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UV Photodesorption and photoconversion of interstellar ices: the laboratory perspective

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Citation

Bulak, M. (2021, December 9). *UV Photodesorption and photoconversion of interstellar ices: the laboratory perspective*. Retrieved from <https://hdl.handle.net/1887/3245781>

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BIBLIOGRAPHY

- Abdulgalil, A. G. M., Marchione, D., Thrower, J. D., et al. 2013, Philos. Trans. R. Soc. A, 371, 20110586
- Abplanalp, M. J., Förstel, M., & Kaiser, R. I. 2016, Chem. Phys. L., 644, 79
- Abplanalp, M. J. & Kaiser, R. I. 2019, PCCP (Incorp. Far. Trans.), 21, 16949
- Abplanalp, M. J. & Kaiser, R. I. 2020, ApJ, 889, 3
- Acharyya, K., Schulte, S. W., & Herbst, E. 2020, ApJS, 247, 4
- Agúndez, M., Cernicharo, J., de Vicente, P., et al. 2015, A&A, 579, L10
- Agúndez, M., Marcelino, N., & Cernicharo, J. 2018, ApJ, 861, L22
- Altwegg, K., Balsiger, H., Bar-Nun, A., et al. 2015, Science, 347, 1261952
- Altwegg, K., Balsiger, H., Bar-Nun, A., et al. 2016, Science Advances, 2, e1600285
- Altwegg, K., Balsiger, H., Berthelier, J. J., et al. 2017, MNRAS, 469, S130
- Altwegg, K., Balsiger, H., & Fuselier, S. A. 2019, ARA&A, 57, 113
- Andersson, S., Al-Halabi, A., Kroes, G.-J., & van Dishoeck, E. F. 2006, J. Chem. Phys., 124, 064715
- Andersson, S. & van Dishoeck, E. F. 2008, A&A, 491, 907
- Arasa, C., Andersson, S., Cuppen, H. M., van Dishoeck, E. F., & Kroes, G. J. 2010, J. Chem. Phys., 132, 184510
- Arasa, C., Andersson, S., Cuppen, H. M., van Dishoeck, E. F., & Kroes, G. J. 2011, J. Chem. Phys., 134, 164503
- Arasa, C., Koning, J., Kroes, G.-J., Walsh, C., & van Dishoeck, E. F. 2015, A&A, 575, A121
- Ball, J. A., Gottlieb, C. A., Lilley, A. E., & Radford, H. E. 1970, ApJ, 162, L203
- Balsiger, H., Altwegg, K., & Geiss, J. 1995, , 100, 5827
- Bar-Nun, A., Herman, G., Rappaport, M., & Mekler, Y. 1985, Surf. Sci., 150, 143
- Baragiola, R. A., Atteberry, C. L., Dukes, C. A., Famá, M., & Teolis, B. D. 2002, Nucl. Instr. Meth. in Phys. R. B, 193, 720
- Baratta, G. A. & Palumbo, M. E. 1998, J. Opt. Soc. Am. A, 15, 3076

- Belloche, A., Garrod, R. T., Müller, H. S. P., et al. 2009, *A&A*, 499, 215
- Belloche, A., Garrod, R. T., Müller, H. S. P., et al. 2019, *A&A*, 628, A10
- Belloche, A., Meshcheryakov, A. A., Garrod, R. T., et al. 2017, *A&A*, 601, A49
- Bennett, C. J., Chen, S.-H., Sun, B.-J., Chang, A. H. H., & Kaiser, R. I. 2007, *ApJ*, 660, 1588
- Bergin, E. A., Hartmann, L. W., Raymond, J. C., & Ballesteros-Paredes, J. 2004, *ApJ*, 612, 921
- Bergin, E. A., Langer, W. D., & Goldsmith, P. F. 1995, *ApJ*, 441, 222
- Bergin, E. A., Maret, S., van der Tak, F. F. S., et al. 2006, *ApJ*, 645, 369
- Bergin, E. A., Melnick, G. J., Stauffer, J. R., et al. 2000, *ApJ*, 539, L129
- Bergin, E. A. & Tafalla, M. 2007, *ARA&A*, 45, 339
- Bergner, J. B., Guzmán, V. G., Öberg, K. I., Loomis, R. A., & Pegues, J. 2018, *ApJ*, 857, 69
- Bernstein, M. P., Dworkin, J. P., Sandford, S. A., Cooper, G. W., & Allamandola, L. J. 2002, *Nature*, 416, 401
- Bernstein, M. P., Sandford, S. A., Allamandola, L. J., Chang, S., & Scharberg, M. A. 1995, *ApJ*, 454, 327
- Bertin, M., Fayolle, E. C., Romanzin, C., et al. 2012, *PCCP*, 14, 9929
- Bertin, M., Fayolle, E. C., Romanzin, C., et al. 2013, *ApJ*, 779, 120
- Bertin, M., Romanzin, C., Doronin, M., et al. 2016, *ApJ*, 817, L12
- Bieler, A., Altwegg, K., Balsiger, H., et al. 2015, *Nature*, 526, 678
- Bisschop, S. E., Fuchs, G. W., Boogert, A. C. A., van Dishoeck, E. F., & Linnartz, H. 2007a, *A&A*, 470, 749
- Bisschop, S. E., Jørgensen, J. K., van Dishoeck, E. F., & de Wachter, E. B. M. 2007b, *A&A*, 465, 913
- Bizzocchi, L., Prudenzano, D., Rivilla, V. M., et al. 2020, arXiv e-prints, arXiv:2006.08401
- Blanksby, S. J. & Ellison, G. B. 2003, *Acc*, 36, 255
- Boamah, M. D., Sullivan, K. K., Shulenberger, K. E., et al. 2014, *Far. Disc.*, 168, 249
- Bockelée-Morvan, D., Lis, D. C., Wink, J. E., et al. 2000, *A&A*, 353, 1101
- Boogert, A. C. A., Gerakines, P. A., & Whittet, D. C. B. 2015, *ARA&A*, 53, 541
- Boogert, A. C. A., Huard, T. L., Cook, A. M., et al. 2011, *ApJ*, 729, 92
- Boogert, A. C. A., Pontoppidan, K. M., Knez, C., et al. 2008, *ApJ*, 678, 985

- Boonman, A. M. S., Doty, S. D., van Dishoeck, E. F., et al. 2003, *A&A*, 406, 937
- Booth, A. S., Walsh, C., Terwisscha van Scheltinga, J., et al. 2021, *Nature Astronomy*, 5, 684
- Borget, F., Müller, S., Grote, D., et al. 2017, *A&A*, 598, A22
- Bossa, J. B., Paardekooper, D. M., Isokoski, K., & Linnartz, H. 2015, *PCCP (Incorp. Far. Trans.)*, 17, 17346
- Bouwman, J., Paardekooper, D. M., Cuppen, H. M., Linnartz, H., & Allamandola, L. J. 2009, *ApJ*, 700, 56
- Brown, W., Augustyniak, W., Simmons, E., et al. 1982, *Nucl. Instr. Meth. in Phys. R.*, 198, 1
- Brunetto, R., Caniglia, G., Baratta, G., & Palumbo, M. 2008, *ApJ*, 686, 1480
- Bulak, M., Paardekooper, D. M., Fedoseev, G., & Linnartz, H. 2020, *A&A*, 636, A32
- Bulak, M., Paardekooper, D. M., Fedoseev, G., & Linnartz, H. 2021, *A&A*, 647, A82
- Bull, J. N., Harland, P. W., & Vallance, C. 2012, *J. Phys. Chem. A*, 116, 767
- Calcutt, H., Jørgensen, J. K., Müller, H. S. P., et al. 2018, *A&A*, 616, A90
- Caselli, P., Keto, E., Bergin, E. A., et al. 2012, *ApJ*, 759, L37
- Castellanos, P., Candian, A., Zhen, J., Linnartz, H., & Tielens, A. G. G. M. 2018, *A&A*, 616, A166
- Ceccarelli, C., Bacmann, A., Boogert, A., et al. 2010, *A&A*, 521, L22
- Cernicharo, J., Marcelino, N., Roueff, E., et al. 2012, *ApJ*, 759, L43
- Charnley, S. B., Rodgers, S. D., & Ehrenfreund, P. 2001, *A&A*, 378, 1024
- Chase Jr, M. & Tables, N.-J. T. 1998, *Journal of Phys. and Chem. Ref. Data*. American Institute of Physics, New York
- Chen, Y.-J., Chuang, K.-J., Caro, G. M., et al. 2013, *ApJ*, 781, 15
- Chen, Y. J., Chuang, K. J., Muñoz Caro, G. M., et al. 2014, *ApJ*, 781, 15
- Chevance, M., Kruijssen, J. M. D., Hygate, A. P. S., et al. 2020, *MNRAS*, 493, 2872
- Chiar, J. E., Adamson, A. J., & Whittet, D. C. B. 1996, *ApJ*, 472, 665
- Chuang, K. J., Fedoseev, G., Ioppolo, S., van Dishoeck, E. F., & Linnartz, H. 2016, *MNRAS*, 455, 1702
- Chuang, K. J., Fedoseev, G., Qasim, D., et al. 2017, *MNRAS*, 467, 2552
- Chuang, K. J., Fedoseev, G., Qasim, D., et al. 2018a, *A&A*, 617, A87
- Chuang, K. J., Fedoseev, G., Qasim, D., et al. 2018b, *ApJ*, 853, 102

- Cleeves, L. I., Bergin, E. A., Alexander, C. M. O. D., et al. 2014, *Science*, 345, 1590
- Collings, M. P., Anderson, M. A., Chen, R., et al. 2004, *MNRAS*, 354, 1133
- Congiu, E., Chaabouni, H., Laffon, C., et al. 2012, *J. Chem. Phys.*, 137, 054713
- Cordiner, M. A., Palmer, M. Y., Nixon, C. A., et al. 2015, *ApJ*, 800, L14
- Crouse, J., Loock, H. P., & Cann, N. M. 2015, *J. Chem. Phys.*, 143, 034502
- Crowley, J. N. & Sodeau, J. R. 1989, *J. Phys. Chem.*, 93, 3100
- Cruz-Diaz, G., Caro, G. M., Chen, Y.-J., & Yih, T.-S. 2014, *A&A*, 562, A119
- Cruz-Diaz, G. A., Martín-Doménech, R., Moreno, E., Muñoz Caro, G. M., & Chen, Y.-J. 2018, *MNRAS*, 474, 3080
- Cruz-Diaz, G. A., Martín-Doménech, R., Muñoz Caro, G. M., & Chen, Y. J. 2016, *A&A*, 592, A68
- Cruz-Diaz, G. A., Muñoz Caro, G. M., Chen, Y. J., & Yih, T. S. 2014a, *A&A*, 562, A119
- Cruz-Diaz, G. A., Muñoz Caro, G. M., Chen, Y. J., & Yih, T. S. 2014b, *A&A*, 562, A120
- Csengeri, T., Belloche, A., Bontemps, S., et al. 2019, *A&A*, 632, A57
- Cuppen, H. M. & Herbst, E. 2007, *ApJ*, 668, 294
- Cuppen, H. M., Ioppolo, S., Romanzin, C., & Linnartz, H. 2010, *PCCP (Inc. Far. Trans.)*, 12, 12077
- Danger, G., Bossa, J. B., de Marcellus, P., et al. 2011, *A&A*, 525, A30
- Danger, G., Duvernay, F., Theulé, P., Borget, F., & Chiavassa, T. 2012, *ApJ*, 756, 11
- Dartois, E., Augé, B., Boduch, P., et al. 2015, *A&A*, 576, A125
- Darwent, B. d. 1970, *Natl. Stand Ref. Data System - Natl. Bur. Stand, U.S. Gov., NSRDS-NBS 31*
- Das, A., Sil, M., Gorai, P., Chakrabarti, S. i. K., & Loison, J. C. 2018, *ApJS*, 237, 9
- DeSimone, A. J., Crowell, V. D., Sherrill, C. D., & Orlando, T. M. 2013, *J. Chem. Phys.*, 139, 164702
- Dobbs, E. R., Figgins, B. F., Jones, G. O., Piercy, D. C., & Riley, D. P. 1956, *Nature*, 178, 483
- Dominik, C., Ceccarelli, C., Hollenbach, D., & Kaufman, M. 2005, *ApJ*, 635, L85
- Draine, B. T. 2010, *Physics of the interstellar and intergalactic medium*, Vol. 19 (Princeton University Press)
- Drozdovskaya, M. N., van Dishoeck, E. F., Rubin, M., Jørgensen, J. K., & Altwegg, K. 2019, *MNRAS*, 490, 50

- Drozdovskaya, M. N., Walsh, C., Visser, R., Harsono, D., & van Dishoeck, E. F. 2014, MNRAS, 445, 913
- Dulieu, F., Minissale, M., & Bockelée-Morvan, D. 2017, A&A, 597, A56
- Dulieu, F., Nguyen, T., Congiu, E., Baouche, S., & Taquet, V. 2019, MNRAS, 484, L119
- Dupuy, R., Bertin, M., Féraud, G., et al. 2018, Nat. Astr., 2, 796
- Dupuy, R., Bertin, M., Féraud, G., et al. 2017, A&A, 603, A61
- Eddington, A. S. 1937, The Observatory, 60, 99
- Ehrenfreund, P., Boogert, A. C. A., Gerakines, P. A., et al. 1996, A&A, 315, L341
- Ehrenfreund, P., Dartois, E., Demyk, K., & D’Hendecourt, L. 1998, A&A, 339, L17
- Eistrup, C. & Walsh, C. 2019, A&A, 621, A75
- Fayolle, E. C., Bertin, M., Romanzin, C., et al. 2011, ApJ Letters, 739, L36
- Fayolle, E. C., Bertin, M., Romanzin, C., et al. 2013, A&A, 556, A122
- Fedoseev, G., Chuang, K. J., Ioppolo, S., et al. 2017, ApJ, 842, 52
- Fedoseev, G., Cuppen, H. M., Ioppolo, S., Lamberts, T., & Linnartz, H. 2015a, MNRAS, 448, 1288
- Fedoseev, G., Ioppolo, S., Lamberts, T., et al. 2012, J. Chem. Phys., 137, 054714
- Fedoseev, G., Ioppolo, S., Zhao, D., Lamberts, T., & Linnartz, H. 2015b, MNRAS, 446, 439
- Fillion, J.-H., Dupuy, R., Féraud, G., et al. 2021, arXiv e-prints, arXiv:2103.15435
- Fillion, J.-H., Fayolle, E. C., Michaut, X., et al. 2014, Far. Disc., 168, 533
- Flagey, N., Goldsmith, P. F., Lis, D. C., et al. 2013, ApJ, 762, 11
- Foner, S. N. & Hudson, R. L. 1962, J. Chem. Phys., 36, 2676
- Fourikis, N., Takagi, K., & Morimoto, M. 1974, ApJ, 191, L139
- Fourré, I., Matz, O., Ellinger, Y., & Guillemin, J. C. 2020, A&A, 639, A16
- Fuchs, G. W., Cuppen, H. M., Ioppolo, S., et al. 2009, A&A, 505, 629
- Gans, B., Peng, Z., Carrasco, N., et al. 2013, Icarus, 223, 330
- Garrod, R. T. & Herbst, E. 2006, A&A
- Garrod, R. T. & Pauly, T. 2011, ApJ, 735, 15
- Garrod, R. T., Widicus Weaver, S. L., & Herbst, E. 2008, ApJ, 682, 283
- Gerakines, P. A., Moore, M. H., & Hudson, R. L. 2004, ICARUS, 170, 202

- Gerakines, P. A., Schutte, W. A., & Ehrenfreund, P. 1996, *A&A*, 312, 289
- Gerakines, P. A., Schutte, W. A., Greenberg, J. M., & van Dishoeck, E. F. 1995, *A&A*, 296, 810
- Gibb, E. L., Whittet, D. C. B., Boogert, A. C. A., & Tielens, A. G. G. M. 2004, *ApJS*, 151, 35
- Gibb, E. L., Whittet, D. C. B., Schutte, W. A., et al. 2000, *ApJ*, 536, 347
- Gillett, F. C. & Forrest, W. J. 1973, *ApJ*, 179, 483
- Goesmann, F., Rosenbauer, H., Bredehofft, J. H., et al. 2015, *Science*, 349, 2.689
- Gomis, O., Leto, G., & Strazzulla, G. 2004, *A&A*, 420, 405
- Goto, M., Vasyunin, A. I., Giuliano, B. M., et al. 2021, *A&A*, 651, A53
- Gratier, P., Pety, J., Guzmán, V., et al. 2013, *A&A*, 557, A101
- Gredel, R., Lepp, S., Dalgarno, A., & Herbst, E. 1989, *ApJ*, 347, 289
- Greenberg, J. M. 1983, *Advances in Space Research*, 3, 19
- Gudipati, M. S. & Yang, R. 2012, *ApJ*, 756, L24
- Guzmán, V. V., Goicoechea, J. R., Pety, J., et al. 2013, *A&A*, 560, A73
- Guzmán, V. V., Pety, J., Gratier, P., et al. 2014, *Faraday Discussions*, 168, 103
- Hagen, W., Allamandola, L. J., & Greenberg, J. M. 1980, *A&A*, 86, L3
- Halfen, D. T., Ilyushin, V. V., & Ziurys, L. M. 2015, *ApJ*, 812, L5
- Hama, T., Yabushita, A., Yokoyama, M., Kawasaki, M., & Watanabe, N. 2009a, *J. Chem. Phys.*, 131, 114510
- Hama, T., Yabushita, A., Yokoyama, M., Kawasaki, M., & Watanabe, N. 2009b, *J. Chem. Phys.*, 131, 114511
- Hama, T., Yokoyama, M., Yabushita, A., & Kawasaki, M. 2010, *J. Chem. Phys.*, 133, 104504
- Harada, N., Herbst, E., & Wakelam, V. 2010, *ApJ*, 721, 1570
- Harich, S. A., Hwang, D. W., Yang, X., et al. 2000, *J. Chem. Phys.*, 113, 10073
- Harich, S. A., Yang, X. F., Yang, X., van Harreveldt, R., & van Hemert, M. C. 2001, , 87, 263001
- Hartogh, P., Lis, D. C., Bockelée-Morvan, D., et al. 2011, *Nature*, 478, 218
- Henderson, B. L. & Gudipati, M. S. 2015, *ApJ*, 800, 66
- Herbst, E. & van Dishoeck, E. F. 2009, *ARA&A*, 47, 427
- Hogerheijde, M. R., Bergin, E. A., Brinch, C., et al. 2011, *Science*, 334, 338

- Hollenbach, D., Kaufman, M. J., Bergin, E. A., & Melnick, G. J. 2009, ApJ, 690, 1497
- Hollenbach, D. J. & Tielens, A. G. G. M. 1997, ARA&A, 35, 179
- Hollis, J. M., Lovas, F. J., Remijan, A. J., et al. 2006, ApJ, 643, L25
- Hudgins, D. M., Sandford, S. A., Allamandola, L. J., & Tielens, A. G. G. M. 1993, ApJ Suppl. Series, 86, 713
- Hudson, R. L. & Moore, M. H. 2004, ICARUS, 172, 466
- Hudson, R. L., Moore, M. H., Dworkin, J. P., Martin, M. P., & Pozun, Z. D. 2008, Astrobiology, 8, 771
- Ioppolo, S. 2010, PhD thesis, Surface formation routes of interstellar molecules (Leiden University)
- Ioppolo, S., Cuppen, H. M., Romanzin, C., van Dishoeck, E. F., & Linnartz, H. 2008, ApJ, 686, 1474
- Ioppolo, S., Cuppen, H. M., Romanzin, C., van Dishoeck, E. F., & Linnartz, H. 2010, PCCP (Inc. Far. Trans.), 12, 12065
- Ioppolo, S., Fedoseev, G., Chuang, K. J., et al. 2021, Nature Astronomy, 5, 197
- Ioppolo, S., van Boheemen, Y., Cuppen, H. M., van Dishoeck, E. F., & Linnartz, H. 2011, MNRAS, 413, 2281
- Isokoski, K., Bossa, J. B., Triemstra, T., & Linnartz, H. 2014, PCCP, 16, 3456
- Isokoski, K., Poteet, C. A., & Linnartz, H. 2013, A&A, 555, A85
- Isokoski, K. M.-R. 2013, PhD Thesis, Physics and Chemistry of Interstellar Ice (Leiden University)
- Jenniskens, P., Blake, D. F., & Kouchi, A. 1998, Amorphous Water Ice. a Solar System Material, ed. B. Schmitt, C. de Bergh, & M. Festou, Vol. 227, 139
- Jensen, M. J., Bilodeau, R. C., Safvan, C. P., et al. 2000, ApJ, 543, 764
- Jiménez-Serra, I., Vasyunin, A. I., Caselli, P., et al. 2016, ApJ, 830, L6
- Jin, M. & Garrod, R. T. 2020, ApJS, 249, 26
- Jo, S. K. & White, J. M. 1991, J. Chem. Phys., 94, 5761
- Johnson, R. E. 1991, , 96, 17553
- Johnson, R. E. & Quickenden, T. I. 1997, , 102, 10985
- Johnson III, R. D. 1999
- Jones, B. M., Bennett, C. J., & Kaiser, R. I. 2011, ApJ, 734, 78
- Jørgensen, J. K., Belloche, A., & Garrod, R. T. 2020, ARA&A, 58, 727
- Jørgensen, J. K., Favre, C., Bisschop, S. E., et al. 2012, ApJ, 757, L4

- Jørgensen, J. K., van der Wiel, M. H. D., Coutens, A., et al. 2016, *A&A*, 595, A117
- Kahane, C., Ceccarelli, C., Faure, A., & Caux, E. 2013, *ApJ*, 763, L38
- Kaifu, N., Morimoto, M., Nagane, K., et al. 1974, *ApJ*, 191, L135
- Kalescky, R., Kraka, E., & Cremer, D. 2013, *J. Phys. Chem. A*, 117, 8981
- Kalvāns, J. 2015, *ApJ*, 803, 52
- Kalvāns, J. 2018, *MNRAS*, 478, 2753
- Kanda, K., Nagata, T., & Ibuki, T. 1999, *Chemical Physics*, 243, 89
- Kim, Y. K., Irikura, K. K., Rudd, M. E., & Ali, M. A. 2014, Electron-Impact Ionization Cross Section for Ionization and Excitation Database (version 3.0)
- Kimmel, G. A. & Orlando, T. M. 1995, , 75, 2606
- Kinugawa, T., Yabushita, A., Kawasaki, M., Hama, T., & Watanabe, N. 2011, PCCP (Inc. Far. Trans.), 13, 15785
- Kobayashi, K. 1983, *J. Phys. Chem.*, 87, 4317
- Kofman, V., He, J., Loes ten Kate, I., & Linnartz, H. 2019, *ApJ*, 875, 131
- Koning, J., Kroes, G. J., & Arasa, C. 2013, *J. Chem. Phys.*, 138, 104701
- Lambert, H. M., Dixit, A. A., Davis, E. W., & Houston, P. L. 2004, *J. Chem. Phys.*, 121, 10437
- Lamberts, T., Cuppen, H. M., Ioppolo, S., & Linnartz, H. 2013, PCCP (Inc. Far. Trans.), 15, 8287
- Lampe, F., Franklin, J., & Field, F. 1957, *J. Am. Chem. Soc.*, 79, 6129
- Larsson, B. & Liseau, R. 2017, *A&A*, 608, A133
- Larsson, B., Liseau, R., Pagani, L., et al. 2007, *A&A*, 466, 999
- Lattelais, M., Pauzat, F., Ellinger, Y., & Ceccarelli, C. 2010, *A&A*, 519, A30
- Lee, J.-E., Lee, S., Baek, G., et al. 2019, *Nat. Astron.*, 3, 314
- Leto, G. & Baratta, G. A. 2003, *A&A*, 397, 7
- Ligterink, N. F. W., Coutens, A., Kofman, V., et al. 2017, *MNRAS*, 469, 2219
- Ligterink, N. F. W., Paardekooper, D. M., Chuang, K. J., et al. 2015, *A&A*, 584, A56
- Ligterink, N. F. W., Terwisscha van Scheltinga, J., Taquet, V., et al. 2018a, *MNRAS*, 480, 3628
- Ligterink, N. F. W., Walsh, C., Bhuin, R. G., et al. 2018b, *A&A*, 612, A88
- Linnartz, H., Ioppolo, S., & Fedoseev, G. 2015, *Int. Rev. Phys. Chem.*, 34, 205
- Liseau, R., Goldsmith, P. F., Larsson, B., et al. 2012, *A&A*, 541, A73

- Liszt, H. & Lucas, R. 2001, A&A, 370, 576
- Lo, J.-I., Lin, M.-Y., Peng, Y.-C., et al. 2015, MNRAS, 451, 159
- Loomis, R. A., Cleeves, L. I., Öberg, K. I., et al. 2018, ApJ, 859, 131
- Loomis, R. A., Zaleski, D. P., Steber, A. L., et al. 2013, ApJ, 765, L9
- Lucas, M., Liu, Y., Bryant, R., Minor, J., & Zhang, J. 2015, Chem. Phys. Lett., 619, 18
- Luna, R., Molpeceres, G., Ortigoso, J., et al. 2018, A&A, 617, A116
- Luspay-Kuti, A., Mousis, O., Lunine, J. I., et al. 2018, Space Sci. Rev., 214, 115
- Lykke, J. M., Coutens, A., Jørgensen, J. K., et al. 2017, A&A, 597, A53
- Mackay, D. D. S. 1999, MNRAS, 304, 61
- Maity, S., Kaiser, R. I., & Jones, B. M. 2014, Far. Disc., 168, 485
- Martín-Doménech, R., Manzano-Santamaría, J., Muñoz Caro, G. M., et al. 2015a, A&A, 584, A14
- Martín-Doménech, R., Manzano-Santamaría, J., Muñoz Caro, G. M., et al. 2015b, A&A, 584, A14
- Martín-Doménech, R., Muñoz Caro, G. M., Bueno, J., & Goesmann, F. 2014, A&A, 564, A8
- Martín-Doménech, R., Muñoz Caro, G. M., & Cruz-Díaz, G. A. 2016, A&A, 589, A107
- Mason, N. J., Dawes, A., Holtom, P. D., et al. 2006, Far. Disc., 133, 311
- Mathis, J. S., Mezger, P. G., & Panagia, N. 1983, A&A, 500, 259
- McGuire, B. A. 2018, ApJS, 239, 17
- Minissale, M., Dulieu, F., Cazaux, S., & Hocuk, S. 2016, A&A, 585, A24
- Miyauchi, N., Hidaka, H., Chigai, T., et al. 2008, Chem. Phys. Lett., 456, 27
- Mousis, O., Ronnet, T., Brugger, B., et al. 2016, ApJ, 823, L41
- Mousis, O., Ronnet, T., Lunine, J. I., et al. 2018, ApJ, 858, 66
- Muñoz Caro, G. M., Dartois, E., Boduch, P., et al. 2014, A&A, 566, A93
- Muñoz Caro, G. M., Jiménez-Escobar, A., Martín-Gago, J. Á., et al. 2010, A&A, 522, A108
- Muñoz Caro, G. M., Meierhenrich, U. J., Schutte, W. A., et al. 2002, Nature, 416, 403
- Müller, B., Giuliano, B. M., Bizzocchi, L., Vasyunin, A. I., & Caselli, P. 2018, A&A, 620, A46
- Mumma, M. J. & Charnley, S. B. 2011, ARA&A, 49, 471

- Nazari, P., van Gelder, M. L., van Dishoeck, E. F., et al. 2021, A&A, 650, A150
- Nguyen, T., Fourré, I., Favre, C., et al. 2019, A&A, 628, A15
- Nishi, N., Shinohara, H., & Okuyama, T. 1984, J. Chem. Phys., 80, 3898
- Notsu, S., van Dishoeck, E. F., Walsh, C., Bosman, A. D., & Nomura, H. 2021, A&A, 650, A180
- Oba, Y., Miyauchi, N., Hidaka, H., et al. 2009, ApJ, 701, 464
- Oba, Y., Tomaru, T., Lamberts, T., Kouchi, A., & Watanabe, N. 2018, Nat. Astr., 2, 228
- Oba, Y., Watanabe, N., Kouchi, A., Hama, T., & Pirronello, V. 2010, ApJ, 712, L174
- Öberg, K. I. 2009, PhD thesis, Complex processes in simple ices (Leiden University)
- Öberg, K. I. & Bergin, E. A. 2021, Phys. Rep., 893, 1
- Öberg, K. I., Boamah, M. D., Fayolle, E. C., et al. 2013, ApJ, 771, 95
- Öberg, K. I., Boogert, A. C. A., Pontoppidan, K. M., et al. 2008, ApJ, 678, 1032
- Öberg, K. I., Boogert, A. C. A., Pontoppidan, K. M., et al. 2011a, ApJ, 740, 109
- Öberg, K. I., Bottinelli, S., Jørgensen, J. K., & van Dishoeck, E. F. 2010a, ApJ, 716, 825
- Öberg, K. I., Fayolle, E. C., Cuppen, H. M., van Dishoeck, E. F., & Linnartz, H. 2009a, A&A, 505, 183
- Öberg, K. I., Fraser, H. J., Boogert, A. C. A., et al. 2007a, A&A, 462, 1187
- Öberg, K. I., Fuchs, G. W., Awad, Z., et al. 2007b, ApJ, 662, L23
- Öberg, K. I., Furuya, K., Loomis, R., et al. 2015, ApJ, 810, 112
- Öberg, K. I., Garrod, R. T., van Dishoeck, E. F., & Linnartz, H. 2009b, A&A
- Öberg, K. I., Garrod, R. T., van Dishoeck, E. F., & Linnartz, H. 2009c, A&A, 504, 891
- Öberg, K. I., Guzmán, V. V., Furuya, K., et al. 2015, Nature, 520, 198
- Öberg, K. I., Linnartz, H., Visser, R., & van Dishoeck, E. F. 2009d, ApJ, 693, 1209
- Öberg, K. I., Murray-Clay, R., & Bergin, E. A. 2011b, ApJ, 743, L16
- Öberg, K. I., van Dishoeck, E. F., & Linnartz, H. 2009e, A&A, 496, 281
- Öberg, K. I., van Dishoeck, E. F., Linnartz, H., & Andersson, S. 2010b, ApJ, 718, 832
- Oka, A., Inoue, A. K., Nakamoto, T., & Honda, M. 2012, ApJ, 747, 138
- Paardekooper, D. M., Bossa, J. B., Isokoski, K., & Linnartz, H. 2014, Rev. Sci. Instr., 85, 104501

- Paardekooper, D. M., Bossa, J. B., & Linnartz, H. 2016a, A&A, 592, A67
- Paardekooper, D. M., Bossa, J. B., & Linnartz, H. 2016b, A&A, 592, A67
- Paardekooper, D. M., Fedoseev, G., Riedo, A., & Linnartz, H. 2016c, A&A, 596, A72
- Paardekooper, D. M., Fedoseev, G., Riedo, A., & Linnartz, H. 2016d, A&A, 596, A72
- Pagani, L., Bacmann, A., Cabrit, S., & Vastel, C. 2007, A&A, 467, 179
- Pandya, S. H., Shelat, F. A., Joshipura, K. N., & Vaishnav, B. G. 2012, International Journal of Mass Spectrometry, 323-324, 28
- Parise, B., Bergman, P., & Du, F. 2012, A&A, 541, L11
- Pearson, K. 1895, Nature, 52, 317
- Petrie, S., Millar, T. J., & Markwick, A. J. 2003, MNRAS, 341, 609
- Pontoppidan, K. M., Boogert, A. C. A., Fraser, H. J., et al. 2008, ApJ, 678, 1005
- Pontoppidan, K. M., van Dishoeck, E. F., & Dartois, E. 2004, A&A, 426, 925
- Poteet, C. A., Pontoppidan, K. M., Megeath, S. T., et al. 2013, ApJ, 766, 117
- Prasad, S. S. & Tarafdar, S. P. 1983, ApJ
- Purcell, C. R., Balasubramanyam, R., Burton, M. G., et al. 2006, MNRAS, 367, 553
- Qasim, D., Fedoseev, G., Chuang, K. J., et al. 2020, Nat. Astr., 4, 781
- Rachid, M. G., Terwisscha van Scheltinga, J., Koletzki, D., & Linnartz, H. 2020, A&A, 639, A4
- Raunier, S., Chiavassa, T., Marinelli, F., & Aycard, J.-P. 2004, Chemical Physics, 302, 259
- Raut, U., Teolis, B. D., Loeffler, M. J., et al. 2007, J. Chem. Phys., 126, 244511
- Ribeiro, F. d. A., Almeida, G. C., Wolff, W., et al. 2020, MNRAS, 492, 2140
- Riddick, J. A., Bunger, W. B., & Sakano, T. K. 1986, Organic solvents: physical properties and methods of purification (John Wiley and Sons, New York, NY)
- Rivilla, V. M., Martín-Pintado, J., Jiménez-Serra, I., et al. 2020, ApJ, 899, L28
- Roux, J. A., Wood, B. E., Smith, A. M., & Plyer, R. R. 1980, Final Report, ARO, Inc., Arnold Air Force Station, TN.
- Rubin, M., Altwegg, K., Balsiger, H., et al. 2019, MNRAS, 489, 594
- Rubin, M., Altwegg, K., van Dishoeck, E. F., & Schwehm, G. 2015, ApJ, 815, L11
- Ruscic, B. 2015, J. Phys. Chem. A, 119, 7810
- Ruscic, B., Pinzon, R. E., Morton, M. L., et al. 2004, J. Phys. Chem. A, 108, 9979
- Salahub, D. R. & Sandorfy, C. 1971, Chem. Phys. Letters, 8, 71

- Satorre, M. Á., Domingo, M., Millán, C., et al. 2008, *Planet. Space Sci.*, 56, 1748
- Sayós, R., Oliva, C., & González, M. 2000, *J. Chem. Phys.*, 113, 6736
- Sayós, R., Oliva, C., & González, M. 2001, *J. Chem. Phys.*, 115, 8828
- Schmalzl, M., Visser, R., Walsh, C., et al. 2014, *A&A*, 572, A81
- Schnepf, O. & Dressler, K. 1960, *The J. of Chem. Phys.*, 33, 49
- Schwell, M., Jochims, H.-W., Baumgärtel, H., & Leach, S. 2008, *Chem. Phys.*, 344, 164
- Shannon, R. J., Blitz, M. A., Goddard, A., & Heard, D. E. 2013, *Nature Chemistry*, 5, 745
- Shen, C. J., Greenberg, J. M., Schutte, W. A., & van Dishoeck, E. F. 2004a, *A&A*
- Shen, C. J., Greenberg, J. M., Schutte, W. A., & van Dishoeck, E. F. 2004b, *A&A*, 415, 203
- Shingledecker, C. N., Tennis, J., Le Gal, R., & Herbst, E. 2018, *ApJ*, 861, 20
- Shingledecker, C. N., Vasyunin, A., Herbst, E., & Caselli, P. 2019, *ApJ*, 876, 140
- Shu, F. H., Adams, F. C., & Lizano, S. 1987, *ARA&A*, 25, 23
- Sieger, M. T., Simpson, W. C., & Orlando, T. M. 1998, *Nature*, 394, 554
- Sinnock, A. C. & Smith, B. L. 1968, *Phys. Lett. A*, 28, 22
- Slanger, T. G. & Black, G. 1978, *J. Chem. Phys.*, 68, 1844
- Slanger, T. G. & Black, G. 1982, *J. Chem. Phys.*, 77, 2432
- Sleiman, C., González, S., Klippenstein, S. J., et al. 2016, *PCCP (Incorporating Faraday Transactions)*, 18, 15118
- Smith, R. G., Charnley, S. B., Pendleton, Y. J., et al. 2011, *ApJ*, 743, 131
- Smith, R. S., May, R. A., & Kay, B. D. 2015, *J. Phys. Chem. A B*, 120, 1979
- Smith, R. S., Petrik, N. G., Kimmel, G. A., & Kay, B. D. 2012, *Acc. Chem. R.*, 45, 33
- Snell, R. L., Howe, J. E., Ashby, M. L. N., et al. 2000, *ApJ*, 539, L101
- Snow, T. 2013, *Proc. IAU*, 9, 3
- Snow, T. P. & McCall, B. J. 2006, *ARA&A*, 44, 367
- Snyder, L. E. & Bhul, D. 1971, in *Bulletin of the American Astronomical Society*, Vol. 3, 388
- Solomon, P. M., Jefferts, K. B., Penzias, A. A., & Wilson, R. W. 1971, *ApJ*, 168, L107
- Stief, L. J., Payne, W. A., & Klemm, R. B. 1975, *J. Chem. Phys.*, 62, 4000
- Suto, M. & Lee, L. C. 1985, , 90, 13,037

- Taquet, V., Furuya, K., Walsh, C., & van Dishoeck, E. F. 2016, MNRAS, 462, S99
- Teolis, B. D., Plainaki, C., Cassidy, T. A., & Raut, U. 2017, J. Geophys. Res. (Planets), 122, 1996
- Terwisscha van Scheltinga, J., Ligterink, N. F. W., Boogert, A. C. A., van Dishoeck, E. F., & Linnartz, H. 2018, A&A, 611, A35
- Theule, P., Borget, F., Mispelaer, F., et al. 2011, A&A, 534, A64
- Theulé, P., Duvernay, F., Danger, G., et al. 2013, Adv. Space Res., 52, 1567
- Thrower, J. D., Abdulgalil, A. G. M., Collings, M. P., et al. 2010, Journal of Vacuum Science Technology A: Vacuum Surfaces and Films, 28, 799
- Tielens, A. G. 2005, The physics and chemistry of the interstellar medium (Cambridge University Press)
- Tielens, A. G. G. M. & Hagen, W. 1982, A&A, 114, 245
- van Broekhuizen, F. A., Keane, J. V., & Schutte, W. A. 2004, A&A, 415, 425
- van Broekhuizen, F. A., Pontoppidan, K. M., Fraser, H. J., & van Dishoeck, E. F. 2005, A&A, 441, 249
- van Dishoeck, E. F. 2014, Faraday Discuss., 168, 9
- van Dishoeck, E. F., Kristensen, L. E., Mottram, J. C., et al. 2021, A&A, 648, A24
- van Gelder, M. L., Tabone, B., Tychoniec, Ł., et al. 2020a, A&A, 639, A87
- van Gelder, M. L., Tabone, B., Tychoniec, Ł., et al. 2020b, A&A, 639, A87
- van Harreveldt, R. & van Hemert, M. C. 2008, J. Phys. Chem. A, 112, 3002
- van Hemert, M. C., Takahashi, J., & van Dishoeck, E. F. 2015, J. Phys. Chem. A, 119, 6354
- Vandenbussche, B., Ehrenfreund, P., Boogert, A. C. A., et al. 1999, A&A, 346, L57
- Vastel, C., Ceccarelli, C., Lefloch, B., & Bachiller, R. 2014, ApJ, 795, L2
- Vasyunin, A. I., Caselli, P., Dulieu, F., & Jiménez-Serra, I. 2017, ApJ, 842, 33
- Vasyunin, A. I. & Herbst, E. 2013, ApJ, 769, 34
- Vigren, E., Kamińska, M., Hamberg, M., et al. 2008, PCCP (Incorporating Faraday Transactions), 10, 4014
- Walsh, C., Herbst, E., Nomura, H., Millar, T. J., & Weaver, S. W. 2014a, Far. Disc., 168, 389
- Walsh, C., Loomis, R. A., Öberg, K. I., et al. 2016, ApJ, 823, L10
- Walsh, C., Millar, T. J., & Nomura, H. 2010, ApJ, 722, 1607
- Walsh, C., Millar, T. J., Nomura, H., et al. 2014b, A&A, 563, A33

- Watanabe, N. & Kouchi, A. 2002, ApJ, 571, L173
- Watanabe, N., Shiraki, T., & Kouchi, A. 2003, ApJ, 588, L121
- Weast, R. C. 1972, Handbook of Chem. and Phys. 53rd ed., The Chem. Rubber Co., 26
- Wen, J. & Thiemens, M. H. 1993, , 98, 12,801
- Westley, M. S., Baragiola, R. A., Johnson, R. E., & Baratta, G. A. 1995a, Nature, 373, 405
- Westley, M. S., Baragiola, R. A., Johnson, R. E., & Baratta, G. A. 1995b, Planet. Space Sci., 43, 1311
- Whittet, D. C. B., Bode, M. F., Longmore, A. J., et al. 1988, MNRAS, 233, 321
- Whittet, D. C. B., Poteet, C. A., Chiar, J. E., et al. 2013, ApJ, 774, 102
- Whittet, D. C. B., Smith, R. G., Adamson, A. J., et al. 1996, ApJ, 458, 363
- Willacy, K. 2007, ApJ, 660, 441
- Willacy, K. & Langer, W. D. 2000, ApJ, 544, 903
- Willacy, K., Williams, D. A., & Minh, Y. C. 1993, MNRAS, 263, L40
- Williams, J. P. & Cieza, L. A. 2011, ARA&A, 49, 67
- Wilson, C. D., Mason, A., Gregersen, E., et al. 2003, A&A, 402, L59
- Wolszczan, A. & Frail, D. A. 1992, Nature, 355, 145
- Woodall, J., Agúndez, M., Markwick-Kemper, A. J., & Millar, T. J. 2007, A&A, 466, 1197
- Woodney, L. M., A'Hearn, M. F., Schleicher, D. G., et al. 2002, ICARUS, 157, 193
- Yıldız, U. A., Acharyya, K., Goldsmith, P. F., et al. 2013, A&A, 558, A58
- Zeng, S., Jiménez-Serra, I., Rivilla, V. M., et al. 2018, MNRAS, 478, 2962
- Zeng, S., Quénard, D., Jiménez-Serra, I., et al. 2019, MNRAS, 484, L43
- Zhen, J. & Linnartz, H. 2014, MNRAS, 437, 3190
- Zheng, W., Jewitt, D., & Kaiser, R. I. 2006a, ApJ, 639, 534
- Zheng, W., Jewitt, D., & Kaiser, R. I. 2006b, ApJ, 648, 753
- Zheng, W., Jewitt, D., & Kaiser, R. I. 2007, Chem. Phys. Lett., 435, 289
- Zhou, W., Wilkinson, L., Lee, J. W. L., Heathcote, D., & Vallance, C. 2019, Molecular Physics, 117, 3066
- Zinnecker, H. & Yorke, H. W. 2007, ARA&A, 45, 481