

# SARAH RUGHEIMER

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CONTACT INFORMATION	Atmospheric Oceanic & Planetary Physics Clarendon Laboratory, Oxford University Sherrington Rd, Oxford, UK OX1 3PU	US Phone: +1 (617) 870-4913 UK Phone: +44 (0)7506 364848 <a href="mailto:sarah.rugheimer@physics.ox.ac.uk">sarah.rugheimer@physics.ox.ac.uk</a> <a href="http://users.ox.ac.uk/~srugheimer/">http://users.ox.ac.uk/~srugheimer/</a>
RESEARCH INTERESTS	I study the climate and atmospheres of habitable exoplanets. My research particularly focuses on the star-planet interaction, studying the effect of UV activity on the atmospheric chemistry and the detectability of biosignatures in a planet's atmosphere with future missions such as JWST, E-ELT and LUVOIR.	
APPOINTMENTS	<b>Glasstone Research Fellow</b> , Oxford University Glasstone Postdoctoral Research Fellowship Hugh Price Fellowship at Jesus College, Oxford	<b>Oct 2018 - present</b>
	<b>Simons Research Fellow</b> , University of St. Andrews Simons Origins of Life Postdoctoral Research Fellow	<b>Oct 2015 - Sept 2018</b>
	<b>Research Associate</b> , Cornell University, Carl Sagan Inst.	<b>Feb 2015 - Aug 2015</b>
EDUCATION	<b>Harvard University</b> , Cambridge, MA M.A. in Astronomy Ph.D. in Astronomy & Astrophysics <ul style="list-style-type: none"><li>• Thesis Title: Hues of Habitability: Characterizing Pale Blue Dots Around Other Stars</li><li>• Advisors: Lisa Kaltenegger and Dimitar Sasselov</li><li>• Chosen as one of 8 PhD students at Harvard in Arts and Sciences as a 2014 Harvard Horizons Scholar: <a href="http://www.gsas.harvard.edu/harvardhorizons">www.gsas.harvard.edu/harvardhorizons</a></li></ul>	<b>September 2008 - January 2015*</b> <i>June 2010</i> <i>June 2010 - January 2015</i>
	* Harvard recognized a 1.5 years delay in time caring for terminally ill father.	
	<b>University of Calgary</b> , Calgary, Alberta Canada B.Sc. (First Class Honors), Physics	<b>September 2003 - June 2007</b>
	<ul style="list-style-type: none"><li>• Graduated top of class in Department of Physics and Astronomy</li><li>• Senior Thesis Topic: Uses of Attractive Bose-Einstein in Atom Interferometers</li><li>• Undergrad summer research projects: placing quantum dots in phospholipid vesicles as a precursor to tracking active neuron cells with Dr. X.L. Wu (2003); modeling MEG data on brain surfaces generated from MRI data with Dr. Mingui Sun (2005); and numerically modeled Earth-like planets in the habitable zone of the nearby star system of HD 69830 with Dr. Haghighipour (2006).</li></ul>	
	<b>Flathead Valley Community College</b>	<b>September 2002 - May 2003</b>
AWARDS	<ul style="list-style-type: none"><li>• Royal Society Rosalind Franklin Prize 2019</li><li>• Caroline Herschel Prize Lectureship 2018</li><li>• Glasstone Oxford Research Fellowship</li><li>• Hugh Price Fellowship at Jesus College, Oxford</li><li>• Simons Postdoctoral Origins of Life Fellowship</li><li>• <a href="#">2014 Harvard Horizons Scholar</a></li><li>• D.A.A.D Fellowship for International Research Collaboration in Germany</li></ul>	

- Derek Bok Center Distinction in Teaching Award for *The Energetic Universe*, Spring 2012, Harvard University
- Venkatesan Silver Medallion, for being the top graduate in my physics class at the University of Calgary in 2007

COMMUNITY INVOLVEMENT

LIFE - Large Interferometer for Exoplanets mission design Core Team Member - <https://www.life-space-mission.com/>  
Co-organizer for Lorentz Exocomet Workshop

OBSERVING PROPOSALS

**Co-I on HST Cycle 22** - The MUSCLES Treasury Survey: Measurements of the Ultraviolet Spectral Characteristics of Low-mass Exoplanetary Systems (PI - Kevin France, ID 13650)

**Co-I on HST Cycle 25** The Mega-MUSCLES Treasury Survey: Measurements of the Ultraviolet Spectral Characteristics of Low-mass Exoplanetary Systems (PI - Cynthia Froning, ID 15071)

**Co-I on HST Cycle 25** The M Dwarf UV Spectra Irradiating Nearby Transiting Terrestrial Planets (PI - Zach Berta-Thompson, ID 15264)

PUBLICATIONS

**Referred Publications** (4 first author, 2 second author, 18 total)

Rimmer, P. & **Rugheimer, S.** (2019) Hydrogen Cyanide in Nitrogen-Rich Atmospheres of Rocky Exoplanets. *in review, Icarus*

Rimmer, P., Shorttle, O., & **Rugheimer, S.** (2019) Oxidised Micrometeorites are Evidence for Low Atmospheric Pressure on the Early Earth. *Geochemical perspective letters*, 9: 38-42. [doi:10.7185/geochemlet.1903](https://doi.org/10.7185/geochemlet.1903)

\*Kawashima, Y. & **Rugheimer, S.** (2018) Theoretical Reflectance Spectra of Earth-Twins Through Their Evolutions: Impact of Clouds and Detectability of O<sub>2</sub>, H<sub>2</sub>O, and CH<sub>4</sub> with LUVIOR Telescope. *in review ApJ*

\*Student Advised

**Rugheimer, S.** and Kaltenegger, L. (2018) Spectra of Earth-like Planets Orbiting FGKM Stars Through Geological Evolution, *ApJ*, 854:19. [doi:10.3847/1538-4357/aaa47a](https://doi.org/10.3847/1538-4357/aaa47a)

Schwieterman, E.W., Kiang, N.Y., Parenteau, M.N., Harman, C.E., DasSarma, S., Fisher, T.M., Arney, G.N., Hartnett, H.E., Reinhard, C.T., Olson, S.L., Meadows, V.S., Cockell, C.S., Walker, S.I., Grenfell, J.L., Hegde, S., **Rugheimer, S.**, Hu, R., Lyons, T.W. (2018) Exoplanet Biosignatures: A Review of Remotely Detectable Signs of Life, *Astrobiology* 18(6), 663-708. [doi:10.1089/ast.2017.1729](https://doi.org/10.1089/ast.2017.1729)

Blumenthal, S.D., Mandell, A.M., Hébrard, E., Batalha, N.E., Cubillos, P.E., **Rugheimer, S.**, Wakeford, H.R. (2018) A Comparison of JWST Spectra From Equilibrium and Disequilibrium Chemistry Models in Gaseous Planets. *ApJ* 853, 138. [doi:10.3847/1538-4357/aa9e51](https://doi.org/10.3847/1538-4357/aa9e51)

Loyd, R.O.P., France, K., Youngblood, A., Schneider, C., Brown, A., Hu, R., Segura, A., Linsky, J., Redfield, S., Tian, F., **Rugheimer, S.**, Miguel, Y., Froning, C. (2018) The Muscles Treasury Survey V: FUV Flares on Active and Inactive M Dwarfs. *ApJ* 867:71. [doi:10.3847/1538-4357/aae2bd](https://doi.org/10.3847/1538-4357/aae2bd)

Youngblood, A., France, K., Loyd, R.O.P., Brown, A., Mason, J.P., Schneider, P.C., Tilley, M.A., Berta-Thompson, Z.K., Buccino, A., Froning, C.S., Hawley, S.L., Linsky, J., Mauas, P.J.D., Redfield, S., Kowalski, A., Miguel, Y., Newton, E.R., **Rugheimer, S.**, Segura, A., Roberge, A., and Vieytes, M. (2017) The Muscles Treasury Survey IV: Scaling Relations for Ultraviolet, Ca II K, and Energetic Particle Fluxes from M Dwarfs. *ApJ*. 843: 31. doi:10.3847/1538-4357/aa76dd

Domagal-Goldman Shawn D., Wright Katherine E., & 47 co-authors including **Rugheimer, S.**, (2016) Astrobiology Primer 2.0, *Astrobiology* 16: 8, 561-653. doi:10.1089/ast.2015.1460

France, K., Loyd, R.O.P., Youngblood, A., Brown, A., Schneider, P.C., Hawley, S.L., Froning, C.S., Linsky, J.L., Roberge, A., Buccino, A.P., Davenport, J., Fontenla, J.M., Kaltenecker, L., Kowalski, A.K., Mauas, P., Miguel, Y., Redfield, S., **Rugheimer, S.**, Tian, F., Vieytes, M.C., Walkowicz, L.M., and Weisenburger, K.L. (2016) The MUSCLES Treasury Survey I: Motivation and Overview, *ApJ*, 820: 2, 89. doi:10.3847/0004-637X/820/2/89

Youngblood, A., France, K., Loyd, R.O.P., Linsky, J.L., Redfield, S., Schneider, P.C., Wood, B.E., Brown, A., Froning, C., Miguel, Y., **Rugheimer, S.**, and Walkowicz, L. (2016) The MUSCLES Treasury Survey II: Intrinsic Lyman Alpha and Extreme Ultraviolet Spectra of K and M Dwarfs with Exoplanets, *ApJ*. 824: 2, 101. doi:10.3847/0004-637X/824/2/101

Loyd, R.O.P., France, K., Youngblood, A., Schneider, C., Brown, A., Hu, R., Linsky, J., Froning, C.S., Redfield, S., **Rugheimer, S.**, and Tian, F. (2016) The MUSCLES Treasury Survey III: XRay to Infrared Spectra of 11 M and K Stars Hosting Planets, *ApJ*. 824: 2, 102. doi:10.3847/0004-637X/824/2/102

**Rugheimer, S.**, Kaltenecker, L., Segura, A., Linsky, J. and Mohanty, S. (2015) Influence of UV activity on the Spectral Fingerprints of Earth-like Planets around M dwarfs. *ApJ*. 809:57. doi:10.1088/0004-637X/809/1/57

**Rugheimer, S.**, Segura, A., Kaltenecker, L., Sasselov, D. (2015) Surface UV fluxes for Earth-like planets around FGKM stars. *ApJ*. 806:137. doi:10.1088/0004-637X/806/1/137

Miguel, Y., Kaltenecker, L., Linsky, J. and **Rugheimer, S.** (2015) The Effect of Lyman alpha Radiation on Mini-Neptune Atmospheres Around M Stars: Application to GJ 436b. *MNRAS*. 446: 345-353. doi:10.1093/mnras/stu2107

Kaltenecker, L., Sasselov, D. and **Rugheimer, S.** (2013) Water Planets in the Habitable Zone: Atmospheric Chemistry, Observable Features, and the case of Kepler-62e and -62f. *ApJL*. 775: L47. doi:10.1088/2041-8205/775/2/L47

**Rugheimer, S.**, Kaltenecker, L., Zsom, A., Segura, A., Sasselov, D., (2013) Spectral Fingerprints of Earth-like Planets around FGK Stars. *Astrobiology*. March 2013, 13(3): 251-269. doi:10.1089/ast.2012.0888

Kaltenecker, L, Miguel, Y. and **Rugheimer, S.**, (2012) Rocky exoplanet characterization and atmospheres. *International Journal of Astrobiology* 11(04): 297-307. doi:10.1017/S1473550412000134

WHITE PAPERS

Parry, I. and 22 co-authors including **Rugheimer, S.** (2018) SUPERSHARP - Segmented Unfolding Primary for Exoplanet Research via Spectroscopic High Angular Resolution Photography. *arXiv:1801.06111*

Domagal-Goldman, S. and 40 co-authors including **Rugheimer, S.** (2018) Life Beyond the Solar System: Remotely Detectable Biosignatures. This is a white paper that was submitted to the National Academies of Sciences Study: Astrobiology Science Strategy for the Search for Life in the Universe. *arXiv:1801.06714*

Airapetian, V. S. , Danchi, W. C.1, Dong, C. F.3, **Rugheimer, S.** and 32 co-authors (2018) Life Beyond the Solar System: Space Weather and Its Impact on Habitable Worlds. Submitted to the National Academy of Sciences in support of the Astrobiology Science Strategy for the Search for Life in the Universe. *arXiv:1801.07333*

ADVISING  
EXPERIENCE

**University of St. Andrews**, St Andrews, UK

- **Co-advising PhD student Bethan Gregory** **Sept 2016 - present**  
Project title: “Numerical modelling of oxygen isotopes over Earth’s history”

**Kavli Exoplanet Atmospheres Summer Program**, Santa Cruz, CA

- **Advised graduate student Yui Kawashima** **Summer 2016**  
Project title: “Impact of clouds on detecting oxygen with LUVOIR” paper submitted
- **Advised postdoc Dr. Liu Hui-Gen** **Summer 2016**  
Project title: “TRAPPIST-1 and Assessing the Habitability of Ultra-cool Dwarfs”

**Cornell University**, Ithaca, NY

- **Co-advised PhD student Thea Kozakis** **Jan 2015 - July 2016**  
Project title: “Habitability of White Dwarfs”

TEACHING  
EXPERIENCE

**University of St. Andrews**, St. Andrews, Scotland, UK

- **Astrobiology: The Search for Life in the Universe, ID1006** **Spring 2017**  
I designed and led a new first year interdisciplinary module with 105 students. The course remains one of the highest enrolled at the University.
- **Environmental Geochemistry, ES 5010** **Spring 2016**  
Taught module “Mineral evolution through geological history” for this senior level geology course

**Tufts University**, Medford, MA USA

- **Life on Earth and Beyond** **Fall 2013**
  - Visiting Lecturer Fall 2013 to teach a course of my own design at Tufts ExCollege and offered for full credit at Tufts University as a natural science credit.
  - Course filled to maximum capacity within 1 hour of registration opening
  - One of 4 courses requested back by Tufts ExCollege for following semester
  - Nominated by graduating seniors in 2016 for this course as having been one of the “most impactful to your intellectual and personal development while at Tufts”
  - Complete course evals: [www.cfa.harvard.edu/~srugheimer/EXP022\\_Eval.pdf](http://www.cfa.harvard.edu/~srugheimer/EXP022_Eval.pdf)

Harvard University, Cambridge, MA USA

*Teaching Fellow for following courses:*

- **The Energetic Universe** **Spring 2012**
  - An introductory Astronomy course for non-majors taught by Robert Kirshner.
  - Received Distinction in Teaching Award
- **Stellar and Planetary Astrophysics** **Fall 2010**
  - A graduate level Astronomy course taught by Dimitar Sasselov.
- **Life as a Planetary Phenomenon** **Spring 2010**
  - An introductory Astrobiology course for non-majors taught by Dimitar Sasselov.

*Teacher Training*

- Completed Harvard's Bok Center Teaching Certificate
- Harvard University's "Scientists Teaching Science" hands-on course on active learning and effective science education with Professor Philip Sadler
- Harvard University's Bok Center Course "Problems with the Blackboard: Tools for Teaching Science & Math" with John Girash.
- Harvard University's Finding Your Voice workshop on giving effective presentations with Nancy Houfek.

SELECTED PRESS [Planetary.org - Creating a guidebook for Earth's hypothetical twin](#)  
[BBC Radio 4 Inside Science - Understanding Biosignatures](#)  
[Cornell - Astronomers create array of Earth planet models](#)  
[Daily Mail UK - Computer models reveal how Earth-like Planets Evolve in Time](#)  
[Harvard Gazette - Doctoral student focuses on atmosphere in search for extrasolar life](#)  
[Flathead Beacon - Looking for life beyond our own](#)

PRESENTATIONS

**Selected Invited Oral**

- *Hues of Habitability* Royal Astronomical Society, London, 20 Nov 2018
- *Hues of Habitability* Caroline Herschel Lecture, Herschel Society, Bath, 21 Nov 2018
- *Biosignatures, Atmospheres, & Implications for Life* ISSI Workshop, Bern, Oct 2018
- *UV, Biosignatures, and Life* Columbia University, colloquium, 18 April 2018
- *UV, Biosignatures, and Life* NYU - Abu Dhabi, colloquium, 8 Oct 2017
- *UV, Biosignatures, and Life* Climate Science, Atmospheres and Life: From the Earth and Beyond, University of Cambridge, 17 May 2017
- *How to Detect Life on Another Planet*, Next in Science, Radcliffe Institute for Advanced Study, Harvard, 14 Oct 2016
- *Terrestrial Exoplanets under M dwarf Irradiation*, Opportunity M, Harvard, 31 August 2016
- *A Review of Biosignatures*, NExSS, 27 June 2016
- *Characterizing Pale Blue Dots Around FGKM Stars*, AGU, San Francisco, 18 Dec 2015

**Selected Contributed Oral**

- *Detecting Biosignatures and Pre-Biosignatures in the Atmospheres of Earth-like Planets Around Other Stars with High Resolution Spectroscopy*, HoRSE - High Resolution Spectroscopy for Exoplanet Atmospheres, Nice France, 2 October 2018
- *Prebiotic Signatures and Geological Progression of Biosignatures* ESO Diversis Mundi: The Solar System in an Exoplanetary context (OPSIII), Chile, 7 March 2018
- *Remote Detectability of Oxygen Through Geological Time Around FGKM Stars*, AbSciCon, Phoenix, 24 April 2017
- *Using the PandExo JWST Simulator*, UK EXOM, St. Andrews, UK, March 2017

- *Importance of UV in Characterizing Pale Blue Dots Around FGKM Stars*, Extreme Solar Systems - Kona, Hawaii, Dec 2015
- *UV Surface Environments of Earth-like Planets Orbiting FGKM Stars Through Geological Evolution*, AbSciCon - Chicago, IL, June 2015
- *Characterizing Pale Blue Dots Around Other Stars*, AAS Dissertation Talk - Seattle, WA, January 2015
- *Influence of UV activity on the Spectral Fingerprints of Earth-like Planets around M dwarfs*, EBI - Search for Life Beyond the Solar System - Tuscon, AZ, March 2014
- *Influence of UV activity on the Spectral Fingerprints of Earth-like Planets around M dwarfs*, Max Planck Institute for Astronomy - Heidelberg, Germany, 5 March 2014
- *Comparison of Transit Spectra of the First Small Exoplanets in the HZ Kepler 62 e & f*, Division for Planetary Sciences - DPS - Denver, Oct 2013
- *Cosmic Habitability*, AbGradCon, Sweden, June 2010

#### MENTORING & SERVICE

At UC Santa Cruz and the University of St. Andrews, I developed two workshops for PhD students on the impostor syndrome and public speaking which have run in my department and are now being run University wide through Student Services. At Columbia University, I was invited to develop a mental health workshop for the equity and diversity program and have now given that at several institutions. I also volunteered for a geoscience outreach to local Scottish secondary schools called GeoBus and am on the Equality and Diversity Committee at St. Andrews. I also helped launch WISSA - Women in Science at St. Andrews and served as our School's representative.

Currently, I mentor two D.Phil students at Oxford in the Physics department. At St. Andrews, I mentored formally a PhD student in geology. I was a mentor through Harvard Graduate Woman in Science and Engineering (HGWISE) for a female undergraduate student at Harvard. I served as a departmental representative on the HGWISE board in 2011 to 2013. I also was a mentor for an internal graduate mentoring program. For four years (2009-2013), I served as one of two graduate representatives on the Committee for Academic Studies which monitored the progress of all graduate students in our department and advocated for student concerns.

#### PUBLIC OUTREACH

I co-host a podcast with Dr. Sarah Ballard called "[Self-care with Drs. Sarah](#)" where we discuss techniques for productivity, mental health, and successfully managing the pressures of academia to bring your full engagement to science in a sustainable way.

On BBC Radio 4's *Inside Science* with Adam Rutherford I gave an [interview](#) on the prospect of detecting biosignatures in the next few decades and the steps required to be prepared for observations with JWST and large ground-based observatories. I was a guest again on BBC Radio 4's *The Curious Cases of Rutherford and Fry* with Drs. Adam Rutherford and Hannah Fry.

Through GeoBus, I've led workshops on Mars exploration and scientific literacy, and created a [youtube video on biosignatures](#) in a minute. This video was chosen as for the Goldschmidt 2017 Wild Orbit Film Festival.

I am interested in science and education policy and how scientists can better communicate our findings to the public. With two other graduate students I launched PolicyLab in 2013 as an outlet for Harvard science graduate students where I served as senior editor the communications director.

I have written for Science in the News (STIN), a public outreach organization dedicated to presenting scientific concepts to the public. Scientific literacy and reforming the way we teach science are fundamental to our future economic, social, and world growth and sustainability. The articles I have written include "[Can Humans Play Red Rover?](#)"; "[A Tale of Two Worlds](#)"; and "[Are We Alone? - How astronomers hope to find life in the Universe.](#)"

I have spoken [on live radio at Boston's National Public Radio \(NPR\)](#) about finding

Earth-like planets and biosignatures, and was on a [panel at MIT](#) to discuss the science behind the movie *Interstellar*. At the Edinburgh Science Festival, I was on a panel about the ethics of detecting and potentially interacting with alien life.

INTERESTS I love high altitude and glacier mountaineering and have climbed e.g. Cayambe (18,996' / 5790m), Chimborazo - Veintimilla (20,440' / 6230m), Mt. Rainier (14,410' / 4392 m), Mt. Baker (10,781' / 3286 m), Mt. Kilimanjaro (19,341' / 5895 m), and Aconcagua (22,841' / 6962 m). I also competed internationally in Irish Dance for 11 years.

ACADEMIC REFERENCES **Prof. Tony Prave** ap13@st-andrews.ac.uk  
Head of School Earth & Environmental Sciences, University of St. Andrews

**Prof. Dimitar Sasselov** dsasselov@cfa.harvard.edu  
Phillips Professor of Astronomy, Harvard University  
Director of Origins of Life Initiative

**Prof. Lisa Kaltenegger** lkaltenegger@astro.cornell.edu  
Associate Professor at Cornell University  
Director of Carl Sagan Institute

**Prof. Robert Kirshner** rkirshner@cfa.harvard.edu  
Clowes Professor of Science, Harvard University  
Chief Program Officer for Science at the Gordon & Betty Moore Foundation

**Prof. Ray Pierrehumbert** raymond.pierrehumbert@physics.ox.ac.uk  
Halley Professor of Physics, University of Oxford

**Prof. Avi Loeb** aloeb@cfa.harvard.edu  
Frank B. Baird Jr. Professor of Science and Chair of Astronomy Dept at Harvard  
Chair of the Advisory Committee for the Breakthrough Starshot Initiative

**Dr. Shawn Domagal-Goldman** shawn.goldman@nasa.gov  
NASA Goddard