

Bibliography

- [1] van Dishoeck, E. F. & Blake, G. A., Chemical evolution of star-forming regions, *Annual Review of Astronomy and Astrophysics*, **36**, 317-368 (1998).
- [2] Cazaux, S., Tielens, A. G. G. M., Ceccarelli, C., Castets, A., Wakelam, V., Caux, E., Parise, B., & Teyssier, D., The hot core around the low-mass protostar IRAS 16293-2422: Scoundrels rule!, *Astrophysical Journal Letters*, **593**, L51-L55 (2003).
- [3] Charnley, S., Interstellar organic chemistry, In *The Bridge Between the Big Bang and Biology: Stars, Planetary Systems, Atmospheres, Volcanoes: Their Link to Life*, F. Giovanelli, ed., 139. Consiglio Nazionale delle Ricerche; Rome (2001).
- [4] Friedel, D. N., Snyder, L. E., Turner, B. E., & Remijan, A., A spectral line survey of selected 3 millimeter bands toward Sagittarius B2(N-LMH) using the National Radio Astronomy Observatory 12 Meter Radio Telescope and the Berkeley-Illinois-Maryland Association Array. I. The observational data, *Astrophysical Journal*, **600**, 234-253 (2004).
- [5] Oro, J., Comets and the formation of biochemical compounds on the primitive Earth, *Nature*, **190**, 389-390 (1961).
- [6] Sephton, M. A., Organic compounds in carbonaceous meteorites, *Natural Product Reports*, **19**, 292-311 (2002).

- [7] Cronin, J. R. & Chang, S., Organic matter in meteorites: molecular and isotopic analyses of the Murchison meteorite, In *NATO ASI Series, Series C: Mathematical and Physical Sciences, 416 (Chemistry of Life's Origins)*, J. M. Greenberg, C. X. Mendoza-Gómez, & V. Pirronello, ed., 209. Kluwer; Boston (1993).
- [8] Cooper, G., Kimmich, N., Belisle, W., Sarinana, J., Brabham, K., Garrel, L., Carbonaceous meteorites as a source of sugar-related organic compounds for the early Earth, *Nature*, **414**, 879-883 (2001).
- [9] Lewis, R. S. & Anders, E., Interstellar matter in meteorites, *Scientific American*, **249**, 66-77 (1983).
- [10] Bernstein, M. P., Sandford, S. A., Allamandola, L. J., Chang, S., & Scharberg, M. A., Organic compounds produced by photolysis of realistic interstellar and cometary ice analogs containing methanol, *Astrophysical Journal*, **454**, 327 (1995).
- [11] Cottin, H., Szopa, C., & Moore, M. H., Production of hexamethylenetetramine in photolyzed and irradiated interstellar cometary ice analogs, *Astrophysical Journal Letters*, **561**, L139-L142 (2001).
- [12] Allen, M. & Robinson, G. W., The molecular composition of dense interstellar clouds, *Astrophysical Journal*, **212**, 396-415 (1977).
- [13] Horn, A., Møllendal, H., Sekiguchi, O., Uggerud, E., Roberts, H., Herbst, E., Viggiano, A. A., & Fridgen, T. D., The gas-phase formation of methyl formate in hot molecular cores, *Astrophysical Journal*, **611**, 605-614 (2004).
- [14] Ohishi, M., Observations of hot cores, In *IAU Symposium No. 178: Molecules in astrophysics*, E. F. van Dishoeck, ed., 61. Kluwer; Dordrecht (1997).

- [15] Hollis, J. M., Lovas, F. J., & Jewell, P. R., Interstellar glycolaldehyde: The first sugar, *Astrophysical Journal Letters*, **540**, L107-L110 (2000).
- [16] Hollis, J. M., Vogel, S. N., Snyder, L. E., Jewell, P. R., & Lovas, F. J., The spatial scale of glycolaldehyde in the Galactic Center, *Astrophysical Journal Letters*, **554**, L81-L85 (2001).
- [17] Hollis, J. M., Jewell, P. R., Lovas, F. J., & Remijan, A., Green Bank Telescope observations of interstellar glycolaldehyde: Low-temperature sugar, *Astrophysical Journal Letters*, **613**, L45-L48 (2004).
- [18] Martín-Pintado, J., Rizzo, J. R., de Vicente, P., Rodríguez-Fernández, N. J., & Fuente, A., Large-scale grain mantle disruption in the galactic center, *Astrophysical Journal Letters*, **548**, L65-L68 (2001).
- [19] Chengalur, J. N. & Kanekar, N., Widespread acetaldehyde near the Galactic Centre, *Astronomy & Astrophysics*, **403**, L43-L46 (2003).
- [20] Balle, T. J., & Flygare, W. H., Fabry-Perot cavity pulsed Fourier transform microwave spectrometer with a pulsed nozzle particle source, *Review of Scientific Instruments*, **52**, 33-45 (1981).
- [21] Emilsson, T. I., Extensions of the capabilities of a Balle-Flygare microwave spectrometer, Ph.D. thesis, *University of Illinois at Urbana-Champaign* (1993).
- [22] McElmurry, B. A., Lucchese, R. R., Bevan, J. W., Leonov, I. I., Belov, S. P., & Legon, A. C., Studies of Ar:HBr using fast scan submillimeter-wave and microwave coaxial pulsed jet spectrometers with sub-kHz precision, *Journal of Chemical Physics*, **119**, 10687-10695 (2003).

- [23] Friedl, R. R., Birk, M., Oh, J. J., & Cohen, E. A., The rotational spectrum and molecular structure of chlorine chlorate, *Journal of Molecular Spectroscopy*, **170**, 383-396 (1995).
- [24] Nummelin, A., Bergman, P., Hjalmarson, A., Friberg, P., Irvine, W. M., Millar, T. J., Ohishi, M., and Saito, S., A three-position spectral line survey of Sagittarius B2 between 218 and 263 GHz. I. The observational data, *Astrophysical Journal Supplement Series*, **117**, 427 (1998).
- [25] Sutton, E. C., Blake, G. A., Masson, C. R., & Phillips, T. G., Molecular line survey of Orion A from 215 to 247 GHz, *Astrophysical Journal Supplement Series*, **58**, 341-378 (1985).
- [26] Kuan, Y., Charnley, S. B., Huang, H., Tseng, W., & Kisiel, Z., Interstellar glycine, *Astrophysical Journal*, **593**, 848-867 (2003).
- [27] Snyder, L. E., Lovas, F. J., Hollis, J. M., Friedel, D. N., Jewell, P. R., Remijan, A., Ilyushin, V. V., Alekseev, E. A., & Dyubko, S. F., A rigorous attempt to verify interstellar glycine, *Astrophysical Journal*, **619**, 914-930 (2005).
- [28] Liu, S., Mehringer, D. M., & Snyder, L. E., Observations of formic acid in hot molecular cores, *Astrophysical Journal*, **552**, 654-663 (2001).
- [29] Nummelin, A., Dickens, J. E., Bergman, P., Hjalmarson, A., Irvine, W. M., Ikeda, M., & Ohishi, M., Abundances of ethylene oxide and acetaldehyde in hot molecular cloud cores, *Astronomy & Astrophysics*, **337**, 275-286 (1998).

- [30] Pickett, H. M., Poynter R. L., Cohen E. A., Delitsky M. L., Pearson J. C., & Muller H. S. P., Submillimeter, millimeter, and microwave spectral line catalog, *Journal of Quantitative Spectroscopy and Radiative Transfer*, **60**, 883-890 (1998).
- [31] Frisch, M. J. , Trucks, G. W., Schlegel, H. B., Scuseria, G. E., Robb, M. A., Cheeseman, J. R., Zakrzewski, V. G., Montgomery, Jr., J. A., Stratmann, R. E., Burant, J. C., Dapprich, S., Millam, J. M., Daniels, A. D., Kudin, K. N., Strain,M. C., Farkas, O., Tomasi, J., Barone, V., Cossi, M., Cammi, R., Mennucci, B., Pomelli, C., Adamo, C., Clifford, S., Ochterski, J., Petersson, G. A., Ayala, P. Y., Cui, Q., Morokuma, K., Malick, D. K., Rabuck, A. D., Raghavachari, K., Foresman, J. B., Cioslowski, J., Ortiz, J. V., Baboul, A. G., Stefanov,B. B., Liu, G., Liashenko, A., Piskorz, P., Komaromi, I., Gomperts, R., Martin, R. L., Fox, D. J., Keith, T., Al-Laham, M. A., Peng, C. Y., Nanayakkara, A., Challacombe, M., Gill, P. M. W., Johnson,B., Chen, W., Wong M. W., Andres, J. L., Gonzalez, C., Head-Gordon,M., Replogle, E. S., & Pople, J. A., *GAUSSIAN 98, Revision A.9.* Gaussian, Inc., Pittsburgh, PA (1998).
- [32] Lovas, F. J., Suenram, R. D., Plusquellec, D. F., & Mollendal, H., The microwave spectrum of the C3 sugars: glyceraldehyde and 1,3-dihydroxy-2-propanone and the dehydration product 2-hydroxy-2-propen-1-al, *Journal of Molecular Spectroscopy*, **222**, 263-272 (2003).
- [33] Widicus, S. L., Braakman, R., Kent, D. R., IV, & Blake, G. A., The millimeter and submillimeter rotational spectrum of 1,3-dihydroxyacetone, *Journal of Molecular Spectroscopy*, **224**, 101-106 (2004).
- [34] Becke, A. D., Density-functional thermochemistry. III. The role of exact exchange, *Journal of Chemical Physics*, **98**, 5648-5652 (1993).

- [35] Lee, C., Yang, W., & Parr, R. G., Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density, *Physical Review B: Condensed Matter and Materials Physics*, **37**, 785-789 (1988).
- [36] Ringnalda, M. N., Langlois, J.-M., Murphy, R. B., Greeley, B. H., Cortis, C., Russo, T. V., Marten, B., Donnelly, Jr., R. E., Pollard, W. T., Cao, Y., Muller, R. P., Mainz, D. T., Wright, J. R., Miller, G. H., Goddard III, W. A., & Friesner, R. A. *Jaguar* 4.2 (2001).
- [37] Hehre, W. J., Ditchfield, R., & Pople, J. A., Self-consistent molecular orbital methods. XII. Further extensions of Gaussian-type basis sets for use in molecular orbital studies of organic molecules, *Journal of Chemical Physics*, **56**, 2257-2261 (1972).
- [38] Clark, T., Chandrasekhar, J., Spitznagel, G. W., & Schleyer, P. v. R., Efficient diffuse function-augmented basis sets for anion calculations. III. The 3-21 + G basis set for first-row elements, lithium to fluorine, *Journal of Computational Chemistry*, **4**, 294-301 (1983).
- [39] Hariharan, P. C. & Pople, J. A., Influence of polarization functions on MO hydrogenation energies, *Theoretica Chimica Acta*, **28**, 213-222 (1973).
- [40] Widicus, S. L., Drouin, B. J., Dyl, K. A., & Blake, G. A., Millimeter wavelength measurements of the rotational spectrum of 2-aminoethanol, *Journal of Molecular Spectroscopy*, **217**, 278-281 (2003).
- [41] Drouin, B. J., Fischer, J., & Gamache, R. R., Temperature-dependent pressure-induced lineshape of O₃ rotational transitions in air, *Journal of Quantitative Spectroscopy and Radiative Transfer*, **83**, 63-81 (2004).

- [42] Remijan, A., Sutton, E. C., Snyder, L. E., Friedel, D. N., Liu, S.-Y., & Pei, C.-C., High-resolution observations of methyl cyanide (CH_3CN) toward the hot core regions W51e1/e2, *Astrophysical Journal*, **606**, 917-928 (2004).
- [43] Scoville, N. Z., Carlstrom, J. E., Chandler, C. J., Phillips, J. A., Scott, S. L., Tilanus, R. P. J., & Wang, Z., The relational database and calibration software for the Caltech millimeter array, *Publications of the Astronomical Society of the Pacific*, **105**, 1482-1494 (1993).
- [44] Sault, R. J., Teuben, P. J., & Wright, M. C. H., A retrospective view of MIRIAD, In *Astronomical Society of the Pacific Conference Series 77: Astronomical Data Analysis Software and Systems IV*, R. A. Shaw, H. E. Payne, & J. J. E. Hayes, ed., 433. The University of Chicago Press; Chicago (1995).
- [45] Hollis, J. M., Pedelty, J. A., Boboltz, D. A., Liu, S.-Y., Snyder, L. E., Palmer, P., Lovas, F. J., & Jewell, P. R., Kinematics of the Sagittarius B2(N-LMH) molecular core, *Astrophysical Journal Letters*, **596**, L235-L238 (2003).
- [46] Snyder, L. E., Lovas, F. J., Mehringer, D. M., Miao, N. Y., Kuan, Y., Hollis, J. M., & Jewell, P. R., Confirmation of interstellar acetone, *Astrophysical Journal*, **578**, 245-255 (2002).
- [47] Widicus Weaver, S. L., Butler, R. A. H., Drouin, B. J., Petkie, D. T., Dyl, K. A., De Lucia, F. C., & Blake, G. A., Millimeter-wave and vibrational state assignments for the rotational spectrum of glycolaldehyde, *Astrophysical Journal Supplement Series*, in press (2005).

- [48] Schöier, F. L., Jørgensen, J. K., van Dishoeck, E. F., & Blake, G. A., Does IRAS 16293-2422 have a hot core? Chemical inventory and abundance changes in its protostellar environment, *Astronomy & Astrophysics*, **390**, 1001-1021 (2002).
- [49] Brochu, M. & Buckley, P., Microwave spectrum and molecular conformation of methyl glycolate, *Canadian Journal of Spectroscopy*, **18**, 165-169 (1973).
- [50] Caminati, W., Cervellati, R., & Smith, Z., Methyl group internal rotation A-E line splittings in several torsionally excited states of methyl glycolate and 2-methoxymethanol, *Journal of Molecular Structure*, **81**, 143-145 (1982).
- [51] Meyer, R., Caminati, W., & Hollenstein, H., Torsional motions in methyl glycolate, *Journal of Molecular Spectroscopy*, **137**, 87-103 (1989).
- [52] Caminati, W. & Cervellati, R., Barrier to internal rotation of methyl in methyl glycolate, *Journal of Molecular Structure*, **81**, 143-145 (1982).
- [53] Groner, P., Albert, S., Herbst, E., De Lucia, F. C., Lovas, F. J., Drouin, B. J., & Pearson, J. C., Acetone: Laboratory assignments and predictions through 620 GHz for the vibrational-torsional ground state, *Astrophysical Journal Supplement Series*, **142**, 145-151 (2002).
- [54] Blake, G. A., Sutton, E. C., Masson, C. R., & Phillips, T. G., Molecular abundances in OMC-1-The chemical composition of interstellar molecular clouds and the influence of massive star formation, *Astrophysical Journal*, **315**, 621-645 (1987).
- [55] Widicus Weaver, S. L. and Blake, G. A., 1,3-Dihydroxyacetone in Sagittarius B2(N-LMH): The first interstellar ketose, *Astrophysical Journal Letters*, **624**, L33-L36 (2005).

- [56] Nummelin, A. & Bergman, P., vibrationally excited vinyl cyanide in SGR B2(N), *Astronomy & Astrophysics*, **341**, L59-L62 (1999).
- [57] Nummelin, A., Bergman, P., Hjalmarson, Å., Friberg, P., Irvine, W. M., Millar, T. J., Ohishi, M., & Saito, S., A three-position spectral line survey of Sagittarius B2 between 218 and 263 GHZ. II. Data analysis, *Astrophysical Journal Supplement Series*, **128**, 213-243 (2000).
- [58] Marstokk, K.-M. & Møllendal, H., Microwave spectrum and dipole moment of glycolaldehyde, *Journal of Molecular Structure*, **5**, 205-213 (1970).
- [59] Marstokk, K.-M. & Møllendal, H., Millimeter wavelength measurements of the rotational spectrum of 2-aminoethanol, *Journal of Molecular Structure*, **16**, 259-270 (1973).
- [60] Butler, R. A. H., De Lucia, F. C., Petkie, D. T., Møllendal, H., Horn, A., & Herbst, E., The millimeter- and submillimeter-wave spectrum of glycolaldehyde (CH_2OHCHO), *Astrophysical Journal Supplement Series*, **134**, 319-321 (2001).
- [61] Michelsen, H. & Klaboe, P., Spectroscopic studies of glycolaldehyde, *Journal of Molecular Structure*, **4**, 293-302 (1969).
- [62] Petkie, D. T., Goyette, T. M., Bettens, R. P. A., Belov, S. P., Albert, S., Helminger, P., & De Lucia, F. C., A fast scan submillimeter spectroscopic technique, *Review of Scientific Instruments*, **68**, 1675-1683 (1997).
- [63] Senent, M. L., Ab initio study of the torsional spectrum of glycolaldehyde, *Journal of Physical Chemistry A*, **108**, 6286-6293 (2004).

- [64] Olmi, L., Cesaroni, R., Hofner, P., Kurtz, S., Churchwell, E., & Walmsley, C. M., High resolution observations of the hot core in G29.96-0.02, *Astronomy & Astrophysics*, **407**, 225-235 (2003).
- [65] Penn, R. E. & Curl, R. F., Microwave spectrum of 2-aminoethanol: Structural effects of the hydrogen bond, *Journal of Chemical Physics*, **53**, 651-658 (1971).
- [66] Kaushik, V. K. & Woods, R. C., Centrifugal distortion effects in the rotational spectrum of 2-aminoethanol, *Zeitschrift fuer Physikalische Chemie*, **132**, 117-120 (1982).
- [67] Korolevich, M. V., Sivchik, V. V., Matveeva, N. A., Zhabankov, R. G., Lastochkina, V. A., Frenkel, M. L., Ladut'ko, A. I., Pavlov, A. V., & Petryaev, E. P., Vibrational spectrum of ethanolamine, *Zhurnal Prikladnoi Spektroskopii*, **46**, 620-624 (1987).
- [68] Ohishi, M., Ishikawa, S., Yamamoto, S., Saito, S., & Amano, T., The detection and mapping observations of C_2H_5OH in Orion Kleinmann-Low, *Astrophysical Journal Letters*, **446**, L43-L46 (1995).
- [69] Hasegawa, T. I., Herbst, E., & Leung, C. M., Models of gas-grain chemistry in dense interstellar clouds with complex organic molecules, *Astrophysical Journal Supplement Series*, **82**, 167-195 (1992).
- [70] Hasegawa, T. I. & Herbst, E., New gas-grain chemical models of quiescent dense interstellar clouds-The effects of H_2 tunnelling reactions and cosmic ray induced desorption, *Monthly Notices of the Royal Astronomical Society*, **261**, 83-102 (1993).

- [71] Ruffle, D. P. & Herbst, E., New models of interstellar gas-grain chemistry—I. Surface diffusion rates, *Monthly Notices of the Royal Astronomical Society*, **319**, 837-850 (2000).
- [72] Ruffle, D. P. & Herbst, E., New models of interstellar gas-grain chemistry—II. Surface photochemistry in quiescent cores, *Monthly Notices of the Royal Astronomical Society*, **322**, 770-778 (2001).
- [73] Charnley, S. B., Kress, M. E., Tielens, A. G. G. M., & Millar, T. J., Interstellar alcohols, *Astrophysical Journal*, **448**, 232 (1995).
- [74] Charnley, S. B., On the nature of interstellar organic chemistry, In *IAU Colloq. 161: Astronomical and Biochemical Origins and the Search for Life in the Universe*, C. B. Cosmovici, S. Bowyer & D. Werthimer, ed., 89. Editrice Compositori; Bologna (1997).
- [75] Bottinelli, S., Ceccarelli, C., Neri, R., Williams, J. P., Caux, E., Cazaux, S., Lefloch, B., Maret, S., & Tielens, A. G. G. M., Near-arcsecond resolution observations of the hot corino of the solar-type protostar IRAS 16293-2422, *Astrophysical Journal Letters*, **617**, L69-L72 (2004).
- [76] Hollis, J. M., Jewell, P. R. , Lovas, F. J., Remijan, A., & Møllendal, H., Green Bank Telescope detection of new interstellar aldehydes: Propenal and propanal, *Astrophysical Journal Letters*, **610**, L21-L24 (2004).
- [77] Hippler, H. & Viskolcz, B., Competition between alkyl radical addition to carbonyl bonds and H-atom abstraction reactions, *Physical Chemistry Chemical Physics*, **4**, 4663-4668 (2002).

- [78] Duley, W. W. & Williams, D. A., *Interstellar Chemistry*. Academic Press Inc., Orlando, FL (1984).
- [79] Hartquist, T. W., Menten, K. M., Lepp, S., & Dalgarno, A., On the spatial coincidence of hydroxyl and methanol masers, *Monthly Notices of the Royal Astronomical Society*, **272**, 184-188 (1995).
- [80] Stief L. J., Payne W. A., & Klemm, R. B., Flash photolysis-resonance fluorescence study of the formation of atomic oxygen (1D) in the photolysis of water and the reaction of atomic oxygen (1D) with molecular hydrogen, argon, and helium, *Journal of Chemical Physics*, **62**, 4000 (1975).
- [81] Satyapal, S., Park, J., Bersohn, R., & Katz, B., Dissociation of methanol and ethanol activated by a chemical reaction or by light, *Journal of Chemical Physics*, **91**, 6873-6879 (1989).
- [82] Chang, A. H. H. & Lin, S. H., A theoretical study of the O(¹D) + CH₄ reaction I, *Chemical Physics Letters*, **363**, 175-181 (2002).
- [83] Boogert, A. C. A. & Eherenfreund, P., Interstellar Ices, In *ASP Conference Series 309: Astrophysics of Dust*, A. N. Witt, G. C. Clayton, & B. T. Drain, ed., 547 (2004).
- [84] Knez, C., Boogert, A. C. A., Pontoppidan, K. M., Lahuis, F., Augereau, J.-C., Kessler-Silacci, J., van Dieshoeck, E. F., Blake, G. A., Brown, J. A., Dullemond, C. P., Evans, N. E., Geers, V., & Jørgensen, J., First detection of ice features at 5–20 μm toward background stars, *Astrophysical Journal* (2005).