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Education:

- University of Barcelona (UB), Facultat de Fisica, Departament de Fisica fundamental, Barcelona (Spain)
PhD in Physics (1/9/2019-1/6/2024)
Supervisors: Ignacio Pagonabarraga and Aurora Hernandez-Machado

- University of Edinburgh (UoE), Institute for Multiescale Themofluids (IMT)
Awarded PhD Research Stay as a part of the UB International PhD program (1/5/2023-1/7/2023)
Supervisors: Rodrigo Ledesma-Aguilar

- University of Barcelona (UB)/Universitat Politecnica de Catalunya (UPC), Barcelona (Spain)
Masters degree in Atomistic and Multiscale Computational Modelling in Physics (1/9/2018-1/9/2019)
Supervisor: Ignacio Pagonabarraga and Pietro Tierno

- University of Barcelona (UB), Barcelona (Spain)
Bachelor in Physics (1/9/2014-1/9/2018)
Supervisor: Ignacio Pagonabarraga

Current position

Northwestern University, Center for Computation & Theory of Soft Materials (CCTSM), Evanston (U.S)
Postdoctoral researcher associate (1/6/2024-Currently)
Project P.I: Monica Olvera de la Cruz

Fellowships, funding received:

Staff researcher: FET – Open: Project Nanophlow (1/9/2019-1/6/2021)
Predocs UB – PhD Fellowship (1/6/2021-1/6/2024)
NSF-MRSEC: IRG-2 Postdoc Fellowship (1/6/2024 - current)

Conferences, Seminars and Summer Schools

National Institute for Theory and Mathematics in Biology (NIST): Mathematical Modeling, Computational Methods, and Biological Fluid Dynamics: Research and Training
Chicago (Illinois), United States (21.7.2025-25.7.2025)
Poster and invited talk: “Spontaneous symmetry breaking in active nanochannels”

Gordon Research Conference (GRC): Complex Active and Adaptive Materials System
Ventura (California), United States (26.1.2025-31.1.2025)
Poster contribution: “Synchronization and assembly of self-oscillating colloids within living crystals”

American Physical Society (APS) March Meeting
Las Vegas (Nevada), United States (6.3.2023-10.3.2023)
Poster and oral contribution: “Spontaneous imbibition in lubricant coated channels”

University of Edinburgh - Institute for Multiescale Themofluids (IMT) Seminar Series
Edinburgh, (Scotland), U.K (30.6.2023)
Invited talk: “Capillary imbibition in lubricant coated channels”

Cargese Summer School 2022: Active Matter and Complex Media
Cargese (Corsica), France (26.9.2022-8.10.2022)
Poster contribution: Hydrodynamic synchronization and clustering in ratcheting colloidal matter

University of Barcelona Workshop on Physics of Condensed Matter (18.7.2022-19.7.2022)
Barcelona (Catalonia), Spain
Invited talk: ”Capillary imbibition in lubricant coated channels and hydrodynamics in driven colloidal matter”

International Soft Matter Conference (ISMC). (19.9.2022-23.9.2022)
Poznan (Greater Poland), Poland
Invited talk: ”Hydrodynamic interactions: Locomotion of magnetic swimmers and collective dynamics in driven colloidal matter”

Conference of the International Association of Colloid and Interface Scientists (IACIS 2022)
Brisbane (Queensland), Australia (27.6.2022-29.6.2022)
Poster contribution: “Hydrodynamic synchronization and clustering in ratcheting colloidal matter”

30th International Conference on Discrete Simulations of Fluid Dynamics (DSFD 2021)
Viterbo (Lazio), Italy (12.9.2021-16.9.2021)
Invited talk: “Lattice-Boltzmann simulation of imbibition in Slippery Liquid-Infused Porous Surfaces”

XXIII Spanish Conference of Statistical Physics (FisEs’22 XXIII) (12.5.2022-14.5.2022)
Zaragoza (Aragon), Spain
Poster communication: “Dynamics and clogging of colloidal monolayers magnetically driven through a heterogeneous landscape ”

Publications

Since my first publication 2020, my publications have received 35 citations (32 excluding self-citations) and my current h-index is 4, according to Web of Science (WoS). Below is a list of peer-reviewed journal articles and recent preprints submitted during my postdoctoral research.

Recently submitted:

2025

11. S. G. Leyva, Ahis Shreshta, Monica Olvera de la Cruz. (2025). Active ionic fluxes induce symmetry breaking in charge-patterned nanochanels (submitted)

10. S. G. Leyva, Zhengyan Zhang, Monica Olvera de la Cruz, Kyle Bishop. (2025). Self-oscillating synchronematic colloids, (preprint in peer-review, https://doi.org/10.21203/rs.3.rs-7041325/v1)

9. S. G. Leyva, A. Naga, S. Oramus, H. Kusumaatmaja, A. Hernández-Machado, I. Pagonabarraga & R. Ledesma-Aguilar. (2025), Contact-line dynamics on a lubricant-coated surface (in peer-review)

Published:

2024

8. A. Benavent-Claró, S. G Leyva, I. Pagonabarraga,, R. Ledesma-Aguilar, & A. Hernández-Machado. (2024). Enhanced Imbibition in Liquid-Infused Coated Microchannels. *Langmuir*, **40** (50), 26600–26606.

7. * T. Curk., S. G. Leyva, & I. Pagonabarraga (2024). Discontinuous transition in electrolyte flow through charge-patterned nanochannels (Editor's suggestion). *Physical Review Letters*, **133** (7), 078201.

6. S. G. Leyva, I. Pagonabarraga, A. Hernández-Machado,. & R Ledesma-Aguilar. (2024). Capillary imbibition in lubricant-coated channels. *Physical Review Fluids*, **9** (7), L072002.

5. S. G. Leyva, & I Pagonabarraga. (2024). Clogging transition and anomalous transport in driven suspensions in a disordered medium. *Physical Review E*, **109** (1), 014618.

4. *D. Boniface, S. G. Leyva, I. Pagonabarraga, & P. Tierno, (2024). Clustering induces switching between phoretic and osmotic propulsion in active colloidal rafts. *Nature Communications*, **15** (1), 5666.

2022

3. *G. Junot., S.G. Leyva, C. Pauer, C. Calero, I. Pagonabarraga, T. Liedl, J. Tavacoli, & P. Tierno. (2022). Friction induces anisotropic propulsion in sliding magnetic microtriangles. *Nano Letters*, **22** (18), 7408–7414.

2. S.G Leyva, R. L Stoop, I Pagonabarraga, & P. Tierno, (2022). Hydrodynamic synchronization and clustering in ratcheting colloidal matter. *Science Advances*, **8** (23), eabo4546.

2020

1. S.G. Leyva, R. L. Stoop, P. Tierno, & I Pagonabarraga. (2020). Dynamics and clogging of colloidal monolayers magnetically driven through a heterogeneous landscape. *Soft Matter*, **16** (30), 6985–6992.

* First and second authors contributed equally

Contribution to each publication is explained in the next section.

Research Experience: PhD

During my PhD, my research covered a broad range of topics in Soft Matter physics. I collaborated with Prof. Pietro Tierno's experimental group at the University of Barcelona (UB), modeling colloidal matter at the microscale. I developed from scratch a Brownian Dynamics code to simulate paramagnetic particles under a periodic substrate subjected to an oscillatory ellipsoidal magnetic field, allowing direct comparison with experiments performed in the lab. This led to the characterization of particle clogging in disordered landscapes and resulted in my first publication in 2020[1]. I subsequently incorporated far-field hydrodynamic interactions via the Blake-Green tensor to investigate the role of hydrodynamics in particle synchronization at increasing area fractions. We discovered that hydrodynamic interactions alone were responsible for a speed-up effect and re-synchronization with the travelling wave at high magnetic field frequencies, which led to my second publication,

published in *Science Advances*[2]. During the same period, I also contributed to modeling a coarse-grained microswimmer consisting of a magnetized triangle with multiple swimming modes, reproducing the experimental observations and leading to my third publication in *Nano Letters*[3]. In a further collaboration with Prof. Tierno's group, we studied the dynamics of a self-assembled active rafts. In these experiments, a hematite ellipsoidal active particle, decomposing hydrogen peroxide under blue light, was placed in a crowded bath of active silica particles. The diffusiophoretic interactions generated non-reciprocal attractive forces between the hematite and silica particles, driving the self-assembly of a self-propelling raft steered by osmotic flows at the solid boundary beneath. Determining the osmotic flows as a steering mechanism of the raft lead to a publication in *Naure Communications*[4]. Additionally, motivated by the initial clogging work, I published a study on the anomalous flow of colloidal particles through disordered landscapes with multiple bottlenecks[5].

In parallel, I implemented a ternary mixture free-energy model into the Lattice-Boltzmann (LB) open source package *Ludwig* (available in GitHub). Using this implementation, I investigated spontaneous capillary imbibition in lubricant-coated channels, unveiling a novel imbibition regime emerging at low lubricant viscosities[6]. The findings were later experimentally validated, leading to a subsequent publication in *Langmuir*[8]. Additionally, as a side project derived from this work, I completed a three-month research stay at the University of Edinburgh, where I studied the role of meniscus dissipation in front dynamics; this work is currently under review.

In the final stage of my PhD, I collaborated with Dr. Tine Curk, currently an assistant professor at John Hopkins University, to investigate charge-patterned nanochannels subjected to pressure gradients and electric fields. I carried out modifications in the *Ludwig* open source code to accommodate surface charge patterns to characterize the response to an external pressure gradient and executed some of the DPDS simulations in the main text. We combined these simulations with DPDS simulations and analytical theory. We demonstrated that charge-patterned nanochannels can exhibit gating effects, producing discontinuous flow transitions controlled by pressure or electric field, leading to a publication in *Physical Review Letters*, which was selected as an Editors' Suggestion[7].

Research Experience: Postdoc

My later work on gating in nanochannels sparked a strong interest in nanofluidics, which led me to a postdoctoral position at Northwestern University (NU) in the Department of Materials Science and Engineering (MSE), ranked 2nd among material science departments in the U.S according to US News and World Report. Under the supervision of Prof. Monica Olvera de la Cruz, I joined the NSF-funded MRSEC project *IRG-2: Orchestrated Iontronics via Dynamic Hybrid Ionic/Electronic Conductors*. Within this framework, I investigated active nanochannels, focusing on how solvent flow and ionic conductivity respond to externally imposed fluxes at the solid–liquid interface. Using a combination of Dissipative Particle Dynamics (DPD), Lattice-Boltzmann (LB) simulations, and analytical theory, we uncovered a mechanism of spontaneous symmetry breaking, yielding directed, self-sustained flows in symmetric configurations. This effect enables purely ionic signal amplification, with potential applications in neuromorphic iontronics (preprint submitted).

In parallel, I collaborated with Prof. Kyle M. Bishop at Columbia University to investigate the collective behavior of oscillators based on low dielectric colloids suspended in weakly conducting media. I developed a Stokesian Dynamics simulation framework incorporating both far-field hydrodynamic and near-field lubrication interactions, coupled to an electrostatic model that reproduced the experimentally observed collective modes of oscillations. This work led to findings of a new class of soft condensed active matter structures, which we termed *Synchronematic Crystals*. Additionally, I contributed to the theoretical modeling of a binary mixture of Quincke rollers composed of two particle populations with distinct sizes. Experiments revealed robust pair formation, with larger particles consistently leading smaller ones in curved trajectories, and a memory effect encoded in the spatial organization of the two species. To reproduce and understand these observations, I implemented size-dependent corrections in a Stokesian Dynamics framework, incorporating both lubrication and far-field hydrodynamic interactions. The simulations successfully captured the emergent behaviors observed experimentally (preprint to be submitted).

During my postdoctoral stay at Northwestern I have participated in mentoring PhD's students in the DPDS and Stokesian Dynamics methods.

Awards

Bachelor Thesis Award (with Honors) - Electrolytes in the presence of a potential barrier: Diffusio-Osmotic flow
Awarded to the best thesis of the graduating class. University of Barcelona, 2018

Cover Feature - *Soft Matter* (*2020*)
Selected for cover image: *Dynamics and clogging of colloidal monolayers magnetically driven through a heterogeneous landscape*.

Other outreach and dissemination activities

I participated as a volunteer in *Camins Infinits*, a science outreach initiative aimed at scientific communication in primary and high schools across the Barcelona metropolitan area. I delivered a total of 6 tailored presentations: 3 at primary schools (ages ~7–12) and 3 at high schools (ages ~12–18).

- For audiences of ages (15-18), close to choosing a career venue, I shared my personal academic journey into science, introduced the field of computational physics, the notion of simulations, and discussed how research in soft matter contributes to societal challenges such as sustainability and its potential future impact.
- For primary school audiences and younger audiences (7-14), I introduced the concept of scientific simulation through analogies with video games. The presentation drew parallels between scientific modeling and the rule-based environments of games, comparing particular examples. It included a custom Python-programmed interactive game where students could direct an active Brownian particle in a crowded environment of passive Brownian obstacles, helping them experience the essence of scientific exploration in an accessible and engaging way. This approach aimed to inspire students by showing how science is already intertwined with familiar aspects of their daily lives.

Peer-reviewing activity:

As an early-career postdoctoral researcher, I have begun serving as a referee for international peer-reviewed journals in my areas of expertise. I have already acted as a reviewer for *Physics of Fluids* (AIP).