

Alexandre Champagne-Ruel

NASA Postdoctoral Program Fellow

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Origins of Life • Astrobiology • Complex Systems

RESEARCH PROFILE

NASA Postdoctoral Fellow and physicist investigating the physical principles underlying the origin of life. My research integrates statistical mechanics, information theory, and evolutionary dynamics to understand how spatial environments drive the emergence of complexity. Currently developing quantitative frameworks for agnostic life detection and biosignature assessment.

ACADEMIC POSITIONS

NASA Postdoctoral Program Fellow
Arizona State University, Mathis Group

2025 – Current
Tempe, AZ, USA

EDUCATION

Ph.D. Physics

2025

Université de Montréal

Montréal, QC, Canada

- Thesis: *Spatiality in Prebiotic Evolution: Toward a Physics of the Emergence of Complexity*
- Advisor: Paul Charbonneau

M.Sc. Physics

2020

Université de Montréal

Montréal, QC, Canada

- Thesis: *From Game Theory to Exobiology: The Emergence of Cooperation as a Critical Phenomenon*
- Advisor: Paul Charbonneau

B.Sc. Physics

2018

Université de Montréal

Montréal, QC, Canada

B.Sc. Philosophy

2012

Université de Montréal

Montréal, QC, Canada

GRANTS & AWARDS

NASA Postdoctoral Program Fellowship NASA

146,496 USD

2025

Project: Mapping Molecular Complexity for Agnostic Life Detection

J. Armand Bombardier Scholarship Fondation Bombardier

10,000 CAD

2024

Globalink Research Award Mitacs Canada

6,000 CAD

2024

J. Armand Bombardier Scholarship Fondation Bombardier

10,000 CAD

2023

J. Armand Bombardier Scholarship Fondation Bombardier

10,000 CAD

2022

Doctoral Scholarship Fonds de Recherche du Québec

70,000 CAD

2022

Excellence Award Université de Montréal

10,000 CAD

2018

Various Travel & Research Grants 15 awards

~30,000 CAD

2011 – 2025

PUBLICATIONS

Articles under Review

- A. **Champagne-Ruel** and C. Mathis, “Spatial Patterning and Selection: How the Environment Shapes Molecular Complexity”, [10.48550/arXiv.2509.04547](https://arxiv.org/abs/10.48550/arXiv.2509.04547) (2025), (Submitted to PNAS Nexus).
- OoLEN, S. Asche, C. Bautista, D. Boulesteix, A. **Champagne-Ruel**, C. Mathis, et al., “What it takes to solve the Origin(s) of Life: An integrated review of techniques”, [10.48550/arXiv.2308.11665](https://arxiv.org/abs/10.48550/arXiv.2308.11665) (2023), (Submitted to Cell Reports Physical Science).

Published Articles

- A. **Champagne-Ruel**, S. Zakaib-Bernier, and P. Charbonneau, “Diffusion and pattern formation in spatial games”, *Physical Review E* **110**, 014301 (2024).
- A. **Champagne-Ruel** and P. Charbonneau, “A Mutation Threshold for Cooperative Takeover”, *Life* **12**, 254 (2022).
- S. Gelin, A. **Champagne-Ruel**, and N. Mousseau, “Enthalpy-entropy compensation of atomic diffusion originates from softening of low frequency phonons”, *Nature Communications* **11**, 3977 (2020).

PRESENTATIONS

Invited Talks

Physics of Complexity And Agnostic Life Detection

Trottier Institute for Research on Exoplanets

2025

Montréal, QC, Canada

Spatial Patterning and Selection

Max Planck Institute for Terrestrial Microbiology

2025

Marburg, Germany

From Emergent Complexity to Reliable Life Detection

Arizona State University

2024

Tempe, AZ, USA

Coopération, émergence et transitions

Université du Québec à Montréal

2022

Montréal, QC, Canada

Contributed Talks

From Emergent Complexity to Reliable Life Detection

Biennial European Astrobiology Conference (BEACON)

2025

Reykjavik, Iceland

Diffusion: An Overlooked Driver of Prebiotic Complexity

Astrobiology Science Conference (AbSciCon)

2024

Providence, RI, USA

Théorie de l'information et origine de la vie

90e Congrès de l'ACFAS

2023

Montréal, QC, Canada

A Mutation Threshold for Cooperative Takeover

Astrobiology Science Conference (AbSciCon)

2022

Atlanta, GA, USA

Cooperation: An Emergent Universal Feature at the Dawn of Life

Interdisciplinary Origin of Life Meeting for Early Career Researchers

2022

Montréal, QC, Canada

Mutation Favors the Emergence of Cooperation

Life and Space Poland

2021

Virtual/Szczecin, Poland

La criticité dans un système évolutif artificiel

Centre de recherche en astrophysique du Québec (CRAQ)

2019

Orford, QC, Canada

Posters

Mapping Molecular Complexity for Agnostic Life Detection <i>NASA Postdoctoral Program Virtual Symposium</i>	2025 <i>Virtual</i>
L'émergence de la coopération via l'évolution de réseaux informationnels <i>90e Congrès de l'ACFAS</i>	2023 <i>Montréal, QC, Canada</i>
Diffusion, structures spatiales et origine de la vie <i>90e Congrès de l'ACFAS</i>	2023 <i>Montréal, QC, Canada</i>
OoLEN - The Origin of Life Early-career Network: Building the Community Needed to Solve the Problem <i>AbSciCon</i>	2022 <i>Atlanta, GA, USA</i>
A Mutation Threshold for Cooperative Takeover <i>Gordon Research Seminar: Challenging Paradigms in Prebiotic Chemistry</i>	2022 <i>Oxnard, CA, USA</i>
A Mutation Threshold for Cooperative Takeover <i>Gordon Research Conference: Environments for the Origins of Life and Habitability</i>	2022 <i>Oxnard, CA, USA</i>
Les mutations favorisent la coopération en contexte évolutif <i>Centenaire, Département de Physique, Université de Montréal</i>	2021 <i>Montréal, QC, Canada</i>
Mutation Favors the Emergence of Cooperative Behavior <i>Molecular Origins of Life Munich</i>	2021 <i>Virtual/Munich, Germany</i>
Mutations Promote Cooperation in an Evolutionary Setting <i>XIXth ISSOL Conference</i>	2021 <i>Virtual</i>
Self-Organized Criticality : A Prelude to Avalanche Models of Solar Flares <i>Space Climate 7 Symposium</i>	2019 <i>Orford, QC, Canada</i>

SCHOOLS & SELECTIVE WORKSHOPS

Assembly Theory for Folded Matter <i>Santa Fe Institute</i>	2025 <i>Santa Fe, NM, USA</i>
Information Driven States of Matter <i>University of Rochester</i>	2024 <i>Rochester, NY, USA</i>

TEACHING EXPERIENCE

Mentor – Biocomputing Scholars program <i>Arizona State University</i>	2025 – 2026 <i>Tempe, AZ, USA</i>
Guiding 3 undergraduate students in developing computational chemistry simulations.	
Undergraduate Internship Supervision <i>Université de Montréal</i>	2022 <i>Montréal, QC, Canada</i>
Supervised a summer research project on diffusion; resulted in journal publication and poster presentation.	
Teaching Assistant – Introduction to Astrobiology <i>Université de Montréal</i>	2021 – 2022 <i>Montréal, QC, Canada</i>

SERVICE & OUTREACH

Scientific Leadership

Positions

Member of the Executive Board <i>Origin of Life Early-career Network (OoLEN)</i>	2022 – Present
Origin of Life Digest (link) <i>Editor</i>	2021 – Present

Conference Organization

Interdisciplinary Origin of Life Meeting <i>Organizing Committee</i>	2026 Tokyo, Japan
Frontiers in Astrobiology and Origins of Life Conference <i>Organizing Committee</i>	2025 Reykjavik, Iceland
Origine de la vie : de l’astrophysique à la philosophie <i>Lead Organizer</i>	2023 Montréal, QC, Canada
Interdisciplinary Origin of Life Meeting for Early Career Researchers <i>Lead Organizer</i>	2022 Montréal, QC, Canada
Space Climate 7 <i>Local Organizing Committee</i>	2019 Orford, QC, Canada

Session Convener

AbSciCon <i>Assembly Theory Across Scales: From Molecules to Planetary Systems</i>	2026 Madison, WI, USA
AbSciCon <i>Exploring Self-Assembly and Self-Organization in Prebiotic Complexity</i>	2026 Madison, WI, USA

Media & Public Engagement

- É. Beaudoin-Paul, “Entrevue avec Alexandre Champagne-Ruel, récipiendaire de la prestigieuse bourse en astrobiologie de la NASA”, [Quartier Libre](#) (2025).
- A. Riopel, “Comment reconnaître la vie sur d’autres planètes”, [Le Devoir](#) (2023).
- C. Tamura, “Cooperation and the Origin of Life”, Quantum Photonics Clubhouse Podcast (2022).

Reviewing Activities

- Royal Society Open Science

Memberships

- International Society for Artificial Life
- Center for Research in Astrophysics of Québec

- Canadian Association of Physicists
- Canadian Astronomical Society
- Origin of Life Early-career Network
- International Society for the Study of the Origin of Life
- Complex Systems Society
- Scientific Society for Astrobiology (Founding Member)

TECHNICAL SKILLS

- **Languages:** Fluent in Spoken/Written French, English
- **Programming:** Python, C++, Fortran, Julia, R, LaTeX, MatLab, Assembly, Bash
- **Modeling:** Agent-based, Evolutionary Algorithms, Machine Learning, Network Theory, Game Theory
- **Development Workflow:** Linux, High Performance Computing (HPC)/SLURM, Git, Jekyll, Hugo, HTML5/CSS3