Hosein Gholami

Technische Universität Darmstadt
Institut für Kernphysik

Personal Information

Date of Birth June 18, 1996
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Education

Since Jan 2022 **PhD candidate in Physics**, *Technical University of Darmstadt*, Darmstadt, Germany
Planned date of defence: December 2025

Thesis: Renormalization Group Studies of QCD-Inspired Mean-Field Models of Dense Quark Matter (Supervisor: Michael Buballa)

- Implemented a mean-field Functional Renormalization Group (FRG) approach to eliminate cutoff artifacts and ensure Renormalization Group (RG) consistency in effective models with color superconductivity.
- Studied the phase diagram of neutral quark matter with color superconductivity, focusing on its application for neutron stars and neutron star mergers.
- Investigated the interplay between Meissner masses, behavior of the diquark gap and its critical temperature at asympotically large densities within the RG consistent effective models.

2018-2020 **M.Sc. in Physics**, *Sharif University of Technology*, Tehran, Iran, *GPA 4/4 – 19.79/20*
Ranked **1st** among 45 M.Sc. graduates at the Physics department.

Thesis: Topological Charges in Magnetized and Rotating Quark Matter (Supervisor: Neda Sadooghi)

- Focused on the simultaneous effects of rotation and inhomogenous ansatz of Chiral Density Wave in a magnetic field background within the NJL model.
- Investigated how combining these factors contributes to nontrivial topological effects in quark matter.

2014–2018 **B.Sc. in Physics**, *Shiraz University*, Shiraz, Iran, *GPA 4/4 – 18.81/20*
Ranked **2nd** among 55 B.Sc. graduates at the Physics department.

Thesis: Study of 2D Electron Gas in a GaAs Quantum Well (Supervisor: Mehdi Pakmehr)

- Focused on understanding the electronic properties and quantum effects in semiconducting heterostructures.
- Implemented a code to numerically solve the Poisson-Schrödinger equation self-consistently to determine the electron number density in a simulated 2D quantum well.

List of Publications

May 2025 **Renormalizing the Quark-Meson-Diquark Model**, H. Gholami, L. Kurth, U. Mire, M. Buballa, and B.J. Schaefer, [arXiv:2505.22542]

March 2025 **Comprehensive Analysis of Constructing Hybrid Stars with an RG-consistent NJL Model**, J. E. Christian, I. A. Rather, H. Gholami and M. Hofmann, [arXiv:2503.13626]

January 2025 **On the Calculation of Pressure Derivatives in Mean-Field Thermal Field Theories**, H. Gholami, [arXiv:2501.05192]

November 2024 **Astrophysical constraints on color-superconducting phases in compact stars within the RG-consistent NJL model**, H. Gholami, I. A. Rather, M. Hofmann, M. Buballa and J. Schaffner-Bielich, PhysRevD.111.103034 [arXiv:2411.04064]

August 2024 **Renormalization-group consistent treatment of color superconductivity in the NJL model**, H. Gholami, M. Hofmann and M. Buballa, PhysRevD.111.014006 [arXiv:2408.06704]

Honors and Awards

• **Quark Matter 2025 Best Poster Award:** Awarded a plenary flash talk for the best poster prize in Quark Matter conference, April 2025

• **Giersch-Excellence-Award:** In recognition of outstanding achievements in the doctoral thesis project "Probing color-superconducting phases in neutron star mergers", October 2024

• Member of **HGS-HIRe for FAIR (graduate school)** since August 2022, including soft skills training and 1000 €/year travel funds.

• Ranked **5th** (2018) and **14th** (2017) at the *Scientific Olympiads for University Students in Physics.*

• Ranked 11th among 3497 in the national M.Sc. entrance exam in Physics.

• **National Elite Foundation Award:** offered a direct PhD entrance at any university in Iran.

• Awarded Member of the *National Elite Foundation of Iran, recognized for exceptional talent and contribution to research.*

• **School of Science Award:** Top Student among physics B.Sc. students for two consecutive years (2017, 2018), Shiraz University.

• Member of Exceptional Talent Organizations of Sharif University of Technology and Shiraz University.

Teaching Experience

Here is a list of selected courses I have been a Teaching Assistant for:

Advanced Quantum Mechanics, Technical University of Darmstadt (WiSe 2024/25, WiSe 2022/23), Sharif University of Technology (Fall 2019)

Theoretical Particle Physics, Technical University of Darmstadt (WiSe 2023/24)

Quantum Field Theory, Sharif University of Technology (Spring 2020)

Mathematical Methods for Physicists (Advanced), Shiraz University (Spring 2018)

Astronomy and Astrophysics, Shiraz University (Fall 2018)

Supervision Experience

Master Thesis — **Renormalization of the Quark–Meson–Diquark Model in Three Flavours**, *Shreedhar Rajesh*, Technical University of Darmstadt, April 2025

Bachelor Thesis — **Der Einfluss verschiedener Ordnungen der Vektorwechselwirkung auf die Schallgeschwindigkeit im NJL-Modell**, *Jaspreet Tumber*, Technical University of Darmstadt, November 2024

Bachelor Thesis — **Analytical Derivation of the Speed of Sound in the NJL-2SC Phase using Jacobians**, *Andres Felipe Cardona Osorio*, Technical University of Darmstadt, October 2023

Conference Contributions

April 2025 — **Quark Matter (Frankfurt am Main)**: Plenary flash talk and poster on "RG Consistent Treatment of NJL Color Superconductivity"

March 2025 — **DPG Spring Meeting (Köln)**: Talk on "Renormalized quark-meson-diquark model"

October 2024 — **Compact Stars in the QCD Phase diagram (Kyoto)**: Online talk on "RG Consistent Treatment of NJL Color Superconductivity."

March 2024 — **DPG Spring Meeting (Giessen)**: Talk on "RG Consistent Treatment of NJL Color Superconductivity."

September 2023 — **NA7-HF-QGP (Sicily)**: Talk on "RG Consistent Treatment of NJL Color-Superconductivity."

March 2023 — **DPG Spring Meeting (Dresden)**: Talk on "Hybrid Equation of State and Mass-Radius Relation."

September 2022 — **HFHF Theory Retreat (Tuscany)**: Talk on "Color Superconductivity in Neutron Star Mergers."

Public Engagement

Since Oct. 2024 — **Young Scientists Deputy Member,** Deputy member of TU Darmstadt in collaborative research project CRC-TR211

Since Aug. 2024 — **Core Member**, *Independent Society of Knowledge (ISK)*

- ISK is an organization committed to reimagining academia through decentralized, collaborative, and open-access initiatives. I contribute to the development of open-source scientific codes, supporting ISK's mission to advance research and promote accessible tools for the scientific community.

Since June 2020 — **Scientific Council Member**, *Shiraz Astronomy Society (SHAS)*

- SHAS is an NGO dedicated to educating the public, particularly younger generations, about astronomy and physics through seminars, workshops, and outreach activities. Here is a list of my selected talks in SHAS:

August 2024 — **Seminar:** "Invisible Architects: How do fundamental interactions shape our world?"

January 2024 — **Seminar:** "Smaller than an Atom: Introduction to Fundamental Particles" (Online)

July 2023 — **Seminar:** "What Do Gravitational Waves Tell Us?" (Online)

June 2018 — **Seminar:** "Gravity; Interaction Or Geometry?"

April 2018 — **Seminar:** "Special Relativity in General Language!"

Computer Skills

Mathematica, Advanced proficiency
- Used it mostly for symbolic calculations and lightweight model computations.
- Developed and published a publicly available package for the symbolic calculation of pressure derivatives, accessible on my GitHub page.

C/C++, Intermediate proficiency
- Contributed to the development of a multi-dimensional optimization code pivotal to my research on the neutral NJL model with diquarks. This work involved leveraging the optimization capabilities of the `GSL` library and the efficient linear algebra tools provided by the `Eigen` library.

Python, Advanced proficiency
- Mostly used for data analysis, postprocessing the data and visualization.
- Created packages for astrophysical data processing and plotting, including a general purpose TOV solver available publicly on my GitHub page.

Julia, Basic proficiency
- Contributed to a collaborative project, implementing Dyson Equation and Dyson Swinger Equation solver in vacuum.

Specialized Tools:
- Experienced with MPI for high-performance parallel computing.
- Experienced in using astrophysics packages, such as FUKA for binary neutron star simulations and Compose for Equation of State (EoS) calculations.

Professional Developement

Workshop **Critical Phenomena in Strong-Interaction Matter from FRG and LQCD**: Attended this lecture week program with focus on FRG and Lattice QCD methods to investigate critical phenomena, October 2023

Workshop **HGS-HIRe Machine Learning Workshop**: Attended workshop focusing on machine learning tools such as scikit-learn and TensorFlow, September 2022

Soft Skills Leadership, teamwork and professional carrier training through HGS-HIRe Basic Courses I & II &III, 2022 to 2025

Language Skills

English (Fluent, IELTS Score: 7), Persian (Native), German (Basic, A2 certificate)