

PAUL B RIMMER

Exoplanets | Origins of Life | Astrochemistry

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EXPERIENCE



Assistant Professor of Experimental Astrophysics

2022 – Present

University of Cambridge: Cavendish Astrophysics

Research Scientist | Simons Senior Fellow

2018 – Present

University of Cambridge: Department of Earth Sciences, Cavendish Astrophysics, MRC-LMB

- Constructed StarLab, the first stellar simulator that mimics the Near-Ultraviolet (NUV) light of the young sun for the surface of early Earth and other planets.
- Founded the field of "prebiosignatures", i.e. the idea that one can use spectroscopic observations of exoplanets to understand early Earth
- Developed the first self-consistent full-atmosphere chemical network for Venus
- Chemical kinetics and experimental simulations of atmospheric, volcanic and impact-generated chemistry

Postdoctoral Research Fellow | Supported by Simons and Kavli

2016 – 2018

University of Cambridge: Cavendish Astrophysics, MRC Laboratory of Molecular Biology

- First defined and delineated the *Abiogenesis Zone*: a planet outside this zone is one on which life cannot originate.
- Transformed the way the exoplanet community considers stellar activity and planetary habitability.
- Identified acetylene as a novel atmospheric tracer for asteroid and cometary impacts on exoplanets.

Postdoctoral Research Fellow | European Research Council

2012 – 2016

School of Physics and Astronomy, University of St Andrews

- Constructed from scratch the STAND chemical kinetics network for ion-neutral atmospheric chemistry valid for the atmospheres of Earth (early and modern), Mars, Venus, Jupiter and exoplanets
- Determined the physical effect of cosmic ray ionization on the upper atmospheres of rocky planets and directly imaged gas giants

EDUCATION



Ph.D., Physics, The Ohio State University, 2012. Dissertation: "The Chemical Impact of Physical Conditions in the Interstellar Medium" (Advisers: Eric Herbst and Richard Freeman)

B.S., Physics, *Cum Laude*, University of Colorado Health Sciences Center, 2005.

GRANTS, MISSIONS, AND AWARDS



- **PI** (2023) on Proposal for LCLU Joint Collaboration Programme, "Chemistry on the Edge: Exploring the Boundaries of the Cyanosulfidic Reaction Network." ~£110,000
- **PI** (2022) on Proposal for IPLU to work on "Quantifying Aliveness." ~£25,000
- **Stanley L. Miller Early Career Award** (2021)
- **Venus Life Finder Mission**, Extended Science and Engineering Team, 2021 - Present
- **Senior Postdoctoral Researcher**, Trinity College Cambridge, 2019 - Present
- **CoI** (2019) on Research Incentive Grant for investigating "Terrestrial hydrothermal environments as a window to prebiotic worlds" (**PI** Claire Cousins) £14,500
- **Simons Senior Fellowship** (2018) to work on "Laboratory Simulations for Prebiotic Chemistry on the Surface of Early Earth and Other Planets", 3 years support. ~£350,000
- **CoI** (2018) on "Stellar Simulator Simons Grant" to support the construction of the StarLab simulator (**PI's** Didier Queloz and John D Sutherland). ~£750,000
- **PI** (2018) on Proposal for Lorentz Center Workshop on "The Roadmap to Universal Life." (other **PI's**: Claire Cousins, Karin Öberg, Claudia Bonfio, Inge Loes ten Kate & Mihkel Kama) ~£17000
- **CoI** (2017) on ReCoVER grant to provide funds in support for the day conference "Climate Science, Atmospheres and Life: from the Earth and Beyond" (**PI** Alex Archibald) ~£3000
- Drafted (2015) the Proposal for Simons and Kavli supported Fellowship for 2 years research work (**PI's**: Didier Queloz & John D. Sutherland)
- Royal Astronomical Society Grant (2014) for the conference "Electrification in Dusty Atmospheres" £2000
- David DeMartini Scholarship (2011) for outstanding graduate research at Ohio State University \$1000

TEACHING



- Instructor (with Annelies Mortier), Exoplanets: Detection and Characterisation, 2015, at University of St Andrews
- Instructor, Chemical Kinetics for Astronomers, 2015, at University of St Andrews
- **Advisor:** Guy Brett-Robertson (2014 MSc, with Kenneth Wood), Matthew Swayne (2014 Summer Student), Aleksandra Ardaseva (2015 BSc, with Christiane Helling), Harry Holt (2018 Part III Student, with Didier Queloz and Samantha Thompson), Alec Granville-Willett (2018 Part III Student, with Alex Archibald and Paul Griffiths), Domas Kalvaitis (2019 Part III Student, with Alex Archibald and Paul Griffiths), Tereza Constantinou (2020 Part III Student, with Oliver Shorttle), Sean Jordan (2020 Part III Student, with Oliver Shorttle), Tom Elgar (2020 Part III Student, with Alex Archibald), Sofia Kalamatianou (2022 MPhil Student)

SOCIETY MEMBERSHIP AND SERVICE



Member of Royal Astronomical Society, American Astronomical Society, American Chemical Society

Referee for PNAS, MNRAS, ApJL, ApJ, Life, Astrobiology, Nature Astronomy

REFERENCES



Prof Eric Herbst

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Prof Didier P. Queloz, FRS

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Dr John D Sutherland, FRS

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Prof Dimitar Sasselov

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Prof Sara Seager

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1. Gerin, M., de Luca, M., Black, J., Goicoechea, J. R., Herbst, E., Neufeld, D. A., ... [Rimmer, P. B.]... & Zmuidzinas, J. (2010). Interstellar OH⁺, H₂O⁺ and H₃O⁺ along the sight-line to G10. 6-0.4. *Astronomy and Astrophysics*, 518, L110.
2. Gerin, M., de Luca, M., Goicoechea, J. R., Herbst, E., Falgarone, E., Godard, B., ... [Rimmer, P. B.]... & Ward, J. S. (2010). Interstellar CH absorption in the diffuse interstellar medium along the sight-lines to G10. 6-0.4 (W31C), W49N, and W51. *Astronomy and Astrophysics*, 521, L16.
3. Neufeld, D. A., Goicoechea, J. R., Sonnentrucker, P., Black, J. H., Pearson, J., Yu, S., ... [Rimmer, P. B.] ... & Shipman, R. (2010). Herschel/HIFI observations of interstellar OH⁺ and H₂O⁺ towards W49N: a probe of diffuse clouds with a small molecular fraction. *Astronomy and Astrophysics*, 521, L10.
4. Gupta, H., Rimmer, P. B., Pearson, J. C., Yu, S., Herbst, E., Harada, N., ... & Nordh, L. H. (2010). Detection of OH⁺ and H₂O⁺ towards Orion KL. *Astronomy and Astrophysics*, 521, L47.
5. Rimmer, P. B., & Herbst, E. (2011). Propagation of low-energy cosmic rays in molecular clouds: calculations in two dimensions. *Memorie della Societa Astronomica Italiana*, 82, 933.
6. Rimmer, P. B., Herbst, E., Morata, O., & Roueff, E. (2012). Observing a column-dependent zeta in dense interstellar sources: the case of the Horsehead nebula. *Astronomy and Astrophysics*, 537, 7.
7. Bilger, C., Rimmer, P. B., & Helling, Ch. (2013). Small hydrocarbon molecules in cloud-forming brown dwarf and giant gas planet atmospheres. *Monthly Notices of the Royal Astronomical Society*, 435(3), 1888-1903.
8. Rimmer, P. B., & Helling, Ch. (2013). Ionization in Atmospheres of Brown Dwarfs and Extrasolar Planets. IV. The Effect of Cosmic Rays. *The Astrophysical Journal*, 774(2), 108.
9. Stark, C. R., Helling, C., Diver, D. A., & Rimmer, P. B. (2013). Ionization in Atmospheres of Brown Dwarfs and Extrasolar Planets. V. Alfvén Ionization. *The Astrophysical Journal*, 776(1), 11.
10. Stark, C. R., Helling, Ch., Diver, D. A., & Rimmer, P. B. (2014). Electrostatic activation of prebiotic chemistry in substellar atmospheres. In Press. *International Journal of Astrobiology* 13(2), 165
11. Rimmer, P. B., Helling, Ch., & Bilger, C. (2014). The Influence of Galactic Cosmic Rays on Ion-Neutral Hydrocarbon Chemistry in the Upper Atmospheres of Free-Floating Exoplanets. *International Journal of Astrobiology* 13(2), 173
12. Helling, C., Woitke, P., Rimmer, P. B., Kamp, I., Thi, W. F., & Meijerink, R. (2014). Disk evolution, element abundances and cloud properties of young gas giant planets. *Life*, 4(2), 142-173.

13. **Rimmer, P. B.**, Stark, C. R., & Helling, C. (2014). Jupiter as a Giant Cosmic Ray Detector. *The Astrophysical Journal Letters*, 787(2), L25.
14. Casewell, S. L., Lawrie, K. A., Maxted, P. F. L., Marley, M. S., Fortney, J. J., **Rimmer, P. B.**, ... & Helling, C. (2015). Multiwaveband photometry of the irradiated brown dwarf WD0137– 349B. *Monthly Notices of the Royal Astronomical Society*, 447(4), 3218-3226.
15. **Rimmer, P. B.** & Helling, Ch. A Chemical Kinetics Network for Lightning and Life in Planetary Atmospheres. (2016) *The Astrophysical Journal Supplement*, 224(1), 9.
16. Helling, Ch., **Rimmer, P. B.**, Rodriguez-Barrera, I. M., Wood, K., Robertson, G. B., and Stark, C. R., (2016). Ionisation and Discharge in Cloud-Forming Atmospheres of Brown Dwarfs and Extrasolar Planets. *Plasma Physics and Controlled Fusion*, 58(7), 074003.
17. Tsai, S.-M., Lyons, J., Grosheintz, L., **Rimmer, P. B.**, Kitzmann, D., Heng, K. (2016) VULCAN: An Open-Source, Validated Chemical Kinetics Python code for Exoplanetary Atmospheres. *The Astrophysical Journal Supplement Series*. 228(2), 20.
18. Hodosan, G., **Rimmer, P. B.**, & Helling, Ch. (2016) Is lightning a possible source of the radio emission on HAT-P-11b? *Monthly Notices of the Royal Astronomical Society*. 461.2, 1222.
19. Hodosán, G., Helling, C., Asensio-Torres, R., Vorgul, I., & **Rimmer, P. B.** (2016). Lightning climatology of exoplanets and brown dwarfs guided by solar system data. *Monthly Notices of the Royal Astronomical Society*, 461(4), 3927-3947.
20. Ardaseva, A., **Rimmer, P. B.**, Hodosan, G., Helling, Ch., Waldman, I., Yurchenko, S. & Tennyson, J. (2017) Lightning Chemistry on Contemporary and Early-Earth-Like Planets. *Monthly Notices of the Royal Astronomical Society*, 470(1), 187.
21. Ferus, M., Koukal, J., Lenža, L., Srba, J., Kubelík, P., Laitl, V., Zanozina, E. M., Váňa, P., Kaiserová, T., Knížek, A., **Rimmer, P. B.**, Chatzitheodoridis, E., & Civiš, S. (2018) Calibration-free quantitative elemental analysis of meteor plasma using reference laser-induced breakdown spectroscopy of meteorite samples. *Astronomy & Astrophysics*, 610, A73.
22. **Rimmer, P. B.**, Xu, J., Thompson, S., Gillen, E., Sutherland, J. D., & Queloz, D. The Origin of RNA Precursors on Exoplanets. (2018) The Origin of RNA Precursors on Exoplanets. *Science Advances*. 4(8), aar3302.
23. Kitzmann, D., Heng, K., **Rimmer, P. B.**, Hoeijmakers, H. J., Tsai, S.-M., Malik, M., Lendl, M., Deitrick, R., & Demory, B.-O. (2018) The Peculiar Atmospheric Chemistry of KELT-9b. *The Astrophysical Journal*. 863(2), 183.
24. Hoeijmakers, H. J., Ehrenreich, D., Heng, K., Kitzmann, D., Grimm, S. L., Allart, R., Deitrick, R., Wyttenbach, A., Oreshenko, M., Pino, L., **Rimmer, P. B.**, Molinari, E., & Di Fabrizio, L. (2018) Atomic iron and titanium in the atmosphere of the exoplanet KELT-9b. *Nature*. 560, 453.

25. Civiš, S., Knížek, A., **Rimmer, P.B.**, Ferus, M., Kubelík P., Zúkalová M., Kavan, L. and Chatzitheodoridis E. (2018) Formation of Methane and (Per)Chlorates on Mars. *ACS Earth and Space Chemistry*. 3, 221.
26. **Rimmer, P. B.**, Shorttle, O., & Rugheimer, S. (2019) Oxidized Micrometeorites are Evidence for Low Atmospheric Pressure on the Early Earth. *Geochemical Perspectives Letters*. 9. 38.
27. **Rimmer, P. B.** & Rugheimer, S. (2019) Photochemical Production of Ammonia and Hydrogen Cyanide on Hydrogen-Rich Super-Earths. *Icarus*. 329, 124.
28. **Rimmer, P.B.** & Shorttle, O., (2019) Origin of Life's Building Blocks in Carbon-and Nitrogen-Rich Surface Hydrothermal Vents. *Life*, 9, 12.
29. Ranjan, S., Todd, Z.R., **Rimmer, P.B.**, Sasselov, D.D., & Babbin, A.R. (2019) Nitrogen Oxide Concentrations in Natural Waters on Early Earth. *Geochemistry, Geophysics, Geosystems*, 20, 2021.
30. Hobbs, R., Shorttle, O., Madhusudhan, N. & **Rimmer, P.B.** (2019) A chemical kinetics code for modelling exoplanet atmospheres. *Monthly Notices of the Royal Astronomical Society*. 487, 2242.
31. Helling, C. & **Rimmer, P.B.** (2019) Lighting and Charge Processes in Brown Dwarf and Exoplanet Atmospheres. *Philosophical Transactions of the Royal Society A*. 377, 2154.
32. **Rimmer, P.B.**, Ferus, M., Waldmann, I., et al. (2019) Identifiable Acetylene Features Predicted for Young Earth-like Exoplanets with Reducing Atmospheres undergoing Late Heavy Bombardment. *The Astrophysical Journal*. 888, 21.
33. **Rimmer, P.B.***, Gillen, E.* & Catling, D.C. (2020) Statistical analysis of Curiosity data shows no evidence for a strong seasonal cycle of Martian methane. *Icarus*, 336, 113407. (*Co-First-Author)
34. Günther, M.N., Zhan, Z., Seager, S., **Rimmer, P.B.** et al. (2020) Stellar Flares from the First Tess Data Release: Exploring a New Sample of M-dwarfs. *The Astronomical Journal*. 159, 60.
35. Ducrot, E., Gillon, M., Delrez, L., Agol, E., **Rimmer, P.B.**, et al. (2020) TRAPPIST-1: Global results of the Spitzer exploration science program *Red Worlds. Astronomy and Astrophysics*. 640, A112.
36. Liggins, P., Shorttle, O. and **Rimmer, P.B.** (2020) Can volcanism build hydrogen-rich early atmospheres? *Earth and Planetary Science Letters*. 550, 116546.
37. Rodgers-Lee, D., Vidotto, A.A., Taylor, A.M., **Rimmer, P.B.** and Downes, T.P. (2020) The Galactic cosmic ray intensity at the evolving Earth and young exoplanets. *Monthly Notices of the Royal Astronomical Society*. 499, 2124.
38. **Rimmer, P.B.***, Ferus, M.*, Cassone, G.* et al. (2020) One-pot HCN-based Prebiotic Synthesis of Canonical Nucleobases and Glycine Initiated by High-velocity Impacts on Early Earth. *Astrobiology*. 20, 1476. (*Co-First-Author)
39. Ferus, M., Adam, V., Cassone, G., ..., [**Rimmer, P.B.**], et al. et al. (2020) Ariel – a window to the origin of life on early earth? *Experimental Astronomy*. 1.

40. Greaves, J. S., Richards, A. M. S., Bains, W., **Rimmer, P.B.**, et al. (2021) Phosphine gas in the cloud decks of Venus. *Nature Astronomy*. 5(7), p.655
41. Barth, P., Helling, Ch., Strüeken, E.E., ..., [**Rimmer, P.B.**], et al. (2021) MOVES IV. Modelling the influence of stellar XUV-flux, cosmic rays, and stellar energetic particles on the atmospheric composition of the hot Jupiter HD 189733b. *Monthly Notices of the Royal Astronomical Society*. 502(4), p.6201
42. Greaves, J. S., Richards, A. M. S., Bains, W., **Rimmer, P.B.**, et al. (2021) Reply to: No evidence of phosphine in the atmosphere of Venus from independent analyses. *Nature Astronomy*. 5(7), p.636
43. Swain, M.R., Estrela, R., Roudier, G.M., ..., [**Rimmer, P.B.**], et al. (2021) Detection of an Atmosphere on a Rocky Exoplanet. *The Astronomical Journal*, 161(5), p.213
44. **Rimmer, P.B.**, Jordan, S., Constantinou, T., et al. (2021) Hydroxide salts in the clouds of Venus: Their effect on the sulfur cycle and cloud droplet pH. *Planetary Science Journal*. 2(4), p.133
45. **Rimmer, P.B.**, Ranjan, S., Rugheimer, S. (2021) Starting Life and Searching for Life on Rocky Planets. *Elements*. 17(4), p.265
46. Hobbs, R., **Rimmer, P.B.**, Shorttle, O., Madhusudhan, N. (2021) Sulfur Chemistry in the Atmospheres of Warm and Hot Jupiters. *Monthly Notices of the Royal Astronomical Society*. 506(3), p.3186
47. **Rimmer, P.B.**, Thompson, S.J., Xu, J. et al. (2021) Timescales for Prebiotic Photochemistry under Realistic Surface Ultraviolet Conditions. *Astrobiology*. 21(9), p.1099
48. Bains, W., Petkowski, J.J., Seager, S., ..., [**Rimmer, P.B.**], et al. (2021) Phosphine on Venus Cannot be Explained by Conventional Processes. *Astrobiology*. 21(10), p.1277
49. Bains, W., Petkowski, J.J., Seager, S., ..., [**Rimmer, P.B.**], et al. (2021) Venusian Phosphine: A 'Wow!' Signal in Chemistry? Phosphorus, Sulfur, and Silicon and the Related Elements. 1, p.6
50. **Rimmer, P.B.**, Majumdar, L., Priyadarshi, A., et al. (2021) Detectable Abundance of Cyanoacetylene (HC₃N) Predicted on Reduced Nitrogen-Rich Super-Earth Atmospheres. *Astrophysical Journal Letters*. 921(2), p.L28
51. Jordan, S., **Rimmer, P.B.**, Shorttle, O., Constantinou, T. (2021) Photochemistry of Venus-Like Planets Orbiting K- and M-Dwarf Stars. *Astrophysical Journal*. 922(1), 44.
52. Bains, W., Petkowski, J.J., **Rimmer, P.B.**, Seager, S. (2021) Production of Ammonia Makes Venusian Clouds Habitable and Explains Observed Cloud-Level Chemical Anomalies. *Proceedings of the National Academy of Sciences*. 118(52).
53. Bains, W., Shorttle, O., Ranjan, S., **Rimmer, P.B.**, et al. (2022) Constraints on the Production of Phosphine by Venusian Volcanoes. *Universe* 8(1), 54.
54. Saeidfirozeh, H., Myakalwar, A.K., Kubelík, P., ..., **Rimmer, P.B.**, et al. (2022). ANN-LIBS analysis of mixture plasmas: detection of xenon. *Journal of Analytical Atomic Spectrometry*, 37(9), 1815.

55. Heays, A.N., Kaiserová, T., **Rimmer, P.B.**, et al. (2022). Nitrogen Oxide Production in Laser-Induced Breakdown Simulating Impacts on the Hadean Atmosphere. *Journal of Geophysical Research: Planets*, 127(3), e2021JE006842.
56. Itcovitz, J.P., Rae, A.S., Citron, R.I., ..., **Rimmer, P.B.** and Shorttle, O. (2022). Reduced atmospheres of post-impact worlds: The early Earth. *The Planetary Science Journal*, 3(5), 115.
57. Dash, S., Majumdar, L., Willacy, K., ..., **Rimmer, P.B.**, et al. (2022). Linking atmospheric chemistry of the hot Jupiter HD 209458b to its formation location through infrared transmission and emission spectra. *The Astrophysical Journal*, 932(1), 20.
58. Jordan, S., Shorttle, O. and **Rimmer, P.B.** (2022). Proposed energy-metabolisms cannot explain the atmospheric chemistry of Venus. *Nature Communications*, 13(1), 3274.
59. Liggins, P., Jordan, S., **Rimmer, P.B.** and Shorttle, O. (2022). Growth and evolution of secondary volcanic atmospheres: I. Identifying the geological character of hot rocky planets. *Journal of Geophysical Research: Planets*, 127(7), e2021JE007123.
60. Greaves, J.S., **Rimmer, P.B.**, Richards, A.M., et al. (2022). Low levels of sulphur dioxide contamination of Venusian phosphine spectra. *Monthly Notices of the Royal Astronomical Society*, 514(2), 2994.
61. Liggins, P., Jordan, S., **Rimmer, P.B.** and Shorttle, O. (2022). Growth and Evolution of Secondary Volcanic Atmospheres: II. The Importance of Kinetics. *Journal of Geophysical Research: Planets*, in press. arXiv preprint arXiv:2208.05338.
62. **Rimmer, P.B.*** and Carol Cleland* (2022). Ammonia and Phosphine in the Clouds of Venus as Potentially Biological Anomalies. *Aerospace*, 9(12), 752. (*Co-First-Author)
63. Walton, C.R., **Rimmer, P.B.** and Shorttle, O. (2022). Can prebiotic systems survive in the wild? An interference chemistry approach. *Frontiers in Earth Science*, 10, 2319.
64. **Rimmer, P.B.** (2023). Origins of Life on Exoplanets. *Conflicting Models for the Origin of Life*, 407.
65. Rodgers-Lee, D., **Rimmer, P.B.**, Vidotto, A.A., et al. (2023). The energetic particle environment of a GJ 436 b-like planet. *MNRAS*, in press. arXiv preprint arXiv:2303.07058.

TALKS, SYMPOSIA AND POSTERS



49 TALKS (22 INVITED), 12 POSTERS, 20 SEMINARS

1. *Optical Jets in the Radio Galaxy 4C30.31* (2004), **Poster** presented at the AAS Meeting in Denver.
2. *H3+ Abundances Modeled with a Variable Cosmic Ray Ionization Rate* (2008), **Talk** at the OSU International Symposium on Molecular Spectroscopy in Columbus, Ohio.
3. *A Variable Zeta and its Impact on the ISM* (2008), **Poster** at the Dalgarno Celebratory Symposium in Cambridge, Massachusetts.

4. *Observing a Column-Dependent Zeta in the Horsehead PDR* (2010), **Talk** at the OSU International Symposium for Molecular Spectroscopy in Columbus, Ohio.
5. *A Waterfall in Orion? Exploring the Violent KL Region* (2010), **Talk** at the Midwest Astrochemistry Meeting in Urbana, Illinois.
6. *The Effect of Various Cosmic Ray Flux-Spectra on PDR Chemistry* (2011), **Invited Talk** at the Lorentz Center Workshop on "Cosmic Ray Interactions: Bridging High and Low Energy Astrophysics" in Leiden.
7. *Is Water Ice a Precursor to OH+ and H₂O+ in Orion KL?* (2011), **Talk** at the OSU International Symposium for Molecular Spectroscopy in Columbus Ohio.
8. *Propagation of Low-Energy Cosmic Rays in Molecular Clouds: Calculations in Two Dimensions*, **Talk** at the "Cosmic Rays and the InterStellar Medium" conference in Montpellier.
9. *Three Explanations for Intermediate Molecules in the Orion KL Region* (2011), **Poster** at IAUS 280: The Molecular Universe in Toledo.
10. *Chemistry and star formation in Orion* (2012), **Talk** at the European Week of Astronomy and Space Science meeting in Rome.
11. *Cosmic Ray Impact on the Ion Fraction in Hot Jupiter and Brown Dwarf Atmospheres* (2012), **Poster** at the "Characterizing & Modeling Extrasolar Planetary Atmospheres: Theory & Observation" meeting in Heidelberg.
12. *Taking Charge: Sources of Ionization in Brown Dwarf Atmospheres* (2012), **Talk** at the Scottish Universities Physics Alliance Cormack Meeting in Edinburgh.
13. (2013), **a Talk and Poster** at the Royal Astronomical Society meeting on "The Planetary Systems of Evolved Stars" in London
14. (2013), **a Poster** at the Royal Astronomical Society meeting on "Physics and Chemistry of Clouds in Brown Dwarfs and Exoplanets" in London
15. *Cosmic Ray Chemistry and its Effect on Complex Hydrocarbons in the Atmospheres of Exoplanets* (2013), **Talk** at the Astrobiology Conference "Molecules and Life in Extremes" conference in Edinburgh.
16. *Astrochemistry applied to Planets: Cosmic-Ray Ionization and Hazes on Hot Jupiters* (2013), **Talk** at the "Stars to Life" conference in Gainesville, Florida.
17. *Cosmic Rays, UV Photons and Haze Formation in the Upper Atmospheres of Hot Jupiters* (2013), **Poster** at IAUS 299: "Exploring the Formation and Evolution of Planetary Systems" in Victoria, British Columbia.
18. *Cosmic Ray Ionization and Hazes on Hot Jupiters* (2013), **Talk** at the OSU International Symposium on Molecular Spectroscopy in Columbus, Ohio.

19. *The Effects of Extensive Air Showers in a Model Brown Dwarf Atmosphere* (2013), **Talk** at the National Astronomy Meeting in St Andrews.
20. *Non-Equilibrium Ion-Neutral Chemistry between Brown Dwarfs and Exoplanets* (2013), **Talk** at "Exoplanets and Brown Dwarfs: Mind the Gap" conference in Hatfield near London.
21. *Cosmic Ray Ionization and Dust Charging at the Cloud Top of a Giant Gas Planet* (2013), **Talk** at the European Planetary Science Council meeting, London.
22. **Symposium** at Leeds in 2013 on Cosmic Ray Chemistry in Exoplanet Atmospheres, invited by Paola Caselli
23. *Cosmic Ray Propagation within the Astrospheres of Solar Twins* (2013), **Talk** at "Wind Bubbles, Astrospheres and the Heliosphere: Environments and Cosmic Rays", Bochum
24. *The Influence of Cool Stellar Winds on Galactic Cosmic Rays* (2014), **Talk** at the Third Bcool Meeting, St Andrews.
25. *Cosmic Ray Transport in the Astrospheres of Solar Twins* (2014), **Talk** at CRISM-2014: Cosmic Rays & their Interstellar Medium Environment, Montpellier. Invited by Alexandre Marcowith.
26. *High Energy Cosmic Rays and Short-Lived Plasmas in Planetary Atmospheres* (2014), **Talk** at Electrification in Dusty Atmospheres Inside and Outside the Solar System, Pitlochry.
27. *Cosmic Ray Transport within 2 AU of the Sun and two Solar Twins* (2015), **Talk** at the Fourth Bcool Meeting, Geneva.
28. **Symposium** at Glasgow in 2015 on Lightning Chemistry in Exoplanet Atmospheres, invited by Declan Diver.
29. **Talk** (2015) at the First Scottish Exoplanet / Brown Dwarf Meeting, St Andrews.
30. *Ion-Neutral Exoplanet Chemistry at High Temperatures and Pressures* (2015), **Talk** at the 11th Rencontres du Vietnam "Planetary Systems: A Synergistic View."
31. *Tracers of Interstellar Chemistry in Exoplanet Atmospheres* (2015), **Poster** at the International Astronomical Union XXIX General Assembly, Hawaii
32. **Symposium** at the Cavendish Astrophysics Group, Cambridge, in 2015, on Lightning Chemistry in Exoplanet Atmospheres, invited by Brice-Olivier Demory.
33. *Auroral Chemistry in Exoplanet Atmospheres* (2015), **Poster** at Extreme Solar Systems III, Hawaii
34. **Lab Talk** at the Medical Research Council Laboratory of Molecular Biology, Cambridge, in 2015, on Synthetic Models of Prebiotic Synthesis Experiments, invited by John Sutherland.
35. **Invited Talk** at the 41st COSPAR Scientific Assembly, Istanbul, Turkey, 30 July – 7 August 2016, on A Chemical Kinetics Network for Lightning and Life in Planetary Atmospheres *Conference was Cancelled*
36. **Talk** (2017) at the Cambridge Exoplanet Day Meeting

37. **Talk** at the UK Exoplanet Community Meeting on March 2017 in St Andrews, titled "Prebiotic Chemistry on Other Worlds"
38. **Discussion Session** at the UK Exoplanet Community Meeting on March 2017 in St Andrews, titled "Laboratory Exoplanet Science"
39. **Talk** at the Simons Foundation meeting on the Origin of Life on May 2017 in New York, New York.
40. **Invited Talk** with Jianfeng Xu on May 2017 in Cambridge, UK, for the conference "Climate Science, Atmospheres and Life: From the Earth and Beyond".
41. **Seminar** on July 2017 in Oxford University about "Looking on the Bright Side: The Impact of Stellar Activity on Prebiotic Chemistry".
42. **Talk** at the Astrobiology Society of Britain Conference ASB7 on September 2017 in Milton-Keynes, titled "Prebiotic Chemistry on Exoplanets"
43. **Poster** at the Habitable Worlds System Science Workshop on November 2017 in Laramie WY, USA, titled "Prebiotic Chemistry on Exoplanets Within the Liquid Water Habitable Zone"
44. **Talk and Poster** at the 51st ESLAB Symposium "Extreme Habitable Worlds" on December 2017 in Noordwijk, Netherlands, called "Universal Life".
45. **Seminars** on January 2018 at Harvard University and MIT.
46. **Poster** at the UK Exoplanet Meeting on March 2018 in Oxford, United Kingdom, called "Simulating the Starlight on Rocky Exoplanets".
47. **Organizer and Chair of Conference Session** at the UK Exoplanet Meeting on March 2018 in Oxford, United Kingdom, called "Origins"
48. **Talk** at Exoplanets II on July 2018 in Cambridge, United Kingdom, called "Abiogenesis Zones around Active M-Dwarfs"
49. **Talk** at the 42nd COSPAR Assembly on July 2018 in Pasadena, California, USA, called "Ultraviolet Chemistry in Warm Little Ponds on Rocky Planets around Cool Stars"
50. **Talk** at the 42nd COSPAR Assembly on July 2018 in Pasadena, California, USA, called "Lightning and Cyanide Chemistry on Exoplanets"
51. **Seminar** on August 2018 at NASA Goddard, USA, called "How Stellar Activity can be Good for Life"
52. **Seminar** on October 2018 at Cambridge, UK, called "Geochemical Constraints for Prebiotic Chemistry"
53. **Seminar** on November 2018 at Imperial College, London, UK, called "Abiogenesis Zones around M-Dwarfs"
54. **Seminar** on November 2018 at Atmospheric, Oceanic and Planetary Physics, University of Oxford, Oxford, UK, called "Prebiotic Chemistry on the Early Earth and Other Planets"

55. **Invited Talk** at WG4: Digital Exoplanets on January 2019 in Prague, Czech Republic, Title: A Lagrangian Code for Atmospheric Chemical Kinetics
56. **Invited Talk** at ExoComets: Understanding the Composition of Planetary Building Blocks on May 2019 in the Lorentz Center, University of Leiden, Netherlands, Title: Impact-Induced Chemistry on Exoplanets
57. **Invited Talk** at Astrobiology Science Conference on June 2019 in Bellevue, Washington, USA, Title: Hydrogen Cyanide Production by High-Energy Chemistry, as a Function of Atmospheric Surface Pressure and C/O Ratio
58. **Invited** to a "Biosignatures" Panel on "The Future of Exoplanet Research" Symposium at the TESS Science Conference I at MIT, Boston, Massachusetts, USA.
59. **Seminar** on September 2019 at University of St Andrews Department of Physics and Astronomy, St Andrews, UK, called "Impacts and Habitability on Exoplanets"
60. **Seminar** on November 2019 at University of California Las Angeles, Las Angeles, California, USA, called "Impacts and Habitability on Exoplanets"
61. **Two Seminars** on February 2020 at Trinity College Dublin, Dublin, Ireland, on "Stellar Energetic Particles, Atmospheric Redox and False Biosignatures" and "Simulating Prebiotic Chemistry on Other Worlds"
62. **Invited Talk** at A Virtual Cambridge - ETH Workshop on the "Origin and Prevalence of Life", Title: "Connecting astrophysics with molecular biology"
63. **Invited Talk** at the Simons Collaboration on the Origins of Life (SCOL) Exoplanet e-Meeting in June 2020, Title: "Origins of Life on Earth-Like Exoplanets"
64. **Seminar** at the University of Cambridge Department of Earth Sciences in September 2020, Title: "Phosphine chemistry in the clouds of Venus"
65. **Invited Talk** for the John Ray Society in November 2020, Title: "Do-Nothing Prebiotic Chemistry"
66. **Keynote Talk** at the CHAMELEON Kick-Off Virtual Meeting in November 2020, Title: "The discovery of phosphine on Venus"
67. **Invited Talk** for the Venus Life Finder Mission Team in February 2021, Title: "Three Different Ways to Explain the Sulfur Depletion in the Clouds of Venus"
68. **Invited Talk** for the Molecular Origins of Life Conference in Munich in August 2021, Title: "The Effect of Broadband Ultraviolet Light on Prebiotic and Abiotic Chemistry"
69. **Invited** to participate in the MIAPP Workshop on The Physics and Emergence of Life in August-September 2021.
70. **Invited** to participate in a Cambridge Symposium on "Nature's Goals: Hylomorphism, Teleology and Design" in March 2022.

71. **Invited Talk** for the Conference Towards Molecular Complexity: At the crossroads between astrophysics and biochemistry at Heidelberg in May 2022.
72. **Poster** at AbSciCon, Atlanta GA, USA., May 2022.
73. **Invited Talk** at JPL Seminar, Los Angeles, CA, USA., May 2022.
74. **Organized Breakout Session** at EGU General Assembly on "Life as a Planetary Phenomenon", May 2022.
75. **Invited Talk** at Lorentz Center Workshop on "Tracing Sulfur From Molecular Clouds To The Origin Of Life", Leiden, Netherlands. September 2022.
76. **Invited Talk** at the Life in the Universe Workshop (Physics of Living Systems) in Sofia, Bulgaria. October 2022.
77. **Invited Talk** at the Royal Astronomical Society Meeting on "Abiotic Baselines in Astrobiology". January 2023.
78. **Invited Talk** at Heraeus Seminar "From the Heliosphere to Astrospheres - Lessons for Exoplanets and their Habitability" in Bad Honnef, Germany. January 2023.
79. **Invited to Panel** at the Venus Surface and Atmosphere Conference. Houston, TX, USA. Attended remotely. February 2023.
80. **Seminar** at the Chemistry Department, University of Cambridge, on "Heterogenous Chemistry and The Possibility for Life in the Clouds of Venus". February 2023.
81. **Seminar** at IWF, Graz, Austria on "Heterogenous Chemistry in the Clouds of Venus", Attended remotely. March 2023.