

Hoda Hashemi

INCOMING MSC IN COMPUTATIONAL SCIENCE AT AUB · PHYSICS GRADUATE AT AUB

Current: Beirut, Lebanon

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Personal Profile

I am a dedicated researcher with a strong foundation in computational physics and a particular focus on physical oceanography. With over two years of experience in computational research and interdisciplinary projects, I have built expertise across machine learning (ML), large language models (LLMs), parallel computing, data assimilation, and numerical modeling. My background combines rigorous training in physics and applied mathematics with advanced computational tools, enabling me to adapt and contribute effectively in diverse research environments. Alongside my current work, I apply advanced numerical frameworks to uncover the complex dynamics of vortices and other large-scale oceanic phenomena shaping our planet.

Education

American University of Beirut

Beirut, Lebanon

MSc in Computational Science

08/2023 - current

- **Courses taken:** Optimization Techniques, Discrete Models for Differ.Equ, Sp.Tp:GPU Computing, ST. Topics in Statistical Learning, Finite Element Methods in Mechanical Engineering, Sp.Tp: Vortex Methods and Dynamics in Oceanography

American University of Beirut

Beirut, Lebanon

BS in Theoretical Physics and Minor in Pure Mathematics

08/2019 - 05/2023

- **Relevant Math Courses:** Introduction to Analysis, Differential Equations, Intr.to Abstract Algebra, Linear Algebra II, Advanced Calculus, Calculus on Manifolds, Number Theory, Numerical Computing, Adv.Probab. and Random Variables

Pitzer College

Claremont, California

Exchange Program for one semester

08/2021 - 01/2022

- In addition to a Statistical physics course, took French class and learned R programming language

Research

Vortex Methods: Using MITGCM numerical code to simulate Professor Marshall's book Atmosphere, Ocean and Climate Dynamics

Beirut-Lebanon

American University of Beirut

08/2024 - current

- Building a code that helps us with our research using MITGCM and to simulate figures from the mentioned MIT book.
- Advisors: Professor Issam Lakkis
- Emails: il01@aub.edu.lb, leila.issa@lau.edu.lb

Oceanography, Vortex Methods: A New Vortex-in-Cell Model of the Quasi-Geostrophic Shallow Water Equations over the Sphere

Beirut-Lebanon

American University of Beirut

05/2024 - current

- We present a new vortex-in-cell method for computational modeling of the quasi-geostrophic shallow water equations on the sphere.
- Advisors: Professor Issam Lakkis
- Emails: il01@aub.edu.lb

University Projects

LLMs and RAG Systems: Agentic System for the MITgcm

Beirut, Lebanon

American University of Beirut

04/2025 - 05/2025

- An experimental solo project that leveraged the reasoning capabilities of Large Language Models (LLMs), enhanced with Retrieval-Augmented Generation (RAG), to create an intuitive conversational interface for the MITgcm. The system allowed users to query documentation, modify code, and execute simulations through natural language, aiming to democratize access to this advanced modeling tool and streamline research workflows.
- Advisor: Professor Amer Mouawad
- Email: aa368@aub.edu.lb

GPU Computing: Needleman-Wunsch Algorithm

Beirut, Lebanon

American University of Beirut

03/2024 - 05/2024

- Implemented the Needleman-Wunsch algorithm for exact string matching using CUDA and Octopus HPC to parallelize and optimize performance. The project applied GPU computing concepts such as reduction trees, stencils, thread coarsening, privatization, and occupancy optimization to achieve efficient execution.
- Advisor: Professor Izzat El Hajj
- Email: izzat.elhajj@aub.edu.lb

Numerical Solutions for PDEs: Diffusion–Convection Equation on a T-shaped Membrane

Beirut, Lebanon

American University of Beirut

11/2023 - 12/2023

- Explored numerical and analytical solutions to the diffusion–convection equation on a T-shaped membrane using the finite element and Galerkin methods. Compared numerical and analytical results to verify the bilinear and symmetric properties of the variational formulation. Implemented the work in FreeFem and MATLAB.
- Advisors: Professors Nabil Nassif and Sophie Moufwad
- Email: nn12@aub.edu.lb, sm101@aub.edu.lb

Advanced Optimization Techniques: Make Sharpness-Aware Minimization Stronger — A Sparsified Perturbation Approach

Beirut, Lebanon

American University of Beirut

10/2023 - 11/2023

- Investigated model generalization in deep learning through Sharpness-Aware Minimization (SAM) and its sparsified variant (SSAM). Implemented and tested SSAM on CIFAR10, CIFAR100, and ImageNet-1K, demonstrating improved computational efficiency and comparable convergence to SAM.
- Advisor: Professor Maher Nouiehid
- Email: mn102@aub.edu.lb

Advanced Optimization Techniques: Movie Recommendation System

Beirut, Lebanon

American University of Beirut

08/2023 - 09/2023

- Developed a movie recommendation engine using real-world data, applying both content-based and collaborative filtering methods. Compared algorithmic performance in predicting user preferences based on item features and inter-user similarity.
- Advisor: Professor Maher Nouiehid
- Email: mn102@aub.edu.lb

Computational Physics: High-Dimensional Inference of Nonlinear Dynamical Systems

Beirut, Lebanon

American University of Beirut

02/2023 - 05/2023

- Studied data assimilation in nonlinear dynamical systems using the Van der Pol oscillator as a test case. Optimized the system's cost function through adjoint-based BFGS and Bayesian optimization, exploring Gibbs–Boltzmann energy landscapes. Integrated methods from nonlinear dynamics, statistical physics, control theory, and machine learning.
- Advisors: Professors Sara Najem and Miguel Alfonso Mendez (Von Karman Institute)
- Email: sn62@aub.edu.lb, miguel.alfonso.mendez@vki.ac.be

Condensed Matter Physics: Laser Cooling, Trapping, and Bose–Einstein Condensation — Principles and Experimental Insights

Beirut, Lebanon

American University of Beirut

02/2023 - 03/2023

- Reviewed William Phillips' seminal work on laser cooling and trapping, analyzing experimental setups such as optical molasses, optical lattices, and time-of-flight measurements. Interpreted Bose-condensed curves to understand deviations in observed data.
- Advisor: Professor Leonid Klushin
- Email: leo@aub.edu.lb

Astrophysics: Assessing the Role of Tides in the Spin–Orbit Interaction of Mercury and the Sun

Beirut, Lebanon

American University of Beirut

08/2022 - 10/2022

- Analyzed key studies by Goldreich, Wisdom, and Peale to understand spin–orbit resonances and their effects on planetary evolution, with extensions to exoplanetary systems and resonance phenomena in plasma physics.
- Advisor: Professor Jihad Touma
- Email: jt00@aub.edu.lb

Computational Physics: Turing's Reaction–Diffusion Equations — Numerical and Analytical Stability

Beirut, Lebanon

American University of Beirut

09/2022 - 12/2022

- Investigated Turing's reaction–diffusion system and its pattern-forming instability under different parameter regimes. Performed nonlinear dynamics and stability analyses to identify bifurcation behavior and emergent spatial patterns.
- Advisor: Professor Sara Najem
- Email: sn62@aub.edu.lb

Solid State Physics: Pulsed Laser Deposition of Crystalline Material

Beirut, Lebanon

American University of Beirut

03/2022 - 05/2022

- Studied the four stages of Pulsed Laser Deposition (PLD) using manganese oxide (MnO) as the ablation target. Investigated vaporization and crystalline formation processes under varying laser conditions.
- Advisor: Professor Malek Tabbal
- Email: mt03@aub.edu.lb

Nonlinear Dynamics: Quantum Chaos — Bunimovich Stadium

Beirut, Lebanon

American University of Beirut

04/2022 - 05/2022

- Implemented a two-dimensional quantum chaotic system using Python to examine how a particle's wave function evolves in a Bunimovich stadium potential as energy increases.
- Advisor: Professor Sara Najem
- Email: sn62@aub.edu.lb

Statistical Physics: Locating Sharks Using Acoustic Telemetry

Claremont, California

Pitzer College

10/2021 - 01/2022

- Applied hidden Markov models to track shark movements using acoustic telemetry data, incorporating swimming speed, signal strength, and receiver distance. Implemented analysis in C#.
- Advisor: Professor Adam Landsberg
- Email: alandsberg@kecksci.claremont.edu

Economic Statistics: Universal Healthcare's Impact on COVID-19 Mortality

Claremont, California

Pitzer College

11/2021 - 12/2021

- Examined correlations between Universal Health Care (UHC) coverage and excess COVID-19 mortality in 2020 through bar graphs, t-tests, and linear regression using RStudio.
- Advisor: Professor Rainita Narender
- Email: Rainita_Narender@pitzer.edu

Work Experience

American University of Beirut

Beirut, Lebanon

Graduate Research Assistant- Microflows and Microscale Heat Transfer Laboratory

08/2025 - current

- Research focuses on analyzing vorticity dynamics, energy transfer, and potential vorticity conservation within the Quasi-Geostrophic Shallow Water (QGSW) framework, employing numerical and grid-free approaches with applications to oceanic circulation modeling.

American University of Beirut

Beirut, Lebanon

Graduate Research Assistant- Microflows and Microscale Heat Transfer Lab

08/2025 - 05/2025

- Course Preparation for Engineering Students to Work with the MITgcm Model and Its Tutorials
- Designing instructional modules and tutorials that introduce the model's structure, governing equations, and numerical framework.
- Creating guided exercises that demonstrate how to configure, run, and visualize MITgcm simulations for various oceanic and atmospheric problems.
- Integrating theoretical concepts with computational practice, helping students understand the link between physical principles (e.g., conservation of mass, momentum, and energy) and their numerical representation.
- Preparing documentation and troubleshooting guides to support students' independent learning.
- Collaborating with faculty and teaching teams to ensure materials align with course objectives and research applications.

American University of Beirut

Beirut, Lebanon

Graduate Assistant- Math Clinic for the Physics Department

01/2024 - 05/2024

- The clinic is student-run and serves as a support for students, particularly questions related to math and concepts encountered in physics courses.
- Office hours are to enable undergraduate physics students to improve the math skills that they need for their physics education.

American University of Beirut

Beirut, Lebanon

Graduate Assistant- Lab Lecturer

08/2023 - 11/2023

- Giving lab lectures
- Performing the experiments
- Preparing reports, quizzes and correcting the lab

Private Tutoring in-person and online

*Beirut, Lebanon and Claremont,
California*

Teaching

04/2018 - Present

- SAT (Math and English)
- University level courses (Linear algebra 2, Quantum Mechanics, Classical Physics, Electromagnetism, Statistical Physics)
- High-school and elementary level (all subjects)

The Islamic Charitable Emdad Committee, founded since 1988.

Beirut, Lebanon

Volunteering

02/2017 - 01/2018

- Helping out two orphans who had to deal with chronic disability and other health issues due to UXO left from 2006 war.
- Fundraising to cover the medical expenses.
- Reaching out to various NGOs to adopt their sensitives case

Skills

Programming skills Python, Julia, Fortran, RStudio, Cuda, C/C++, FreeFem++, MatLab, Maple, LaTeX, HPC, slurm
Soft Skills high stamina, sustained focus, strong work ethic, teamwork, problem-solving, documentation, engaging presentation, time management, interdisciplinary thinking, computational adaptability, analytical reasoning

Achievements

- 03/2017 - **Rank1**, Winning Sports Championships: Basketball and Handball in the same year *Lebanon*
04/2017
- 07/2019 - **Summer Boot Camp for Physics Majors**, Discussing theoretical topics in Physics with the department's Professors as a prep for the sophomore year *Lebanon*
08/2019
- 08/2021 - **Active member in different clubs and societies at AUB**, clubs I was active in: Physics Student Society, Astronomy Club, Lebanese Automotive and Aerospace Society, German Club, Philosophy Student Society *Lebanon*
05/2023
- 08/2020 - **Physics Reading Groups**, Had various physics topics and hold intensive discussions and analysis *Lebanon*
12/2020
- 08/2021 - **Active member at PISA**, PISA stands for Pitzer College International Students Association. *California*
01/2022
- 08/2021 - **Certified Attendance of a seminar in Number Theory by Prof. Nikolaos Diamantis [The University of Nottingham, United Kingdom]**, We discussed a new L-series they have recently attached to weakly holomorphic forms, jointly with Lee, Raji and Rolon. This is used to present an application to certain cycle integrals that arose in important works on regularised theta lifts by Bruinier-Funke-Imamogluand *Lebanon*
01/2022
- 08/2022 - **Member at large at the Physics Student Society**, Assisting with the planning and execution of events, representing the interests and concerns of individual members of the society to the executive committee or board, helping to recruit new members and promote the society to the broader student population, and serving on committees or task forces to address specific issues or initiatives within the society. *Lebanon*
05/2023
- 07/2022 - **Certified Attendance of series of 23 seminars held in Center for Advanced Mathematical Sciences, "CAMS"**, Networked Complexity talks *Lebanon*
03/2023

Languages

English Professional proficiency
Arabic Native proficiency
French Elementary proficiency
Persian Advanced proficiency