | 4.58(12) |
| (1, 0)                  | 4.93(12) | 3.53(12) | 2.53(12) | 2.32(12) | 2.13(12) |
| (1, 1)                  | 9.73(12) | 7.00(12) | 5.01(12) | 4.56(12) | 4.17(12) |
| (1, 2)                  | 1.43(11) | 1.04(11) | 7.47(12) | 6.81(12) | 6.22(12) |
| (1, 3)                  | 1.87(11) | 1.36(11) | 9.86(12) | 8.94(12) | 8.14(12) |
| (1, 4)                  | 2.29(11) | 1.67(11) | 1.21(11) | 1.09(11) | 9.92(12) |
| (1, 5)                  | 2.68(11) | 1.97(11) | 1.43(11) | 1.27(11) | 1.15(11) |
| (1, 6)                  | 3.04(11) | 2.26(11) | 1.62(11) | 1.43(11) | 1.28(11) |
| (1, 7)                  | 3.38(11) | 2.53(11) | 1.78(11) | 1.55(11) | 1.38(11) |
| (1, 8)                  | 3.68(11) | 2.78(11) | 1.91(11) | 1.63(11) | 1.45(11) |
| (1, 9)                  | 3.96(11) | 3.00(11) | 1.97(11) | 1.65(11) | 1.47(11) |
| (1,10)                  | 4.19(11) | 3.18(11) | 1.94(11) | 1.60(11) | 1.43(11) |
| (1,11)                  | 4.34(11) | 3.19(11) | 1.76(11) | 1.46(11) | 1.32(11) |
| (1,12)                  | 2.45(11) | 1.83(11) | 1.24(11) | 1.15(11) | 1.09(11) |
| (1,13)                  | 3.37(15) | 1.63(13) | 4.40(12) | 6.67(12) | 7.53(12) |
| (1,14)                  | 6.10(20) | 6.85(16) | 1.26(12) | 3.43(12) | 4.77(12) |
| (1,15)                  | 1.77(22) | 2.17(17) | 4.81(13) | 2.02(12) | 3.28(12) |
| (2, 0)                  | 8.03(19) | 1.01(15) | 2.34(13) | 4.31(13) | 4.96(13) |
| (2, 1)                  | 1.09(18) | 1.61(15) | 4.30(13) | 8.10(13) | 9.39(13) |
| (2, 2)                  | 3.64(19) | 1.09(15) | 5.29(13) | 1.09(12) | 1.30(12) |
| (2, 3)                  | 4.60(20) | 4.36(16) | 5.25(13) | 1.22(12) | 1.52(12) |
| (2, 4)                  | 4.36(21) | 1.29(16) | 4.28(13) | 1.20(12) | 1.59(12) |
| (2, 5)                  | 1.00(22) | 1.23(17) | 2.65(13) | 1.03(12) | 1.50(12) |

Table 27: Same as Table 26 for  $C^+ + H_2(v = 2, j = 1) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 3.06(12) | 2.19(12) | 1.69(12) | 1.75(12) | 1.74(12) |
| (0, 1)                  | 8.15(12) | 5.81(12) | 4.42(12) | 4.58(12) | 4.56(12) |
| (0, 2)                  | 1.30(11) | 9.31(12) | 7.11(12) | 7.39(12) | 7.36(12) |
| (0, 3)                  | 1.76(11) | 1.27(11) | 9.76(12) | 1.02(11) | 1.01(11) |
| (0, 4)                  | 2.19(11) | 1.59(11) | 1.24(11) | 1.29(11) | 1.28(11) |
| (0, 5)                  | 2.60(11) | 1.90(11) | 1.49(11) | 1.55(11) | 1.54(11) |
| (0, 6)                  | 2.97(11) | 2.19(11) | 1.74(11) | 1.81(11) | 1.79(11) |
| (0, 7)                  | 3.32(11) | 2.46(11) | 1.99(11) | 2.05(11) | 2.03(11) |
| (0, 8)                  | 3.64(11) | 2.72(11) | 2.22(11) | 2.29(11) | 2.24(11) |
| (0, 9)                  | 3.92(11) | 2.97(11) | 2.45(11) | 2.50(11) | 2.44(11) |
| (0,10)                  | 4.18(11) | 3.19(11) | 2.67(11) | 2.70(11) | 2.60(11) |
| (0,11)                  | 4.40(11) | 3.40(11) | 2.87(11) | 2.86(11) | 2.73(11) |
| (0,12)                  | 4.59(11) | 3.59(11) | 3.05(11) | 2.99(11) | 2.82(11) |
| (0,13)                  | 4.75(11) | 3.76(11) | 3.21(11) | 3.07(11) | 2.86(11) |
| (0,14)                  | 4.89(11) | 3.91(11) | 3.30(11) | 3.07(11) | 2.83(11) |
| (0,15)                  | 4.99(11) | 4.04(11) | 3.31(11) | 2.99(11) | 2.71(11) |
| (0,16)                  | 5.07(11) | 4.13(11) | 3.18(11) | 2.79(11) | 2.51(11) |
| (0,17)                  | 5.09(11) | 4.07(11) | 2.83(11) | 2.44(11) | 2.20(11) |
| (0,18)                  | 4.24(11) | 3.19(11) | 2.10(11) | 1.87(11) | 1.73(11) |
| (0,19)                  | 9.72(14) | 7.20(13) | 6.64(12) | 9.36(12) | 1.04(11) |
| (0,20)                  | 2.79(20) | 3.35(16) | 1.03(12) | 3.44(12) | 5.18(12) |
| (1, 0)                  | 3.07(12) | 2.20(12) | 1.62(12) | 1.51(12) | 1.39(12) |
| (1, 1)                  | 8.18(12) | 5.83(12) | 4.23(12) | 3.90(12) | 3.58(12) |
| (1, 2)                  | 1.30(11) | 9.33(12) | 6.78(12) | 6.24(12) | 5.72(12) |
| (1, 3)                  | 1.76(11) | 1.27(11) | 9.27(12) | 8.49(12) | 7.75(12) |
| (1, 4)                  | 2.20(11) | 1.59(11) | 1.17(11) | 1.06(11) | 9.64(12) |
| (1, 5)                  | 2.60(11) | 1.90(11) | 1.39(11) | 1.25(11) | 1.14(11) |
| (1, 6)                  | 2.98(11) | 2.19(11) | 1.60(11) | 1.42(11) | 1.28(11) |
| (1, 7)                  | 3.33(11) | 2.47(11) | 1.78(11) | 1.56(11) | 1.40(11) |
| (1, 8)                  | 3.65(11) | 2.73(11) | 1.92(11) | 1.66(11) | 1.48(11) |
| (1, 9)                  | 3.93(11) | 2.96(11) | 2.01(11) | 1.70(11) | 1.51(11) |
| (1,10)                  | 4.18(11) | 3.16(11) | 2.02(11) | 1.68(11) | 1.49(11) |
| (1,11)                  | 4.37(11) | 3.25(11) | 1.89(11) | 1.57(11) | 1.40(11) |
| (1,12)                  | 3.87(11) | 2.69(11) | 1.52(11) | 1.31(11) | 1.21(11) |
| (1,13)                  | 6.96(14) | 8.13(13) | 6.33(12) | 8.11(12) | 8.63(12) |
| (1,14)                  | 1.95(18) | 3.75(15) | 1.90(12) | 4.27(12) | 5.54(12) |
| (1,15)                  | 1.96(22) | 2.40(17) | 5.30(13) | 2.19(12) | 3.52(12) |
| (2, 0)                  | 5.17(17) | 5.69(15) | 2.31(13) | 3.52(13) | 3.94(13) |
| (2, 1)                  | 2.31(17) | 6.84(15) | 5.22(13) | 8.43(13) | 9.63(13) |
| (2, 2)                  | 2.06(17) | 7.08(15) | 7.18(13) | 1.23(12) | 1.44(12) |
| (2, 3)                  | 2.71(18) | 2.96(15) | 7.43(13) | 1.44(12) | 1.76(12) |
| (2, 4)                  | 5.47(20) | 5.16(16) | 6.17(13) | 1.46(12) | 1.90(12) |
| (2, 5)                  | 3.59(21) | 1.08(16) | 4.20(13) | 1.28(12) | 1.85(12) |

Table 28: Same as Table 26 for  $C^+ + H_2(v = 2, j = 2) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 2.71(12) | 1.90(12) | 1.40(12) | 1.46(12) | 1.45(12) |
| (0, 1)                  | 7.66(12) | 5.37(12) | 3.94(12) | 4.08(12) | 4.08(12) |
| (0, 2)                  | 1.22(11) | 8.61(12) | 6.41(12) | 6.67(12) | 6.67(12) |
| (0, 3)                  | 1.65(11) | 1.17(11) | 8.83(12) | 9.21(12) | 9.22(12) |
| (0, 4)                  | 2.05(11) | 1.47(11) | 1.12(11) | 1.17(11) | 1.17(11) |
| (0, 5)                  | 2.42(11) | 1.75(11) | 1.36(11) | 1.42(11) | 1.41(11) |
| (0, 6)                  | 2.77(11) | 2.02(11) | 1.59(11) | 1.65(11) | 1.65(11) |
| (0, 7)                  | 3.09(11) | 2.27(11) | 1.81(11) | 1.88(11) | 1.87(11) |
| (0, 8)                  | 3.38(11) | 2.51(11) | 2.03(11) | 2.10(11) | 2.08(11) |
| (0, 9)                  | 3.64(11) | 2.73(11) | 2.24(11) | 2.30(11) | 2.27(11) |
| (0,10)                  | 3.86(11) | 2.94(11) | 2.44(11) | 2.48(11) | 2.35(11) |
| (0,11)                  | 4.06(11) | 3.13(11) | 2.63(11) | 2.64(11) | 2.48(11) |
| (0,12)                  | 4.23(11) | 3.30(11) | 2.80(11) | 2.77(11) | 2.58(11) |
| (0,13)                  | 4.38(11) | 3.45(11) | 2.95(11) | 2.87(11) | 2.64(11) |
| (0,14)                  | 4.50(11) | 3.59(11) | 3.07(11) | 2.90(11) | 2.64(11) |
| (0,15)                  | 4.59(11) | 3.71(11) | 3.11(11) | 2.87(11) | 2.57(11) |
| (0,16)                  | 4.66(11) | 3.80(11) | 3.05(11) | 2.73(11) | 2.42(11) |
| (0,17)                  | 4.70(11) | 3.82(11) | 2.82(11) | 2.46(11) | 2.17(11) |
| (0,18)                  | 4.53(11) | 3.50(11) | 2.32(11) | 2.02(11) | 1.80(11) |
| (0,19)                  | 4.42(12) | 6.71(12) | 1.15(11) | 1.25(11) | 1.22(11) |
| (0,20)                  | 1.54(17) | 7.84(15) | 2.20(12) | 5.05(12) | 6.68(12) |
| (1, 0)                  | 2.72(12) | 1.91(12) | 1.36(12) | 1.28(12) | 1.19(12) |
| (1, 1)                  | 7.69(12) | 5.38(12) | 3.81(12) | 3.56(12) | 3.31(12) |
| (1, 2)                  | 1.22(11) | 8.63(12) | 6.18(12) | 5.78(12) | 5.35(12) |
| (1, 3)                  | 1.65(11) | 1.18(11) | 8.49(12) | 7.91(12) | 7.31(12) |
| (1, 4)                  | 2.05(11) | 1.47(11) | 1.07(11) | 9.94(12) | 9.15(12) |
| (1, 5)                  | 2.43(11) | 1.76(11) | 1.29(11) | 1.18(11) | 1.09(11) |
| (1, 6)                  | 2.78(11) | 2.03(11) | 1.49(11) | 1.36(11) | 1.24(11) |
| (1, 7)                  | 3.10(11) | 2.28(11) | 1.67(11) | 1.50(11) | 1.36(11) |
| (1, 8)                  | 3.38(11) | 2.52(11) | 1.82(11) | 1.61(11) | 1.46(11) |
| (1, 9)                  | 3.64(11) | 2.74(11) | 1.94(11) | 1.68(11) | 1.51(11) |
| (1,10)                  | 3.87(11) | 2.93(11) | 1.98(11) | 1.68(11) | 1.47(11) |
| (1,11)                  | 4.06(11) | 3.08(11) | 1.94(11) | 1.62(11) | 1.41(11) |
| (1,12)                  | 4.16(11) | 3.05(11) | 1.74(11) | 1.45(11) | 1.28(11) |
| (1,13)                  | 1.49(11) | 1.35(11) | 1.14(11) | 1.09(11) | 1.02(11) |
| (1,14)                  | 6.42(16) | 7.45(14) | 3.70(12) | 5.99(12) | 6.62(12) |
| (1,15)                  | 8.91(21) | 1.95(16) | 8.54(13) | 2.75(12) | 3.78(12) |
| (2, 0)                  | 8.06(15) | 7.66(14) | 3.75(13) | 4.31(13) | 4.40(13) |
| (2, 1)                  | 1.83(14) | 1.80(13) | 9.73(13) | 1.15(12) | 1.18(12) |
| (2, 2)                  | 3.51(15) | 1.04(13) | 1.29(12) | 1.67(12) | 1.77(12) |
| (2, 3)                  | 4.66(16) | 4.37(14) | 1.36(12) | 1.98(12) | 2.19(12) |
| (2, 4)                  | 4.67(17) | 1.45(14) | 1.25(12) | 2.09(12) | 2.43(12) |
| (2, 5)                  | 6.45(19) | 1.93(15) | 9.36(13) | 1.95(12) | 2.45(12) |

Table 29: Same as Table 1 for  $C^+ + H_2(v = 2, j = 3) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 2.58(12) | 1.78(12) | 1.27(12) | 1.31(12) | 1.31(12) |
| (0, 1)                  | 7.52(12) | 5.19(12) | 3.67(12) | 3.78(12) | 3.78(12) |
| (0, 2)                  | 1.19(11) | 8.32(12) | 6.00(12) | 6.20(12) | 6.21(12) |
| (0, 3)                  | 1.60(11) | 1.13(11) | 8.27(12) | 8.58(12) | 8.60(12) |
| (0, 4)                  | 1.98(11) | 1.41(11) | 1.05(11) | 1.09(11) | 1.10(11) |
| (0, 5)                  | 2.34(11) | 1.68(11) | 1.27(11) | 1.32(11) | 1.32(11) |
| (0, 6)                  | 2.67(11) | 1.93(11) | 1.48(11) | 1.55(11) | 1.55(11) |
| (0, 7)                  | 2.97(11) | 2.17(11) | 1.69(11) | 1.76(11) | 1.76(11) |
| (0, 8)                  | 3.24(11) | 2.40(11) | 1.90(11) | 1.97(11) | 1.96(11) |
| (0, 9)                  | 3.49(11) | 2.61(11) | 2.10(11) | 2.17(11) | 2.14(11) |
| (0,10)                  | 3.71(11) | 2.81(11) | 2.29(11) | 2.35(11) | 2.31(11) |
| (0,11)                  | 3.90(11) | 2.99(11) | 2.47(11) | 2.51(11) | 2.44(11) |
| (0,12)                  | 4.06(11) | 3.15(11) | 2.64(11) | 2.64(11) | 2.55(11) |
| (0,13)                  | 4.20(11) | 3.29(11) | 2.79(11) | 2.75(11) | 2.62(11) |
| (0,14)                  | 4.31(11) | 3.42(11) | 2.92(11) | 2.82(11) | 2.64(11) |
| (0,15)                  | 4.40(11) | 3.54(11) | 3.00(11) | 2.82(11) | 2.61(11) |
| (0,16)                  | 4.47(11) | 3.63(11) | 3.00(11) | 2.74(11) | 2.50(11) |
| (0,17)                  | 4.52(11) | 3.69(11) | 2.88(11) | 2.55(11) | 2.31(11) |
| (0,18)                  | 4.52(11) | 3.63(11) | 2.56(11) | 2.22(11) | 2.02(11) |
| (0,19)                  | 3.71(11) | 2.80(11) | 1.88(11) | 1.69(11) | 1.58(11) |
| (0,20)                  | 1.27(13) | 7.27(13) | 5.86(12) | 8.39(12) | 9.41(12) |
| (1, 0)                  | 2.59(12) | 1.79(12) | 1.24(12) | 1.18(12) | 1.10(12) |
| (1, 1)                  | 7.54(12) | 5.21(12) | 3.59(12) | 3.38(12) | 3.16(12) |
| (1, 2)                  | 1.19(11) | 8.34(12) | 5.84(12) | 5.51(12) | 5.15(12) |
| (1, 3)                  | 1.60(11) | 1.13(11) | 8.03(12) | 7.56(12) | 7.04(12) |
| (1, 4)                  | 1.99(11) | 1.41(11) | 1.02(11) | 9.52(12) | 8.84(12) |
| (1, 5)                  | 2.34(11) | 1.68(11) | 1.22(11) | 1.14(11) | 1.05(11) |
| (1, 6)                  | 2.67(11) | 1.94(11) | 1.42(11) | 1.31(11) | 1.20(11) |
| (1, 7)                  | 2.98(11) | 2.18(11) | 1.60(11) | 1.46(11) | 1.34(11) |
| (1, 8)                  | 3.25(11) | 2.41(11) | 1.77(11) | 1.59(11) | 1.45(11) |
| (1, 9)                  | 3.50(11) | 2.62(11) | 1.90(11) | 1.69(11) | 1.52(11) |
| (1,10)                  | 3.72(11) | 2.81(11) | 1.99(11) | 1.73(11) | 1.55(11) |
| (1,11)                  | 3.91(11) | 2.98(11) | 2.01(11) | 1.71(11) | 1.53(11) |
| (1,12)                  | 4.06(11) | 3.09(11) | 1.93(11) | 1.61(11) | 1.44(11) |
| (1,13)                  | 4.07(11) | 2.97(11) | 1.67(11) | 1.41(11) | 1.28(11) |
| (1,14)                  | 4.39(12) | 6.52(12) | 9.34(12) | 9.76(12) | 9.73(12) |
| (1,15)                  | 7.02(17) | 2.23(14) | 2.74(12) | 5.09(12) | 6.19(12) |
| (2, 0)                  | 2.48(12) | 1.59(12) | 7.46(13) | 6.12(13) | 5.53(13) |
| (2, 1)                  | 1.04(11) | 6.49(12) | 3.12(12) | 2.63(12) | 2.40(12) |
| (2, 2)                  | 7.08(12) | 4.47(12) | 2.08(12) | 1.71(12) | 1.55(12) |
| (2, 3)                  | 5.57(12) | 4.98(12) | 3.55(12) | 3.22(12) | 3.04(12) |
| (2, 4)                  | 4.37(13) | 1.42(12) | 3.18(12) | 3.39(12) | 3.37(12) |
| (2, 5)                  | 6.49(15) | 1.94(13) | 2.45(12) | 3.21(12) | 3.42(12) |

Table 30: Same as Table 26 for  $C^+ + H_2(v = 2, j = 4) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 2.28(12) | 1.57(12) | 1.10(12) | 1.13(12) | 1.14(12) |
| (0, 1)                  | 6.83(12) | 4.67(12) | 3.26(12) | 3.34(12) | 3.35(12) |
| (0, 2)                  | 1.07(11) | 7.44(12) | 5.31(12) | 5.48(12) | 5.52(12) |
| (0, 3)                  | 1.43(11) | 1.00(11) | 7.31(12) | 7.58(12) | 7.64(12) |
| (0, 4)                  | 1.76(11) | 1.25(11) | 9.27(12) | 9.65(12) | 9.73(12) |
| (0, 5)                  | 2.06(11) | 1.48(11) | 1.12(11) | 1.17(11) | 1.18(11) |
| (0, 6)                  | 2.35(11) | 1.70(11) | 1.31(11) | 1.37(11) | 1.38(11) |
| (0, 7)                  | 2.61(11) | 1.91(11) | 1.49(11) | 1.56(11) | 1.57(11) |
| (0, 8)                  | 2.84(11) | 2.10(11) | 1.67(11) | 1.75(11) | 1.76(11) |
| (0, 9)                  | 3.06(11) | 2.28(11) | 1.85(11) | 1.93(11) | 1.93(11) |
| (0, 10)                 | 3.25(11) | 2.45(11) | 2.02(11) | 2.10(11) | 2.09(11) |
| (0, 11)                 | 3.41(11) | 2.61(11) | 2.18(11) | 2.26(11) | 2.23(11) |
| (0, 12)                 | 3.55(11) | 2.75(11) | 2.33(11) | 2.39(11) | 2.35(11) |
| (0, 13)                 | 3.67(11) | 2.87(11) | 2.47(11) | 2.51(11) | 2.43(11) |
| (0, 14)                 | 3.77(11) | 2.98(11) | 2.60(11) | 2.59(11) | 2.48(11) |
| (0, 15)                 | 3.84(11) | 3.08(11) | 2.71(11) | 2.64(11) | 2.49(11) |
| (0, 16)                 | 3.90(11) | 3.17(11) | 2.76(11) | 2.62(11) | 2.44(11) |
| (0, 17)                 | 3.95(11) | 3.23(11) | 2.73(11) | 2.52(11) | 2.31(11) |
| (0, 18)                 | 3.98(11) | 3.26(11) | 2.58(11) | 2.31(11) | 2.11(11) |
| (0, 19)                 | 3.92(11) | 3.12(11) | 2.21(11) | 1.96(11) | 1.80(11) |
| (0, 20)                 | 2.10(11) | 1.75(11) | 1.45(11) | 1.39(11) | 1.34(11) |
| (1, 0)                  | 2.29(12) | 1.57(12) | 1.09(12) | 1.05(12) | 1.01(12) |
| (1, 1)                  | 6.85(12) | 4.69(12) | 3.22(12) | 3.10(12) | 2.95(12) |
| (1, 2)                  | 1.08(11) | 7.47(12) | 5.24(12) | 5.06(12) | 4.81(12) |
| (1, 3)                  | 1.43(11) | 1.01(11) | 7.19(12) | 6.94(12) | 6.59(12) |
| (1, 4)                  | 1.76(11) | 1.25(11) | 9.09(12) | 8.75(12) | 8.28(12) |
| (1, 5)                  | 2.07(11) | 1.48(11) | 1.09(11) | 1.05(11) | 9.88(12) |
| (1, 6)                  | 2.35(11) | 1.70(11) | 1.27(11) | 1.21(11) | 1.14(11) |
| (1, 7)                  | 2.62(11) | 1.91(11) | 1.44(11) | 1.36(11) | 1.27(11) |
| (1, 8)                  | 2.85(11) | 2.11(11) | 1.60(11) | 1.50(11) | 1.39(11) |
| (1, 9)                  | 3.07(11) | 2.29(11) | 1.75(11) | 1.61(11) | 1.48(11) |
| (1, 10)                 | 3.25(11) | 2.46(11) | 1.86(11) | 1.69(11) | 1.54(11) |
| (1, 11)                 | 3.42(11) | 2.61(11) | 1.94(11) | 1.72(11) | 1.55(11) |
| (1, 12)                 | 3.56(11) | 2.74(11) | 1.95(11) | 1.69(11) | 1.52(11) |
| (1, 13)                 | 3.67(11) | 2.82(11) | 1.86(11) | 1.58(11) | 1.42(11) |
| (1, 14)                 | 3.66(11) | 2.71(11) | 1.61(11) | 1.37(11) | 1.25(11) |
| (1, 15)                 | 6.00(12) | 7.47(12) | 9.25(12) | 9.53(12) | 9.48(12) |
| (2, 0)                  | 2.29(12) | 1.56(12) | 8.43(13) | 6.88(13) | 6.11(13) |
| (2, 1)                  | 6.86(12) | 4.63(12) | 2.45(12) | 1.99(12) | 1.76(12) |
| (2, 2)                  | 1.08(11) | 7.33(12) | 3.87(12) | 3.15(12) | 2.80(12) |
| (2, 3)                  | 1.43(11) | 9.77(12) | 5.09(12) | 4.15(12) | 3.70(12) |
| (2, 4)                  | 1.75(11) | 1.19(11) | 6.03(12) | 4.94(12) | 4.43(12) |
| (2, 5)                  | 1.98(11) | 1.30(11) | 6.47(12) | 5.40(12) | 4.91(12) |

Table 31: Same as Table 26 for  $C^+ + H_2(v = 2, j = 5) \rightarrow H^+ + CH(v', j')$  transitions.

| $T$ [K]<br>( $v', j'$ ) | 50       | 100      | 500      | 1000     | 1500     |
|-------------------------|----------|----------|----------|----------|----------|
| (0, 0)                  | 2.09(12) | 1.41(12) | 9.53(13) | 9.45(13) | 9.38(13) |
| (0, 1)                  | 6.34(12) | 4.26(12) | 2.85(12) | 2.82(12) | 2.78(12) |
| (0, 2)                  | 9.90(12) | 6.75(12) | 4.63(12) | 4.62(12) | 4.57(12) |
| (0, 3)                  | 1.31(11) | 9.02(12) | 6.35(12) | 6.37(12) | 6.33(12) |
| (0, 4)                  | 1.59(11) | 1.11(11) | 8.03(12) | 8.10(12) | 8.06(12) |
| (0, 5)                  | 1.85(11) | 1.31(11) | 9.67(12) | 9.81(12) | 9.77(12) |
| (0, 6)                  | 2.10(11) | 1.50(11) | 1.13(11) | 1.15(11) | 1.15(11) |
| (0, 7)                  | 2.32(11) | 1.68(11) | 1.28(11) | 1.31(11) | 1.31(11) |
| (0, 8)                  | 2.52(11) | 1.85(11) | 1.44(11) | 1.48(11) | 1.47(11) |
| (0, 9)                  | 2.70(11) | 2.00(11) | 1.59(11) | 1.63(11) | 1.63(11) |
| (0,10)                  | 2.86(11) | 2.14(11) | 1.74(11) | 1.79(11) | 1.78(11) |
| (0,11)                  | 3.00(11) | 2.28(11) | 1.88(11) | 1.93(11) | 1.92(11) |
| (0,12)                  | 3.12(11) | 2.39(11) | 2.01(11) | 2.07(11) | 2.05(11) |
| (0,13)                  | 3.22(11) | 2.50(11) | 2.14(11) | 2.19(11) | 2.15(11) |
| (0,14)                  | 3.30(11) | 2.60(11) | 2.26(11) | 2.29(11) | 2.23(11) |
| (0,15)                  | 3.37(11) | 2.68(11) | 2.36(11) | 2.37(11) | 2.28(11) |
| (0,16)                  | 3.42(11) | 2.75(11) | 2.45(11) | 2.40(11) | 2.29(11) |
| (0,17)                  | 3.46(11) | 2.81(11) | 2.48(11) | 2.38(11) | 2.23(11) |
| (0,18)                  | 3.49(11) | 2.86(11) | 2.44(11) | 2.27(11) | 2.11(11) |
| (0,19)                  | 3.50(11) | 2.87(11) | 2.29(11) | 2.07(11) | 1.91(11) |
| (0,20)                  | 3.41(11) | 2.68(11) | 1.93(11) | 1.73(11) | 1.61(11) |
| (1, 0)                  | 2.10(12) | 1.42(12) | 9.50(13) | 9.22(13) | 8.89(13) |
| (1, 1)                  | 6.37(12) | 4.28(12) | 2.84(12) | 2.74(12) | 2.64(12) |
| (1, 2)                  | 9.94(12) | 6.77(12) | 4.61(12) | 4.49(12) | 4.32(12) |
| (1, 3)                  | 1.31(11) | 9.05(12) | 6.32(12) | 6.17(12) | 5.94(12) |
| (1, 4)                  | 1.60(11) | 1.12(11) | 7.98(12) | 7.79(12) | 7.49(12) |
| (1, 5)                  | 1.86(11) | 1.32(11) | 9.58(12) | 9.36(12) | 8.98(12) |
| (1, 6)                  | 2.10(11) | 1.51(11) | 1.11(11) | 1.09(11) | 1.04(11) |
| (1, 7)                  | 2.33(11) | 1.68(11) | 1.27(11) | 1.23(11) | 1.17(11) |
| (1, 8)                  | 2.53(11) | 1.85(11) | 1.41(11) | 1.36(11) | 1.29(11) |
| (1, 9)                  | 2.71(11) | 2.01(11) | 1.55(11) | 1.48(11) | 1.39(11) |
| (1,10)                  | 2.87(11) | 2.15(11) | 1.67(11) | 1.57(11) | 1.47(11) |
| (1,11)                  | 3.01(11) | 2.28(11) | 1.77(11) | 1.64(11) | 1.52(11) |
| (1,12)                  | 3.13(11) | 2.40(11) | 1.84(11) | 1.67(11) | 1.53(11) |
| (1,13)                  | 3.23(11) | 2.50(11) | 1.85(11) | 1.64(11) | 1.49(11) |
| (1,14)                  | 3.31(11) | 2.57(11) | 1.78(11) | 1.54(11) | 1.40(11) |
| (1,15)                  | 3.32(11) | 2.51(11) | 1.57(11) | 1.35(11) | 1.24(11) |
| (2, 0)                  | 2.11(12) | 1.42(12) | 8.48(13) | 7.18(13) | 6.41(13) |
| (2, 1)                  | 6.39(12) | 4.28(12) | 2.51(12) | 2.11(12) | 1.88(12) |
| (2, 2)                  | 9.97(12) | 6.78(12) | 4.02(12) | 3.38(12) | 3.01(12) |
| (2, 3)                  | 1.31(11) | 9.05(12) | 5.39(12) | 4.52(12) | 4.03(12) |
| (2, 4)                  | 1.60(11) | 1.11(11) | 6.60(12) | 5.51(12) | 4.92(12) |
| (2, 5)                  | 1.87(11) | 1.31(11) | 7.62(12) | 6.33(12) | 5.65(12) |