

DIVISION XII / COMMISSION 14 / WORKING GROUP SOLIDS AND THEIR SURFACES

CHAIR

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1. Introduction

In the last decade there has been a tremendous increase of interest in studying processes occurring on IS dust. In part this is due to the availability of ground-based and spaceborne high quality instruments which have been used to detect molecules in diverse astrophysical environments, from protoplanetary disks to hot cores and dense clouds. It has also been recognized that IS dust has an important role in the formation of molecules, from molecular hydrogen to methanol. Therefore, it is necessary not to study only properties of dust, but also understand how atoms and molecules interact with and on dust.

This has prompted a number of laboratories with a tradition of working in surface science to study the processes associated with dust. Besides the standard probes that have been used in the past, now there are available techniques that can give precise information at the atomic/molecular level about the formation of molecules on dust. For instance, Thermal Programmed Desorption (TPD), Reflection Absorption Infrared Spectrometry (RAIRS), Resonant Enhanced Multiphoton Ionization (REMPI), and Atom Force Microscopy (AFM) give information about the kinetics and energetics of diffusion of atoms/molecules on and desorption from surfaces, the products of reaction, the ro-vibrational state of ejected products, and the morphology of the solid surfaces, respectively. One of the consequences of the interest by surface science laboratories in studying physical/chemical properties of dust analogues and reactions occurring on them is that works of interest to astrochemistry are now regularly published in chemical physics/surface science journals such as *J. Chem. Phys.*, *J. Phys. Chem.*, *Phys. Chem. Chem. Phys.*, *Surface Science*, and others.

While in the past there has been a large number of laboratory studies of the interaction of charged particles and radiation with ice-covered dust grain analogues, most recent work points at new directions of research that will likely continue to be studied in the near future, i.e. the formation of molecules in/on ices by hydrogenation reactions, the properties of mixed ices, and the formation and properties of dust particles, including nanoparticles. Observations with ALMA, *SOFIA* and *Herschel* will yield more detailed information on dust and molecules, and theoretical studies will need to sort out the role of dust particles in molecule formation.

2. Meetings

Sessions about atomic/molecular interaction with surfaces are often featured at regularly scheduled COSPAR, AAS and Lunar and Planetary Institute meetings. For more

information about these meetings, visit the Web sites of the respective organizations. For information about the meetings below, visit the web site of the Canadian Astronomy Data Centre (Web link: <www1.cadc-ccda.hia-ihp.nrc-cnrc.gc.ca/meetings/>). Unfortunately, a number of meetings' official web sites have been taken down.

Most important meetings (listed in inverse chronological order):

- *Cosmic Dust – Near And Far*, Heidelberg, Germany, 8-12 September 2008
- *Bridging the Laboratory and Astrophysics*, 212th AAS, St. Louis, MO, USA, 1-5 June 2008
- *The Molecular Universe: International Meeting on the Physics and Chemistry of the IS Medium*, Arcachon, France, 5-8 May 2008
- *AbSciCon 2008: Fifth Astrobiology Science Conference*, Santa Clara, CA, USA, 15-17 April 2008
- *Titan Observations, Experiments, Computations, and Modeling*, Miami, FL, USA, 24-26 March 2008
- *Organic Matter in Space*, IAU Symposium No. 251, Hong Kong, 18-22 February 2008
- *The Evolving Interstellar Medium in the Milky Way and Nearby Galaxies*, Pasadena, CA, USA, 2-5 December 2007
- *Bioastronomy 2007: Molecules, Microbes, and Extraterrestrial Life*, San Juan, PR, USA, 16-20 July 2007
- *Origins of Solar Systems*, 2007 Gordon Conference, South Hadley, MA, USA, 8-13 July 2007
- *Molecules in Space and Laboratory*, Paris, France, 14-18 May 2007
- *Astronomy in the Submillimeter and Far Infrared Domains with the Herschel Space Observatory*, Les Houches Winter School, France, 23 April - 4 May 2007
- *Titan Observations, Experiments, Computations, and Modeling*, Honolulu, HI, USA, 5-7 February 2007
- *Science with ALMA: a New Era for Astrophysics*, Madrid, Spain, 13-16 November 2006
- *IS Medium*, Heidelberg Summer School, Germany, 25-29 September 2006
- *From Dust to Planetesimals*, Ringberg Castle, Bavaria, Germany, 11-15 September 2006
- *Cosmic Chemistry and Molecular Astrophysics*, Nobel Symposium, Sudertuna, Sweden, 10-15 June 2006
- *Complex Molecules in Space – present Status and Prospects with ALMA*, Fuglsocentret, Denmark, 8-11 June 2006
- *Carbon in Space*, International workshop, Lago di Como, Italy, 22-25 June 2006
- *NASA Laboratory Astrophysics Workshop*, Las Vegas, NV, USA, 14-16 February 2006
- *Astrochemistry - A Molecular Approach*, Honolulu, HI, USA, 17-18 December 2005
- *Hunt for Molecules*, Paris, France, 19-20 September 2005
- *Protostars and Planets. V*, Big Island, HI, USA, 24-28 October 2005
- *5th. European Workshop on Astrobiology*, Budapest, Hungary, 10-12 October 2005
- *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, IAU Symposium No. 231, Monterey, CA, USA, 29 August - 2 September 2005
- *Astrobiology and the Origins of Life*, Hamilton, Canada, 24 May -10 June 2005
- *The Spitzer Space Telescope: New Views of the Cosmos*, Pasadena, CA, USA, 9-12 November 2004
- *The Dusty and Molecular Universe: A prelude to Herschel and ALMA*, Paris, France, 27-29 October 2004

- *Effects of Space Radiation on Solar System Ices*, AOGS 2004 Session SP2, Singapore, 5-9 July 2004
- *Astrophysics of Dust*, Estes Park, CO, USA, 2003

Published works in the area of molecular reactions on solid surfaces have been sorted in 4 sections:

- reviews
- observations of dust and ices in the ISM
- dust (formation, properties, and exposure to space environment)
- interactions of atoms and molecules with solids in simulated ISM conditions
- interaction of radiation and charged particles with ices in simulated ISM conditions

Obviously, there is a certain degree of arbitrariness in the sorting. Several papers could be entered in more than one section. The papers listed here are the ones that appeared in print since the last review by the Working Group on Molecular Reactions on Solid Surfaces in 2002; therefore, this report covers a six-year period. Works are listed in inverse chronological order.

3. Reviews

References

- Charnley, S. B. & Rodgers, S. D. 2008, *SSRv*, 40. *IS reservoirs of cometary matter*
- Williams, D. A., Brown, W. A., Price, S. D., *et al.* 2007, *Astron. & Geophys.*, 48, 25. *Molecules, ices and astronomy*
- Tothill, N. F. H. 2007, *EAS-PS*, 25, 327. *AST/RO: lessons from a decade of sub-mm astronomy at the South Pole*
- Slavin, J. D. & Frisch, P. C. 2007, *SSRv*, 130, 409. *The chemical composition of IS matter at the solar location*
- Herbst, E. & Cuppen, H. M. 2006, *PNAS*, 103, 12257. *IS chemistry special feature: Monte Carlo studies of surface chemistry and nonthermal desorption involving IS grains*
- Dartois, E. 2005, *SSRv*, 119, 293. *The ice survey opportunity of ISO.*
- Abergel, A., Verstraete, L., Joblin, C., *et al.* 2005, *SSRv*, 119, 247. *The cool IS medium*
- Molster, F. & Kemper, C. 2005, *SSRv*, 119, 3. *Crystalline silicates*
- Grün, E., Srama, R., Krüger, H., *et al.* 2005, *Icarus*, 174, 1. *Dust astronomy. 2002 Kuiper Prize lecture*
- van Dishoeck, E. F. 2004, *ARAA* 42, 119. *ISO spectroscopy of gas and dust – from molecular clouds to protoplanetary disks*
- Clayton, D. D., Nittler, L. R. 2004, *ARAA*, 42, 39. *Astrophysics with presolar stardust*
- Dorschner, J. 2003, *Astromineralogy* 609, 1. *From dust astrophysics towards dust mineralogy - a historical review*
- Draine, B. T. 2003, *ARAA* 41, 241. *IS dust grains*
- Williams, D. A. & Viti, S. 2002, *Ann. Rep. Prog. Chem. Sect. C* 98, 87. *Recent progress in astrochemistry*

4. Observations of dust and ices in the ISM

References

- Öberg, K. I., Boogert, A. C. A., Pontoppidan, K. M., *et al.* 2008, *ApJ*, 678, 1032. *The c2d Spitzer spectroscopic survey of ices around low-mass young stellar objects. III. CH₄*
- Pontoppidan, K. M., Boogert, A. C. A., Fraser, H. J., *et al.* 2008, *ApJ*, 678, 1005. *The c2d Spitzer spectroscopic survey of ices around low-mass young stellar objects. II. CO₂*
- Boogert, A. C. A., Pontoppidan, K. M., Knez, C., *et al.*, 2008, *ApJ*, 678, 985. *The c2d Spitzer spectroscopic survey of ices around low-mass young stellar objects. I. H₂O and the 5-8 μm bands*

- Sonnentrucker, P., Neufeld, D. A., Gerakines, P. A., *et al.* 2008, *ApJ*, 672, 361-370. *Fully sampled maps of ices and silicates in front of Cepheus A East with the Spitzer Space Telescope*
- Li, Y., Li, A., & Wei, D. M. 2008, *ApJ*, 678, 1136. *Determining the dust extinction of gamma-ray burst host galaxies: a direct method based on optical and X-ray photometry*
- Hough, J. H., Aitken, D. K., Whittet, D. C. B., *et al.* 2008, *MNRAS*, 387, 797. *Grain alignment in dense IS environments: spectropolarimetry of the 4.67- μm CO-ice feature in the field star Elias 16 (Taurus dark cloud)*
- Sirocky, M. M., Levenson, N. A., Elitzur, M., *et al.* 2008, *ApJ*, 678, 729. *Silicates in ultraluminous infrared galaxies*
- Berné, O., Joblin, C., Rapacioli, M., *et al.* 2008, *A&A* (Letters), 479, L41. *Extended red emission and the evolution of carbonaceous nanograins in NGC 7023*
- Li, Y., Hopkins, P. F., Hernquist, L., *et al.* 2008, *ApJ*, 678, 41. *Modeling the dust properties of $z \approx 6$ quasars with ART² – All-wavelength Radiative Transfer with Adaptive Refinement Tree*
- Nozawa, T., Kozasa, T., Habe, A., *et al.* 2008, in: *Origin of Matter and Evolution of Galaxies*, AIP-CP, 1016, 55. *Evolution of dust in primordial supernova remnants and its influence on the elemental composition of hyper-metal-poor stars*
- Dwek, E., Arendt, R. G.; Bouchet, P., *et al.* 2008, *ApJ*, 676, 1029. *Infrared and X-Ray evidence for circumstellar grain destruction by the blast wave of Supernova 1987A*
- Draine, B. T., Dale, D. A., Bendo, G., *et al.* 2007, *ApJ*, 663, 866. *Dust masses, PAH abundances, and starlight intensities in the SINGS galaxy sample*
- Angeloni, R., Contini, M., Ciroi, S., & Rafanelli, P. 2007, *AJ*, 134, 205. *Silicates in D-Type symbiotic stars: an Infrared Space Observatory overview*
- Mason, R. E., Wright, G. S., Adamson, A., & Pendleton, Y. 2007, *ApJ*, 656, 798. *Spectropolarimetry of the 3.4 μm absorption feature in NGC 1068*
- Terada, H., Tokunaga, A. T., Kobayashi, *et al.* 2007, *ApJ*, 667, 303. *Detection of water ice in edge-on protoplanetary disks: HK Tauri B and HV Tauri C*
- Quanz, S. P., Henning, T., Bouwman, J., *et al.* 2007, *ApJ*, 668, 359. *Evolution of dust and ice features around FU Orionis objects*
- Whittet, D. C. B., Shenoy, S. S., Bergin, E. A., *et al.* 2007. *ApJ*, 655, 332. *The abundance of carbon dioxide ice in the quiescent intracloud medium*
- Markwick-Kemper, F., Gallagher, S. C., Hines, D. C., & Bouwman, J. 2007, *ApJ* (Letters), 668, L107. *Dust in the wind: crystalline silicates, corundum, and periclase in PG 2112+059*
- Bottinelli, S., Boogert, A. C. A., van Dishoeck, E. F., Oberg, K., *et al.* 2007, in: J. L. Lemaire & F. Combes (eds.), *Molecules in Space and Laboratory* (Paris: S. Diana), p. 11. *NH₃ and CH₃OH in ices surrounding low-mass YSOs*
- Bai, L., Rieke, G. H., & Rieke, M. J. 2007, *ApJ* (Letters), 668, L5. *A search for infrared emission from intracluster dust in Abell 2029*
- Davis, S. S. 2007, *ApJ*, 660, 1580. *Ice formation in radiated accretion disks*
- Ellison, S. L., Prochaska, J. X., & Lopez, S. 2007, *MNRAS*, 380, 1245. *The Galactic deuterium abundance and dust depletion: insights from an expanded Ti/H sample*
- Vollmer, C., Hoppe, P., Brenker, F. E., & Holzapfel, C. 2007, *ApJ* (Letters), 666, L49. *Stellar MgSiO₃ perovskite: a shock-transformed stardust silicate found in a meteorite*
- Bacmann, A., Lefloch, B., Parise, B., *et al.* 2007, in: J. L. Lemaire & F. Combes (eds.), *Molecules in Space and Laboratory* (Paris: S. Diana), p. 9. *Methanol and deuterium fractionation in pre-stellar cores*
- Maiolino, R. 2007, in: K. A. van der Hucht (ed.), *Highlights of Astronomy*, 14, 262. *Dust at $z > 6$. Observations and theory*
- Andersson, B.-G. & Potter, S. B. 2007, *ApJ* 665, 369. *Observational constraints on IS grain alignment*
- Sujatha, N. V., Murthy, J., Shalima, P., & Henry, R. C. 2007, *ApJ*, 665, 363. *Measurement of dust optical properties in the Coalsack nebula*
- Kulkarni, V. P., York, D. G., Vladilo, G., & Welty, D. E. 2007, *ApJ* (Letters), 663, L81. *9.7 μm silicate absorption in a damped Ly α absorber at $z = 0.52$*
- Bethell, T. J., Chepurnov, A., Lazarian, A., & Kim, J. 2007, *ApJ*, 663, 1055. *polarization of dust emission in clumpy molecular clouds and cores*

- Dwek, E., Galliano, F., & Jones, A. P. 2007, *ApJ*, 662, 927. *The evolution of dust in the early Universe with applications to the galaxy SDSS J1148+5251*
- Dessauges-Zavadsky, M., Combes, F., & Pfenniger, D. 2007, *A&A* 473, 863. *Molecular gas in high-velocity clouds: revisited scenario*
- Bisschop, S. E., Jørgensen, J. K., van Dishoeck, E. F., & de Wachter, E. B. M. 2007, *A&A*, 465, 913. *Testing grain-surface chemistry in massive hot-core regions*
- Inoue, A. K., Buat, V., Burgarella, D., et al. 2006, *MNRAS*, 370, 380. *Effects of dust scattering albedo and 2175-Å bump on ultraviolet colours of normal disc galaxies*
- Colangeli, L. 2006, *MemSAIS*, 9, 161. *Measurement of dust properties in different solar system environments*
- Nozawa, T., Kozasa, T., & Habe, A. 2006, *ApJ*, 648, 435. *Dust destruction in the high-velocity shocks driven by supernovae in the early Universe*
- Spoon, H. W. W., Tielens, A. G. G. M., Armus, L., et al. 2006, *ApJ*, 638, 759. *The detection of crystalline silicates in ultraluminous infrared galaxies*
- Sofia, U. J., Gordon, K. D., Clayton, G. C., et al. 2006, *ApJ*, 636, 753. *Probing the dust responsible for Small Magellanic Cloud extinction*
- Huard, T. L., Pontoppidan, K. M., Boogert, A., et al. 2006, *BAAS*, 38, 1055. *Variations in the extinction law, ice abundance, and dust grains in molecular cloud cores*
- Chiar, J. E., Pendleton, Y., Ennico, K., et al. 2006, *BAAS*, 38, 1013. *The non-linear relationship between silicate absorption depth and IR extinction in dense clouds*
- Huebner, W. F. & Snyder, L. E. 2006, in: *Comets and the Origin and Evolution of Life* (Springer), p.113. *Macromolecules: from star-forming regions to comets to the origins of life*
- Prieto-Ballesteros, O., Kargel, J. S., Fernández-Sampedro, M., et al. 2005, *Icarus*, 177, 491. *Evaluation of the possible presence of clathrate hydrates in Europa's icy shell or seafloor*
- Knez, C., Boogert, A. C. A., Pontoppidan, K. M., Kessler-Silacci, J., et al. 2005. *ApJ* (Letters), 635, L145. *Spitzer mid-infrared spectroscopy of ices toward extincted background stars.*
- Velusamy, T., Langer, W. D., & Willacy, K. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p.137. *CO₂ ice in cold dense dark cloud cores: abundance vs. visual extinction*
- Lee, J. C. & Ravel, B. 2005, in: *X-ray Diagnostics of Astrophysical Plasmas: Theory, Experiment, and Observation AIP-CP*, 774, 255. *Prospects for determining the grain composition of the IS medium with Chandra and Astro E2.*
- Bernstein, M. P., Sandford, S. A., & Allamandola, L. J. 2005, *ApJS*, 161, 53. *The mid-infrared absorption spectra of neutral polycyclic aromatic hydrocarbons in conditions relevant to dense IS clouds*
- Ruiterkamp, R., Cox, N. L. J., Spaans, M., et al. 2005, *A&A*, 432, 515. *PAH charge state distribution and DIB carriers: implications from the line of sight toward HD 147889*
- Massey, P., Plez, B., Levesque, E. M., et al. 2005, *ApJ*, 634, 1286. *The reddening of red supergiants: when smoke gets in your eyes*
- Andrews, S. M. & Williams, J. P. 2005, *ApJ*, 631, 1134. *Circumstellar dust disks in Taurus-Auriga: the sub-millimeter perspective*
- Stratta, G., Perna, R., Lazzati, D., et al. 2005, *NCimC* 28, 693. *Dust extinction properties of a sample of bright X-rays afterglows*
- del Burgo, C. & Laureijs, R. J. 2005, *MNRAS*, 360, 901. *New Insights into the dust properties of the Taurus molecular cloud TMC-2 and its surroundings*
- Joblin, C., Abergel, A., Bernard, J.-P., et al. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p.194. *Very small particles and chemistry in photo-dissociation regions: from ISO to Spitzer*
- Remijan, A. J., Hollis, J. M., Lovas, F. J., et al. 2005, *ApJ*, 632, 333. *IS isomers: the importance of bonding energy differences*
- Gerakines, P. A., Bray, J. J., Davis, A., & Richey, C. R. 2005, *ApJ*, 620, 1140. *The strengths of near-infrared absorption features relevant to IS and planetary ices*
- Snell, R. L., Hollenbach, D., Howe, J. E., et al. 2005, *ApJ*, 620, 758. *Detection of water in the shocked gas associated with IC 443: constraints on shock models*

- Pontoppidan, K. M. & the c2d Team 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p.319. *The spatial distribution of ices in star-forming regions*
- van Boekel, R., Min, M., Waters, L. B. F. M., *et al.* 2005, *A&A*, 437, 189. *A 10 μm spectroscopic survey of herbig Ae star disks: grain growth and crystallization*
- Duchêne, G., McCabe, C., Ghez, A. M., & Macintosh, B. A. 2004, *ApJ*, 606, 969. *A multiwavelength scattered light analysis of the dust grain population in the GG Tauri circum-binary ring*
- Jones, A. P., d'Hendecourt, L. B., Sheu, S.-Y., *et al.* 2004, *A&A*, 416, 235. *Surface C-H stretching features on meteoritic nanodiamonds*
- Pendleton, Y. J. 2004, in: A. N. Witt, G. C. Clayton & B. T. Draine (eds.), *Astrophysics of Dust ASP-CS*, 309, 573. *Hydrocarbons in meteorites, the Milky Way, and other galaxies*
- Bot, C., Boulanger, F., Lagache, *et al.* 2004, *A&A*, 423, 567. *Multi-wavelength analysis of the dust emission in the Small Magellanic Cloud*
- Ehrenfreund, P., Fraser, H. J., Blum, J., *et al.* 2003, *P&SS*, 51, 473. *Physics and chemistry of icy particles in the Universe: answers from microgravity*
- Johnstone, D., Fiege, J. D., Redman, R. O., *et al.* 2003, *ApJ* (Letters), 588, L37. *The G11.11-0.12 infrared-dark cloud: anomalous dust and a non-magnetic isothermal model*
- Wolf, S., Padgett, D. L., & Stapelfeldt, K. R. 2003, *ApJ*, 588, 373. *The circumstellar disk of the butterfly star in Taurus.*
- Kimura, H., Mann, I., & Jessberger, E. K. 2003, *ApJ*, 582, 846. *Elemental abundances and mass densities of dust and gas in the Local IS Cloud*
- Lu, N., Helou, G., Werner, M. W., *et al.* 2003, *ApJ*, 588, 199. *Infrared emission of normal galaxies from 2.5 to 12 μm : ISO spectra, near-IR continuum, and mid-IR emission features*
- Savaglio, S., Fall, S. M., & Fiore, F. 2003, *ApJ*, 585, 638. *Heavy-element abundances and dust depletions in the host galaxies of three γ -ray bursts*
- Weingartner, J. C. & Murray, N. 2002, *ApJ*, 580, 88. *X-ray vs. optical observations of active galactic nuclei: evidence for large grains?*
- Dupac, X., Giard, M., Bernard, J.-P., *et al.* 2002, *A&A*, 392, 691. *Sub-millimeter dust emission of the M 17 complex measured with PRONAOS*
- Ishii, M., Nagata, T., Chrysostomou, A., & Hough, J. H. 2002, *AJ*, 124, 2790. *3.4 μm feature on the shoulder of ice-band absorptions in three luminous young stellar objects: IRAS 18511+0146, IRAS 21413+5442, and IRAS 04579+4703*
- Boogert, A. C. A., Blake, G. A., Tielens, A. G. G. M. 2002, *ApJ*, 577, 271. *High-resolution 4.7 μm Keck/NIRSPEC spectra of protostars. II. Detection of the ^{13}C CO isotope in icy grain mantles*
- Chiar, J. E., Adamson, A. J., Pendleton, Y. J., *et al.* 2002, *ApJ*, 570, 209. *Hydrocarbons, ices, and 'XCN' in the line of sight toward the Galactic Center*
- Pendleton, Y. J. & Allamandola, L. J. 2002, *ApJS*, 138, 75. *The organic refractory material in the diffuse IS medium: mid-IR spectroscopic constraints*

5. Properties of dust

References

- Thompson, S. P. 2008, *A&A*, 484, 251. *Structural signatures of medium-range order in annealed laboratory silicates*
- Mason, N. J., Drage, E. A., Webb, S. M., *et al.* 2008, *Faraday Discuss.*, 137, 367. *The spectroscopy and chemical dynamics of micro-particles explored using an ultrasonic trap*
- Whittet, D. C. B., Hough, J. H., Lazarian, A., & Hoang, T. 2008, *ApJ*, 674, 304. *The efficiency of grain alignment in dense IS clouds: a re-assessment of constraints from near-IR polarization*
- Iatì, M. A., Saija, R., Borghese, F., *et al.* 2008, *MNRAS*, 384, 591. *Stratified dust grains in the IS medium. I. An accurate computational method for calculating their optical properties*
- Lazzati, D. 2008, *MNRAS*, 384, 165. *Non-LTE dust nucleation in sub-saturated vapours*
- Rosenberg, J. L., Wu, Y., Le Floc'h, E., *et al.* 2008, *ApJ*, 674, 814. *Dust properties and star-formation rates in star-forming dwarf galaxies*

- Engelbracht, C. W., Rieke, G. H., Gordon, K. D., *et al.* 2008, *ApJ*, 678, 804. *Metallicity effects on dust properties in starbursting galaxies*
- Voshchinnikov, N. V., & Henning, T. 2008, *A&A* (Letters), 483, L9. *Is the silicate emission feature only influenced by grain size?*
- Jiménez-Serra, I., Caselli, P., Martín-Pintado, J., Hartquist, T. W. 2008, *A&A*, 482, 549. *Parametrization of C-shocks. Evolution of the sputtering of grains*
- Pitman, K. M., Hofmeister, A. M., Cormann, A. B., & Speck, A. K. 2008, *A&A*, 483, 661. *Optical properties of silicon carbide for astrophysical applications. I. New laboratory IR reflectance spectra and optical constants*
- Calura, F., Pipino, A., & Matteucci, F. 2008, *A&A*, 479, 669. *The cycle of IS dust in galaxies of different morphological types*
- Weingartner, J. C. & Jordan, M. E. 2008, *ApJ*, 672, 382. *Torques on spheroidal silicate grains exposed to anisotropic IS radiation fields*
- Fabian, A. C., Vasudevan, R. V., & Gandhi, P. 2008, *MNRAS* (Letters), 385, L43. *The effect of radiation pressure on dusty absorbing gas around active galactic nuclei*
- Lazarian, A. & Hoang, T. 2008, *ApJ* (Letters), 676, L25. *Alignment of dust with magnetic inclusions: radiative torques and superparamagnetic Barnett and nuclear relaxation*
- Nozawa, T., Kozasa, T., Habe, A., *et al.* 2008, in: *First Stars III AIP-CP*, 990, 426. *Dust evolution in Pop. III supernova remnants*
- Zhukovska, S., Gail, H.-P., & Trieloff, M. 2008, *A&A*, 479, 453. *Evolution of IS dust and stardust in the solar neighbourhood*
- Guillet, V., Pineau Des Forêts, G., & Jones, A. P. 2007, *A&A*, 476, 263. *Shocks in dense clouds. I. Dust dynamics*
- Dartois, E. 2007, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 54. *IS dust grains: the hydrogenated amorphous carbon contribution*
- Wada, K., Tanaka, H., Suyama, T., *et al.* 2007, *ApJ*, 661, 320. *Numerical simulation of dust aggregate collisions. I. Compression and disruption of 2-D aggregates*
- Draine, B. T., Li, A. 2007, *ApJ*, 657, 810. *Infrared emission from IS dust. IV. The silicate-graphite-PAH model in the post-Spitzer era*
- Ferguson, J. W., Heffner-Wong, A., Penley, J. J., *et al.* 2007, *ApJ*, 666, 261. *Grain physics and Rosseland-mean opacities*
- Vaidya, D. B., Gupta, R., & Snow, T. P. 2007, *MNRAS*, 379, 800. *Composite IS grains*
- Miville-Deschênes, M.-A., Lagache, G., Boulanger, F., & Puget, J.-L. 2007, *A&A*, 469, 595. *Statistical properties of dust far-IR emission*
- Maheswar, G., Muthu, C., Sujatha, N. V., *et al.* 2007, *BASI*, 35, 233. *IS dust studies with TAUVEX*
- Djouadi, Z., Gattacceca, J., D'Hendecourt, L., *et al.* 2007, *A&A* (Letters), 468, L9. *Ferromagnetic inclusions in silicate thin films: insights into the magnetic properties of cosmic grains*
- Huss, G. R. & Draine, B. T. 2007, in: K. A. van der Hucht (ed.), *Highlights of Astronomy*, 14, 353. *What can pre-solar grains tell us about the Solar nebula?*
- Nguyen, A. N., Stadermann, F. J., Zinner, E., *et al.* 2007, *ApJ*, 656, 1223. *Characterization of pre-solar silicate and oxide grains in primitive carbonaceous chondrites*
- Ott, U., Hoppe, P. 2007. Pre-solar Grains in Meteorites and Interplanetary Dust: an Overview. *Highlights of Astronomy* 14, 341-344
- Min, M., Waters, L. B. F. M., de Koter, A., *et al.* 2007, *A&A*, 462, 667. *The shape and composition of IS silicate grains*
- Pelkonen, V.-M., Juvela, M., & Padoan, P. 2007, *A&A*, 461, 551. *Simulations of polarized dust emission*
- Ormel, C. W., Spaans, M., Tielens, A. G. G. M. 2007, *A&A*, 461, 215. *Dust coagulation in protoplanetary disks: porosity matters*
- Patil, M. K., Pandey, S. K., Sahu, D. K., & Kembhavi, A. 2007, *A&A*, 461, 103. *Properties of dust in early-type galaxies*
- Vaillancourt, J. E. 2007, *EAS-PS*, 23, 147. *Polarized emission from IS dust*
- Lazarian, A. 2007, *JQSRT*, 106, 225. *Tracing magnetic fields with aligned grains*
- Ehrenfreund, P., Ruiterkamp, R., Peeters, Z., *et al.* 2007, *P&SS*, 55, 383. *The ORGANICS Experiment on BIOPAN V: UV and space exposure of aromatic compounds*

- Li, M. P., Zhao, G., & Li, A. 2007, *MNRAS* (Letters), 382, L26. *On the crystallinity of silicate dust in the IS medium*
- Bianchi, S. & Schneider, R. 2007, *MNRAS*, 378, 973. *Dust formation and survival in supernova ejecta*
- Lazarian, A. & Hoang, T. 2007, *MNRAS*, 378, 910. *Radiative torques: analytical model and basic properties*
- Abbas, M. M., Tankosic, D., Craven, P. D., et al. 2006, *ApJ*, 645, 324. *Photoelectric emission measurements on the analogs of individual cosmic dust grains*
- Duley, W. W. 2006, *Faraday Discuss.*, 133, 415. *Polycyclic aromatic hydrocarbons, carbon nanoparticles and the diffuse IS bands*
- Ehrenfreund, P., Ruiterkamp, R., Peeters, Z., et al. 2006, *COSPAR*, 36, 3635. *The ORGANICS Experiments on BIOPAN V: UV and space exposure of aromatic compounds*
- Freund, M. M. & Freund, F. T. 2006, *ApJ*, 639, 210. *Solid solution model for IS dust grains and their organics*
- Altobelli, N., Grün, E., & Landgraf, M. 2006, *A&A*, 448, 243. *A new look into the Helios dust experiment data: presence of IS dust inside the Earth's orbit*
- Stroud, R. M. 2005, in: A. N. Krot, E. R. D. Scott & B. Reipurth (eds.), *Chondrites and the Protoplanetary Disk, ASP-CS*, 341, 645. *Micro-structural investigations of the cosmochemical histories of pre-solar grains*
- Kemper, F., Vriend, W. J., & Tielens, A. G. G. M. 2005, *ApJ* 633, 534. *Erratum: 'The absence of crystalline silicates in the diffuse IS medium', ApJ, 609, 826, 2004*
- Ruiterkamp, R., Cox, N. L. J., Spaans, M., et al. 2005, *A&A*, 432, 515. *PAH charge state distribution and DIB carriers: implications from the line of sight toward HD 147889*
- Tielens, A. G. G. M., Waters, L. B. F. M., & Bernatowicz, T. J. 2005, in: A. N. Krot, E. R. D. Scott & B. Reipurth (eds.), *Chondrites and the Protoplanetary Disk, ASP-CS*, 341, 605. *Origin and evolution of dust in circumstellar and IS environments*
- Dwek, E. 2005, in: *Planetary Nebulae as Astronomical Tools, AIP-CP*, 804, 197. *The chemical evolution of IS dust*
- Grün, E., Srama, R., Krüger, H., et al. 2005, *Icarus*, 174, 1. *2002 Kuiper Prize Lecture: Dust Astronomy*
- Draine, B. T. 2005, *ESA-SP*, 577, 251. *Infrared emission and models of IS dust*
- Voshchinnikov, N. V., Il'in, V. B., & Henning, T. 2005, *A&A*, 429, 371. *Modelling the optical properties of composite and porous IS grains*
- Bréchnignac, P. & Schmidt, M. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p.255. *From cold gas phase coronene clusters to hydrocarbonated nanograins*
- Rapacioli, M., Joblin, C., Calvo, F., et al. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p.200. *Theoretical properties of polycyclic aromatic hydrocarbon clusters of astrophysical interest*
- Mennella, V. 2005, *JPhCS*, 6, 197. *Dust evolution from the laboratory to the IS medium*
- van Breugel, W., Bajt, S., Bradley, J., et al. 2005, in: A. Wilson (ed.), *The Dusty and Molecular Universe: a Prelude to Herschel and ALMA, ESA-SP*, 577, 91. *Star formation in high-pressure, high-energy density environments: laboratory experiments of ISM dust analogs*
- Wooden, D. H., Harker, D. E., & Brearley, A. J. 2005, in: A. N. Krot, E. R. D. Scott & B. Reipurth (eds.), *Chondrites and the Protoplanetary Disk, ASP-CS*, 341, 774. *Thermal processing and radial mixing of dust: evidence from comets and primitive chondrites*
- Zinov'Eva, T. V. 2005, *AstL*, 31, 458. *Modeling infrared absorption bands with non-spherical particles*
- Biennier, L., Hammond, M., Elsila, J., et al. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p.214. *From organic molecules to carbon particles: implications for the formation of IS Dust*
- Keane, J. V., Pendleton, Y. J., & Allamandola, L. J. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*,

- Proc. IAU Symposium No. 231 (Cambridge: CUP), p.242. *Refractory carbonaceous material in luminous galaxies: mid-IR spectroscopic constraints*
- Salama, F. & Biennier, L. 2004, *COSPAR*, 35, 3067. *Formation and destruction processes of IS dust: from organic molecules to carbonaceous grains*
- Zubko, V., Dwek, E., & Arendt, R. G. 2004, *ApJS*, 152, 211. *IS dust models consistent with extinction, emission, and abundance constraints*
- Li, A. 2004. in: A. N. Witt, G. C. Clayton & B. T. Draine (eds.), *Astrophysics of Dust*, ASP-CS, 309, 417. *Interaction of nanoparticles with radiation*
- Iatì, M. A., Giusto, A., Saija, R., et al. 2004, *ApJ*, 615, 286. *Optical properties of composite IS grains: a morphological analysis*
- Jones, A. P. & D'Hendecourt, L. B. 2004, in: A. N. Witt, G. C. Clayton & B. T. Draine (eds.), *Astrophysics of Dust*, ASP-CS, 309, 589. *IS nano-diamonds*
- Shenoy, S. S., Whittet, D. C. B., Chiar, J. E., et al. 2003, *ApJ*, 591, 962. *A test case for the organic refractory model of IS dust*
- Hegmann, M. & Kegel, W. H. 2003, *MNRAS*, 342, 453. *Radiative transfer in clumpy environments: absorption and scattering by dust*
- Gibson, S. J. & Nordsieck, K. H. 2003, *ApJ*, 589, 362. *The Pleiades reflection nebula. II. Simple model constraints on dust properties and scattering geometry*
- Stepnik, B., Abergel, A., Bernard, J.-P., et al. 2003, *A&A*, 398, 551. *Evolution of dust properties in an IS filament*
- Juvela, M. & Padoan, P. 2003, *A&A*, 397, 201. *Dust emission from inhomogeneous IS clouds: radiative transfer in 3-D with transiently heated particles*
- Mann, I. & Jessberger, E. K. 2003, *Astromineralogy*, 609, 189. *The in-situ study of solid particles in the Solar system*
- Hanner, M. S. 2003, *Astromineralogy* 609, 171. *The mineralogy of cometary dust*
- Lazarian, A. 2003, *JQSRT* 79, 881. *Magnetic fields via polarimetry: progress of grain alignment theory*
- Mathis, J. S., Whitney, B. A., & Wood, K. 2002, *ApJ*, 574, 812. *Can reflection from grains diagnose the albedo?*
- Stepnik, B., Abergel, A., Bernard, J. P., et al. 2002, in: M. Giard et al. (eds.), *Infrared and Sub-millimeter Space Astronomy*, EAS-PS, 4, 309. *Evolution of IS dust properties from diffuse medium to a dense cloud*
- Stepnik, B., Jones, A. P., Abergel, A., et al. 2002. in: M. Giard et al. (eds.), *Infrared and Sub-millimeter Space Astronomy*, EAS-PS, 4, 31. *Grain-grain co-agulation in the ISM*
- Ruiterkamp, R., Ehrenfreund, P., et al. 2002, in: F. Salama (ed.), *NASA Laboratory Astrophysics Workshop, NASA/CP-2002-21186*, p. 149. *Laboratory calibration studies in support of ORGANICS on the International Space Station: evolution of organic matter in space*
- Cox, N., Ehrenfreund, P., Cami, J., et al. 2002, in: H. Lacoste (ed.), *Proc. First European Workshop on Exo-Astrobiology*, ESA-SP 518, 447. *Complex carbon chemistry and the diffuse IS bands in the Magellanic Clouds*

6. Interactions of atoms and molecules with solids in simulated ISM conditions

References

- Luna, R., Millán, C., Domingo, M., & Satorre, M. Á. 2008, *Ap&SS*, 314, 113. *Thermal desorption of CH₄ retained in CO₂ ice*
- Cazaux, S., Caselli, P., Cobut, V., & Le Bourlot, J. 2008, *A&A*, 483, 495. *The role of carbon grains in the deuteration of H₂*
- Vidali, G., Pirronello, V., Li, L., et al. 2007, *JPhChA*, 111, 12611. *Analysis of molecular hydrogen formation on low temperature surfaces in temperature programmed desorption experiments*
- Li, L., Manico, G., Congiu, E., et al. 2007, in: J. L. Lemaire & F. Combes (eds.), *Molecules in Space and Laboratory* (Paris: S. Diana), p.58. *Formation of molecular hydrogen on amorphous silicate surfaces*
- Al-Halabi, A., van Dishoeck, E. F., 2007, *MNRAS*, 382, 1648. *Hydrogen adsorption and diffusion on amorphous solid water ice*

- Roberts, J. F., Rawlings, J. M. C., Viti, S., & Williams, D. A. 2007, *MNRAS*, 382, 733. *Description from IS ices*
- Perets, H. B., Lederhendler, A., Biham, O., *et al.* 2007, *ApJ* (Letters), 661, L163. *Molecular hydrogen formation on amorphous silicates under IS conditions*
- Bouwman, J., Ludwig, W., Awad, Z., *et al.* 2007, *A&A*, 476, 995. *Band profiles and band strengths in mixed H₂O:CO ices*
- Öberg, K. I., Fuchs, G. W., Awad, Z., *et al.* 2007, *ApJ* (Letters), 662, L23. *Photodesorption of CO ice*
- Chaabouni, H., Amiaud, L., Dulieu, F., *et al.* 2007, in: J. L. Lemaire & F. Combes (eds.), *Molecules in Space and Laboratory* (Paris: S. Diana), p.67. *Sticking of deuterium molecules onto non-porous water ice surface: temperature dependence of the impinging molecules*
- Chang, Q., Cuppen, H. M., & Herbst, E. 2007, *A&A*, 469, 973. *Gas-grain chemistry in cold IS cloud cores with a microscopic Monte Carlo approach to surface chemistry*
- Watanabe, N., Mouri, O., *et al.* 2007, *ApJ*, 668, 1001. *Laboratory simulation of competition between hydrogenation and photolysis in the chemical evolution of H₂O-CO ice mixtures*
- Canto, J., Gomis, O., Vilaplana, R., & Domingo, M. 2007, in: J. L. Lemaire & F. Combes (eds.), *Molecules in Space and Laboratory* (Paris: S. Diana), p. 65. *A laboratory for studying simple ices and their mixtures in the far-IR region*
- Bisschop, S. E., Fuchs, G. W., van Dishoeck, E. F., & Linnartz, H. 2007, *A&A*, 474, 1061. *H-atom bombardment of CO₂, HCOOH, and CH₃CHO containing ices*
- Xie, H.-B., Shao, C.-B., & Ding, Y.-H., 2007, *ApJ*, 670, 449. *Radical-molecule reaction C₃H + H₂O on amorphous water ice: a promising route for IS propynal*
- Amiaud, L., Dulieu, F., Fillion, J.-H., *et al.* 2007, *JChPh*, 127, 4709. *Interaction of atomic and molecular deuterium with a non-porous amorphous water ice surface between 8 and 30 K*
- Goldsmith, P.F. 2007, in: J. L. Lemaire & F. Combes (eds.), *Molecules in Space and Laboratory* (Paris: S. Diana), p.93. *Conversion of HI to H₂ and the age of molecular clouds*
- Goumans, T. P. M., Wander, A., Catlow, C. R. A., & Brown, W. A. 2007, *MNRAS*, 382, 1829. *Silica grain catalysis of methanol formation*
- Elsila, J. E., Dworkin, J. P., Bernstein, M. P., *et al.* 2007, *Mechanisms of amino acid formation in IS ice analogs ApJ*, 660, 911
- Bar-Nun, A., Notesco, G., & Owen, T. 2007, *Icarus*, 190, 655. *Trapping of N₂, CO and Ar in amorphous ice application to comets*
- Öberg, K. I., Fraser, H. J., Boogert, A. C. A., *et al.* 2007, *A&A*, 462, 1187. *Effects of CO₂ on H₂O band profiles and band strengths in mixed H₂O:CO₂ ices*
- Brown, W. A. & Bolina, A. S. 2007, *MNRAS*, 374, 1006. *Fundamental data on the desorption of pure IS ices*
- Hidaka, H., Kouchi, A., & Watanabe, N. 2007, *JChPh*, 126, 204707. *Temperature, composition, and hydrogen isotope effect in the hydrogenation of CO on amorphous ice surface at 10-20 K*
- Gálvez, O., Ortega, I. K., Maté, B., *et al.* 2007, *A&A*, 472, 691. *A study of the interaction of CO₂ with water ice*
- Acharyya, K., Fuchs, G. W., Fraser, H. J., *et al.* 2007, *A&A*, 466, 1005. *Desorption of CO and O₂ IS ice analogs*
- Garrod, R. T., Wakelam, V., & Herbst, E. 2007, *A&A*, 467, 1103. *Non-thermal desorption from IS dust grains via exo-thermic surface reactions*
- Xie, H.-B., Shi, G.-S., & Ding, Y.-H. 2007, *ApJ*, 662, 758. *Chemical behavior of polycyanoacetylene radicals on gaseous and ice water: a computational perspective*
- Linnartz, H., Acharyya, K., Awad, Z., *et al.* 2007, in: J. L. Lemaire & F. Combes (eds.), *Molecules in Space and Laboratory* (Paris: S. Diana), p.47. *Solid state astrophysics and -Chemistry four Questions- four answers*
- Bisschop, S. E., Fuchs, G. W., Boogert, A. C. A., *et al.* 2007, *A&A*, 470, 749. *Infrared spectroscopy of HCOOH in IS ice analogues*
- Bernstein, M. P., Sandford, S. A., Mattioda, A. L., & Allamandola, L. J. 2007, *ApJ*, 664, 1264. *Near- and mid-IR laboratory spectra of PAH cations in solid H₂O*
- Barzel, B. & Biham, O. 2007, *ApJ* (Letters), 658, L37. *Efficient simulations of IS gas-grain chemistry using moment equations*
- Cuppen, H. M. & Herbst, E. 2007, *ApJ*, 668, 294. *Simulation of the formation and morphology of ice mantles on IS grains*

- Xie, H.-B., Ding, Y.-H., & Sun, C.-C. 2006, *ApJ*, 643, 573. *Reaction mechanism of oxygen atoms with cyanoacetylene in the gas phase and on water ice*
- Brown, W. A., Viti, S., Wolff, A. J., & Bolina, A. S. 2006, *Faraday Discuss.*, 133, 113. *Laboratory investigations of the role of the grain surface in astrochemical models*
- Ehrenfreund, P. & Sephton, M. A. 2006, *Carbon molecules in space: from astrochemistry to astrobiology Faraday Discuss.* 133, 277
- Garrod, R., Park, I. H., Caselli, P., & Herbst, E. 2006, *Faraday Discuss.*, 133, 51. *Are gas-phase models of IS chemistry tenable? The case of methanol*
- Madzunkov, S., Shortt, B. J., MacAskill, J. A., et al. 2006, *PRA*, 73, 020901. *Measurements of polyatomic molecule formation on an icy grain analog using fast atoms*
- Hiraoka, K., Mochizuki, N., & Wada, A. 2006, in: *Astrochemistry - from Laboratory Studies to Astronomical Observations AIP-CP*, 855, 86. *How are CH₃OH, HNC/HCN, and NH₃ formed in the IS Medium?*
- van Dishoeck, E. F., Acharyya, K., Al-Halabi, A., et al. 2006, in: *Astrochemistry - from Laboratory Studies to Astronomical Observations AIP-CP*, 855, 113. *Spectroscopy and processing of IS ice analogs*
- Peeters, Z., Rodgers, S. D., Charnley, S. B., et al. 2006, *A&A*, 445, 197. *Astrochemistry of dimethyl ether*
- Bisschop, S. E., Fraser, H. J., Öberg, K. I., et al. 2006, *A&A*, 449, 1297. *Desorption rates and sticking coefficients for CO and N₂ IS ices*
- Collings, M. P., Chen, R., & McCoustra, M. R. S. 2006, in: *Astrochemistry - from Laboratory Studies to Astronomical Observations AIP-CP*, 855, 62. *Probing the morphology of IS ice analogues*
- Amiaud, L., Fillion, J. H., Baouche, S., et al. 2006, *JChPh*, 124, 4702. *Interaction of D₂ with H₂O amorphous ice studied by temperature-programed desorption experiments*
- Vidali, G., Roser, J. E., Li, L., et al. 2006, *Faraday Discuss.*, 133, 125. *The formation of IS molecules via reactions on dust grain surfaces*
- Watanabe, N., Hidaka, H., & Kouchi, A. 2006, in: *Astrochemistry - from Laboratory Studies to Astronomical Observations AIP-CP*, 855, 122. *Relative reaction rates of hydrogenation and deuteration of solid CO at very low temperatures*
- Woon, D. E. 2006, in: *Astrochemistry - from Laboratory Studies to Astronomical Observations AIP-CP*, 855, 305. *Ab initio quantum chemical studies of reactions in astrophysical ices - reactions involving CH₃OH, CO₂, CO, and HNCO in H₂CO/NH₃/H₂O ices*
- Fraser, H. J., Bisschop, S. E., Pontoppidan, K. M., et al. 2005, *MNRAS*, 356, 1283. *Probing the surfaces of IS dust grains: the adsorption of CO at bare grain surfaces*
- Lipshtat, A. & Biham, O. 2005, *MNRAS*, 362, 666. *The effect of grain size distribution on H₂ formation rate in the IS medium*
- Collings, M. P., Dever, J. W., McCoustra, & M. R. S. 2005, *CPL*, 415, 40. *Sub-monolayer coverages of CO on water ice*
- Öberg, K. I., van Broekhuizen, F., Fraser, H. J., et al. 2005, *ApJ (Letters)*, 621, L33. *Competition between CO and N₂ desorption from IS ices*
- Bisschop, S. E., Fraser, H. J., Fuchs, G., et al. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p.168. *The behavior of N₂ and O₂ in pure, mixed or layered CO ices*
- Roberts, H. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p.27. *Modelling of deuterium chemistry in star-forming regions*
- Charnley, S. B. & Rodgers, S. D. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p.237. *Pathways to molecular complexity*
- Hornekaer, L., Baurichter, A., Petrunin, V. V., & Luntz, A. C. 2005, *ESA-SP*, 577, 369. *The influence of dust grain morphology on H₂ formation and desorption in the IS medium*
- Fraser, H. J., Bisschop, S. E., Pontoppidan, K. M., et al. 2005, *MNRAS*, 356, 1283. *Probing the surfaces of IS dust grains: the adsorption of CO at bare grain surfaces*
- Woon, D. E. & Park, J.-Y. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium

- No. 231 (Cambridge: CUP), p. 89. *A density functional theory study of the formation and spectroscopy of the formate (HCOO^-) and ammonium (NH_4^+) ions in IS ices*
- Cuppen, H. M. & Herbst, E. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 34. *Molecular hydrogen formation on IS grains*
- Fillion, J.-H., Amiaud, L., Dulieu, F., *et al.* 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 101. *Experimental studies of H_2 and D_2 interaction with water ice films*
- Wolff, A. J. & Brown, W. A. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 57. *Mixed methanol/water ice on cosmic dust grain analogues*
- Vidali, G., Roser, J. E., Manicó, G., & Pirronello, V. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 355. *Molecular hydrogen formation on dust grains: a summary of experimental results on molecular hydrogen formation on dust grain analogues*
- Perets, H. B., Biham, O., Manicó, G., *et al.* 2005, *ApJ*, 627, 850. *Molecular hydrogen formation on ice under IS conditions*
- Vidali, G., Roser, J. E., Manicó, G., *et al.* 2005, *JPhCS*, 6, 36. *Formation of molecular hydrogen on analogues of IS dust grains: experiments and modelling*
- Fraser, H. J., Bisschop, S. E., Pontoppidan, K. M., *et al.* 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 31. *CO chemisorbed on bare grain surfaces: the potential for heterogeneous chemistry*
- Amiaud, L., Baouche, S., Dulieu, F., *et al.* 2004, in: F. Combes *et al.* (eds.), *SF2A-2004: Semaine de l'Astrophysique Française* (EdP-CS), p. 487. *D_2 sticking coefficient and desorption rate on various forms of water ice films under IS conditions*
- Al-Halabi, A., Fraser, H., Kroes, G. J., & van Dishoeck, E. F. 2004, *A&A*, 422, 777. *Adsorption of CO on amorphous water-ice surfaces*
- Sandford, S. A., Bernstein, M. P., & Allamandola, L. J. 2004, *ApJ*, 607, 346. *The mid-IR laboratory spectra of naphthalene (C_{10}H_8) in Solid H_2O*
- Vidali, G., Roser, J. E., Manicó, G., & Pirronello, V. 2004, *JGRE*, 109, E07S14. *Laboratory studies of formation of molecules on dust grain analogues under ISM conditions*
- Lipshtat, A., Biham, O., & Herbst, E. 2004, *MNRAS*, 348, 1055. *Enhanced production of HD and D_2 molecules on small dust grains in diffuse clouds*
- Morisset, S., Aguilon, F., Sizun, M., & Sidis, V. 2003, *PCCP*, 5, 506. *The dynamics of H_2 formation on a graphite surface at low temperature*
- Lipshtat, A. & Biham, O., 2003, *A&A*, 400, 585. *Moment equations for chemical reactions on IS dust grains*
- Meierhenrich, U. J., Muñoz Caro, G. M., Schutte, W. A., *et al.* 2002, *Exo-Astrobiology*, 518, 25. *The prebiotic synthesis of amino acids – IS vs. atmospheric mechanisms*
- Woon, D. E. 2002, *ApJ*, 569, 541. *Modeling gas-grain chemistry with quantum chemical cluster calculations. I. Heterogeneous hydrogenation of CO and H_2CO on icy grain mantles*
- Basiuk, V. A. & Bogillo, V. I. 2002, *AdSpR*, 30, 1439. *Theoretical study of amino acid precursor formation in the IS medium. I. Reaction of methylenimine with hydrogen cyanide*

7. Interaction of radiation and charged particles with ices in simulated ISM conditions

References

- Chen, Y.-J., Nuevo, M., Yih, T.-S., *et al.* 2008, *MNRAS*, 384, 605. *Amino acids produced from the UV/EUV irradiation of naphthalene in a $\text{H}_2\text{O}+\text{NH}_3$ ice mixture*
- Nuevo, M., Auger, G., Blanot, D., & D'Hendecourt, L. 2008, *OLEB*, 38, 37. *A detailed study of the amino acids produced from the vacuum UV irradiation of IS ice analogs*

- Zheng, W., Jewitt, D., Osamura, Y., & Kaiser, R. I. 2008, *ApJ*, 674, 1242. *Formation of nitrogen and hydrogen-bearing molecules in solid ammonia and implications for Solar system and IS ices*
- Thrower, J. D., Burke, D. J., Collings, M. P., *et al.* 2008, *ApJ*, 673, 1233. *Desorption of hot molecules from photon irradiated IS ices*
- Davoisne, C., Leroux, H., Frère, M., *et al.* 2008, *A&A*, 482, 541. *Chemical and morphological evolution of a silicate surface under low-energy ion irradiation*
- Chen, Y.-J., Nuevo, M., Hsieh, J.-M., *et al.* 2007, *A&A*, 464, 253. *Carbamic acid produced by the UV/EUV irradiation of IS ice analogs*
- Bringa, E. M., Kucheyev, S. O., Loeffler, M. J., *et al.* 2007, *ApJ*, 662, 372. *Energetic processing of IS silicate grains by cosmic rays*
- Zheng, W. & Kaiser, R. I. 2007, *CP*, 450, 55. *On the formation of carbonic acid (H_2CO_3) in Solar system ices*
- Bennett, C. J. & Kaiser, R. I. 2007, *ApJ*, 660, 1289. *The formation of acetic acid (CH_3COOH) in IS ice analogs*
- Bennett, C. J. & Kaiser, R. I. 2007, *ApJ*, 661, 899. *On the formation of glycolaldehyde ($HCOCH_2OH$) and methyl formate ($HCOOCH_3$) in IS ice analogs*
- Sivaraman, B., Jamieson, C. S., Mason, N. J., & Kaiser, R. I. 2007, *ApJ*, 669, 1414. *Temperature-dependent formation of ozone in solid oxygen by 5 keV electron irradiation and implications for Solar system ices*
- Wada, A., Mochizuki, N., & Hiraoka, K. 2006, *ApJ*, 644, 300. *Methanol formation from electron-irradiated mixed H_2O/CH_4 ice at 10 K*
- Ricca, A., Bakes, E. L. O., Bauschlicher, C. W. 2007, *ApJ*, 659, 858. *The energetics for hydrogen addition to naphthalene cations*
- Öberg, K. I., Fuchs, G. W., Awad, Z., *et al.* 2007, *ApJ* (Letters), 662, L23. *Photodesorption of CO ice*
- Schriver, A., Schriver-Mazzuoli, L., Ehrenfreund, P., & D'Hendecourt, L. 2007, *CP*, 334, 128. *One possible origin of ethanol in IS medium: photochemistry of mixed $CO_2C_2H_6$ films at 11 K. A FTIR study*
- Mason, N. J., Dawes, A., Holtom, P. D., *et al.* 2006, in: *Astrochemistry - From Laboratory Studies to Astronomical Observations AIP-CP*, 855, 128. *VUV spectroscopy of extraterrestrial ices*
- Loeffler, M. J., Raut, U., Vidal, R. A., *et al.* 2006, *Icarus*, 180, 265. *Synthesis of hydrogen peroxide in water ice by ion irradiation*
- Jamieson, C. S., Mebel, A. M., & Kaiser, R. I. 2006, *ApJS*, 163, 184. *Understanding the kinetics and dynamics of radiation-induced reaction pathways in carbon monoxide ice at 10 K*
- Palumbo, M. E. 2006, *A&A*, 453, 903. *Formation of compact solid water after ion irradiation at 15 K*
- Jamieson, C. S., Guo, Y., Gu, X., *et al.* 2006, in: F. Salama (ed.), *NASA Laboratory Astrophysics Workshop, NASA/CP-2002-21186*, p. 68. *Laboratory studies on the formation of carbon-bearing molecules in extraterrestrial environments: from the gas phase to the solid state*
- Wooden, D. H., Harker, D. E., & Brearley, A. J. 2005, in: A. N. Krot, E. R. D. Scott & B. Reipurth (eds.) *Chondrites and the Protoplanetary Disk ASP-CS*, 341, 774. *Thermal processing and radial mixing of dust: evidence from comets and primitive chondrites*
- Bernstein, M. P., Sandford, S. A., & Allamandola, L. J. 2005, *ApJS*, 161, 53. *The mid-IR absorption spectra of neutral PAHs in conditions relevant to dense IS clouds*
- Moore, M. H. & Hudson, R. L. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 247. *Production of complex molecules in astrophysical ices*
- Farenzena, L. S., Iza, P., Martinez, R., *et al.* 2005, *EM&P*, 97, 311. *Electronic sputtering analysis of astrophysical ices*
- Hudson, R. L., Khanna, R. K., & Moore, M. H. 2005, *ApJS*, 159, 277. *Laboratory evidence for solid-phase protonation of HNC O in IS ices*
- Holtom, P. D., Bennett, C. J., Osamura, Y., *et al.* 2005, *ApJ*, 626, 940. *A combined experimental and theoretical study on the formation of the amino acid glycine (NH_2CH_2COOH) and its isomer ($CH_3NHCOOH$) in extraterrestrial ices*

- Bernstein, M. P., Mattioda, A. L., Sandford, S. A., & Hudgins, D. M. 2005, *ApJ*, 626, 909. *Laboratory IR spectra of polycyclic aromatic nitrogen heterocycles: quinoline and phenanthridine in solid argon and H₂O*
- Shalabiea, O. M., Awad, Z., Chigai, T., & Yamamoto, T. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 64. *New rate constants of hydrogenation on IS grains and their astrophysical implications*
- Creighan, S. C. & Price, S. D. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 55. *Studies of hydrogen formation on IS grain analogues*
- Strazzulla, G. & Moroz, L. 2005, *A&A*, 434, 593. *Ion irradiation of asphaltite as an analogue of solid hydrocarbons in the IS medium*
- Mukerji, R. J., Dawes, A., Holtom, P. D., et al. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 188. *Studies of the temperature dependence of the photo-absorption spectrum of solid ammonia*
- Strazzulla, G., Leto, G., LaDelfa, S., et al. 2005, *MemSAIS*, 6, 51. *Oxidants produced after ion bombardment of water/carbon dioxide icy mixtures*
- Holtom, P. D., Dawes, A., Davis, M. P., et al. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 130. *VUV photo-absorption spectroscopy of amorphous and crystalline sulphur dioxide films*
- Davis, M. P., Dawes, A., Holtom, P. D., et al. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 128. *Vacuum UV spectroscopy of laboratory-simulated astrophysical ices*
- Dawes, A., Holtom, P. D., Mukerji, R. J., et al. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 131. *Low-energy singly and multiply charged ion irradiation of astrophysical ices*
- Gomis, O. & Strazzulla, G. 2005, *Icarus*, 177, 570. *CO₂ production by ion irradiation of H₂O ice on top of carbonaceous materials and its relevance to the galilean satellites*
- Hudson, R. L., Moore, M. H., & Cook, A.M. 2005, *AdSpR*, 36, 184. *IR characterization and radiation chemistry of glycolaldehyde and ethylene glycol ices*
- Kroes, G. J. & Andersson, S. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 427. *Theory of molecular scattering from and photo-chemistry at ice surfaces*
- Palumbo, M. E. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 59. *Formation of compact solid water after cosmic ion irradiation*
- Mennella, V., Baratta, G. A., Palumbo, M. E., & Bergin, E. A. 2006, *ApJ*, 643, 923. *Synthesis of CO and CO₂ molecules by UV irradiation of water ice-covered hydrogenated carbon grains*
- Loeffler, M. J., Raut, U., Vidal, R. A., et al. 2006, *Icarus*, 180, 265. *Synthesis of hydrogen peroxide in water ice by ion irradiation*
- Hudson, R. L. & Moore, M. H. 2004, *Icarus*, 172, 466. *Reactions of nitriles in ices relevant to Titan, comets, and the IS medium: formation of cyanate ion, ketenimines, and isonitriles*
- Palumbo, M. E., 2005, *JPhCS*, 6, 211. *The morphology of IS water ice*
- Moore, M. H. & Hudson, R. L. 2005, in: D. C. Lis, G. A. Blake & E. Herbst (eds.), *Astrochemistry throughout the Universe: Recent Successes and Current Challenges*, Proc. IAU Symposium No. 231 (Cambridge: CUP), p. 247. *Production of complex molecules in astrophysical ices*
- Tatischeff, V. & Kiener, J. 2004, *NwARv*, 48, 99. *Gamma-ray lines from cosmic-ray interactions with IS dust grains*
- Mennella, V., Palumbo, M. E., & Baratta, G. A. 2004, *ApJ*, 615, 1073. *Formation of CO and CO₂ molecules by ion irradiation of water ice-covered hydrogenated carbon grains*
- Gerakines, P. A., Moore, M. H., Hudson, R. L. 2004, *Icarus*, 170, 202. *UV photolysis and proton irradiation of astrophysical ice analogs containing hydrogen cyanide*

- Gomis, O., Leto, G., & Strazzulla, G. 2004, *A&A*, 420, 405. *Hydrogen peroxide production by ion irradiation of thin water ice films*
- Sandford, S. A., Bernstein, M. P., & Allamandola, L. J. 2004, *ApJ*, 607, 346. *The mid-IR laboratory spectra of naphthalene ($C_{10}H_8$) in solid H_2O*
- Muñoz Caro, G. M., Meierhenrich, U., Schutte, W. A., et al. 2004, *A&A*, 413, 209. *UV-photo-processing of IS ice analogs: detection of hexamethylenetetramine-based species*
- Baratta, G. A., Brunetto, R., Leto, G., et al. 2004, *MemSAIS*, 5, 33. *Ion irradiation of ices relevant to astrophysics*
- Woon, D. E. 2004, *AdSpR*, 33, 44. *Photoionization in UV processing of astrophysical ice analogs at cryogenic temperatures*
- Mennella, V., Baratta, G. A., Esposito, A., et al. 2003, *The effects of ion irradiation on the evolution of the carrier of the $3.4\mu m$ IS absorption band* *ApJ*, 587, 727
- Chilton, D. L., Mohr, R., & Gerakines, P. 2003, *BAAS*, 35, 1269. *Simulating the effect of UV photolysis on IS ices*
- Muñoz Caro, G. M., & Schutte, W. A. 2003, *A&A*, 412, 121. *UV-photo-processing of IS ice analogs: new IR spectroscopic results*
- Cooper, J. F., Christian, E. R., Richardson, J. D., & Wang, C. 2003, *EM&P*, 92, 261. *Proton irradiation of Centaur, Kuiper Belt, and Oort Cloud objects at plasma to cosmic ray energy*
- Wu, C. Y. R., Judge, D. L., Cheng, B.-M., et al. 2003, *JGRE*, 108, 5032. *EUV photolysis of CO_2 - H_2O mixed ices at 10 K.*
- Mennella, V., Baratta, G. A., Esposito, A., et al. 2003, *ApJ*, 587, 727. *The effects of ion irradiation on the evolution of the carrier of the $3.4\mu m$ IS absorption band*
- Muñoz Caro, G. M., Meierhenrich, U.J., Schutte, W.A., et al. 2002, *Nature*, 416, 403. *Amino acids from UV irradiation of IS ice analogues*
- Carrez, P., Demyk, K., Cordier, P., et al. 2002, *Science*, 37, 1599. *Low-energy helium ion irradiation-induced amorphization and chemical changes in olivine: insights for silicate dust evolution in the IS medium, meteoritics and planetary*
- Mennella, V., Brucato, J. R., Colangeli, L., & Palumbo, P. 2002, *AdSpR*, 30, 1451. *Hydrogenation of carbon grains by exposure to hydrogen atoms: implications for the $3.4\mu m$ IS absorption band*