Alexandre Champagne-Ruel

Ph.D Candidate – Physics

Université de Montréal

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major evolutionary transitions — origin of life — complex systems — assembly theory

Current Position

Ph.D. Candidate ongoing
Université de Montréal
Groupe de Recherche en Physique Solaire

Visiting Scholar ongoing
Arizona State University
Mathis Group

Education

Ph.D. Physics 2025
Université de Montréal (expected Oct. 2025)
Thesis: *Spatiality in Prebiotic Evolution: Toward a Physics of the Emergence of Complexity*
Advisor: Paul Charbonneau

M.Sc. Physics 2020
Université de Montréal
Thesis: *From Game Theory to Exobiology: The Emergence of Cooperation as a Critical Phenomenon* (link)
Advisor: Paul Charbonneau

B.Sc. Physics 2018
Université de Montréal

B.Sc. Philosophy 2012
Université de Montréal

Publications

Manuscripts in preparation:

A. **Champagne-Ruel**, "Signals of Life: The Concept of Information in Astrobiology", In prep. 2025.
A. **Champagne-Ruel** and C. Mathis, "Spatial Patterning and Selection: How the Environment Sets the Stage for Complexity", In prep. 2025.

Articles under review:

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 (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).

Invited talks:

A. **Champagne-Ruel**, "From Emergent Complexity to Reliable Life Detection", Arizona State University, 2024.
A. **Champagne-Ruel**, "Cooperation and the Origin of Life", Quantum Photonics Clubhouse Podcast, 2022.
A. **Champagne-Ruel**, "Coopération, émergence et transitions: comment la physique statistique peut nous éclairer sur la question des origines", Qu'est-Ce Qu'expliquer Une Origine En Science ? (CIRST, UQAM), 2022.

Oral presentations:

A. **Champagne-Ruel** and C. Mathis, "From Emergent Complexity to Reliable Life Detection", BEACON (Iceland), 2025.
A. **Champagne-Ruel**, "Diffusion: an Overlooked Driver of Prebiotic Complexity", AbSciCon (Providence), 2024.
A. **Champagne-Ruel**, "Théorie de l'information et origine de la vie", 90e Congrès de l'ACFAS, 2023.
A. **Champagne-Ruel**, "A Mutation Threshold for Cooperative Takeover", AbSciCon (Atlanta), 2022.
A. **Champagne-Ruel**, "Cooperation: an emergent universal feature at the dawn of life", Interdisciplinary Origin of Life Meeting for Early Career Researchers (Montréal), 2022.

A. **Champagne-Ruel**, "Mutation favors the emergence of cooperation", Life and Space Poland, 2021.
A. **Champagne-Ruel**, "La criticalité dans un système évolutif artificiel", Centre de Recherche En Astrophysique Du Québec (CRAQ) - Rencontre Annuelle, 2019.

Posters:

A. **Champagne-Ruel**, A. Demers-Bergeron, and P. Charbonneau, "L'émergence de la coopération via l'évolution de réseaux informationnels", 90e Congrès de l'ACFAS, 2023.
A. **Champagne-Ruel**, S. Zakaib-Bernier, and P. Charbonneau, "Diffusion, structures spatiales et origine de la vie", 90e Congrès de l'ACFAS, 2023.
S. Asche, A. **Champagne-Ruel**, S. F. Jordan, M. Preiner, A. d. N. Vieira, J. C. Xavier, et al., "OoLEN - The Origin of Life Early-career Network: Building the community needed to solve the problem", AbSciCon Atlanta, 2022.
A. **Champagne-Ruel**, "A Mutation Threshold for Cooperative Takeover", Gordon Research Conference: Environments for the Origins of Life and Habitability (Oxnard), 2022.
A. **Champagne-Ruel**, "A Mutation Threshold for Cooperative Takeover", Gordon Research Seminar: Challenging Paradigms in Prebiotic Chemistry (Oxnard), 2022.
A. **Champagne-Ruel** and P. Charbonneau, "Les mutations favorisent la coopération en contexte évolutif", Centenaire, Département de Physique, Université de Montréal, 2021.
A. **Champagne-Ruel** and P. Charbonneau, "Mutation favors the emergence of cooperative behavior", Molecular Origins of Life Munich, 2021.
A. **Champagne-Ruel** and P. Charbonneau, "Mutations promote cooperation in an evolutionary setting", XIXth ISSOL Conference, 2021.
A. **Champagne-Ruel** and P. Charbonneau, "Self-organized criticality : a prelude to avalanche models of solar flares", Space Climate 7 Symposium, 2019.

Grants and Awards

NASA Postdoctoral Fellowship	146,496$USD	NASA	2025
Mobility Scholarship	500$CAD	Fédération des assoc. étud. de l'Université de Montréal	2025
Mobility Scholarship	1 500$CAD	Université de Montréal	2025
Google Cloud Research Grant	1 000$USD	Google Cloud Research	2024
J. Armand Bombardier Scholarship	10 000$CAD	Fondation J. Armand Bombardier	2024
Globalink Research Award	6 000$CAD	Mitacs Canada	2024
Mobility Scholarship	2 000$CAD	Université de Montréal	2024
Mobility Scholarship	3 000$CAD	Centre de Recherche en Astrophysique du Québec	2024
Google Cloud Research Grant	1 000$USD	Google Cloud Research	2024
J. Armand Bombardier Scholarship	10 000$CAD	Fondation J. Armand Bombardier	2023
Excellence Award	5 000$CAD	Université de Montréal	2023
Google Cloud Research Grant	1 000$USD	Google Cloud Research	2022
J. Armand Bombardier Scholarship	10 000$CAD	Fondation J. Armand Bombardier	2022
Doctoral Scholarship	70 000$CAD	Fonds de Recherche du Québec	2022
Best Poster Award	250$CAD	Université de Montréal	2021
Student Initiative Project	2 000$CAD	Université de Montréal	2021
Scholarship for Transition to PhD	2 500$CAD	Université de Montréal	2020
Excellence Award	1 000$CAD	Université de Montréal	2020
Excellence Award	10 000$CAD	Université de Montréal	2018
John Low Brebner Scholarship	2 500$CAD	Réseau Québécois des Matériaux de Pointe	2017
Excellence Scholarship	4 000$CAD	Université du Québec à Montréal	2014
Student Initiative Project	1 000$CAD	Université de Montréal	2011

Conferences & Workshops

Assembly Theory for Folded Matter	Santa Fe Institute — Santa Fe, NM (2025)
Biennial European Astrobiology Conference (BEACON)	Reykjavik — Iceland (2025)
Information Driven States of Matter	University of Rochester — Rochester, NY (2024)
AbSciCon	NASA/American Geophysical Union — Providence, RI (2024)
Origine de la vie : de l'astrophysique à la philosophie	90e Congrès de l'ACFAS — Montréal, Canada (2023)
Interdisciplinary OoL Meeting	Origin of Life Early-Career Network (OoLEN) — Montréal, Canada (2022)
Qu'est-ce qu'expliquer une origine en science?	CIRST/Université du Québec à Montréal — Montréal, Canada (2022)
AbSciCon	NASA/American Geophysical Union — Atlanta, GA (2022)
XIXth ISSOL conference	International Society for the Study of the Origin of Life — online (2021)
Life and Space Conference	Polish Astrobiological Society — online (2021)
Molecular Origins of Life Munich	CRC 235 Emergence of Life — online (2021)
Space Climate 7	Université de Montréal — online (2019)
Annual Meeting	Center for Research in Astrophysics of Québec — Saint-Alexis-des-Monts, Canada (2019)

Teaching

Undergraduate Internship Supervision Université de Montréal 2022
Teaching Assistant – Introduction to Astrobiology Université de Montréal 2021–2022
Tutoring – Undergraduate Level Université de Montréal 2018–2022

Skills

Languages:	Fluent in Spoken/Written French, English
Computing Languages:	Python, C++, Fortran, Julia, R, LaTeX, MatLab, Assembly, Bash, CSS
Modeling:	Agent-based, Evolutionary Algorithms, Machine Learning, Network Theory, Game Theory
Operational:	Linux, High Performance Computing, Git, Web Development, Network Security

Service & Outreach

Coordinator – Virtual Meetings Workgroup Origin of Life Early-career Network 2023–Present
Member of the Executive Board Origin of Life Early-career Network 2022–Present
Origin of Life Digest (link) 2021–Present
Astrobiobites (link) 2023

Conference Organizer

Frontiers in Astrobiology and Origins of Life Conference 2025 – organizing committee (Reykjavik, 2025)
Origine de la vie : de l'astrophysique à la philosophie – lead organizer (Canada, 2023)
Interdisciplinary Origin of Life Meeting for Early Career Researchers – lead organizer (Canada, 2022)
Space Climate 7 – local organizing committee (Canada, 2019)

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)