

Tyler Gorda

POSTDOCTORAL RESEARCHER · INSTITUTE FOR THEORETICAL PHYSICS · GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Max-von-Laue-Str. 1 60438 Frankfurt am Main, Germany

✉ gorda@itp.uni-frankfurt.de | ☎ 0000-0003-3469-7574

Research Interests

Dense nuclear matter	Bulk and transport properties of dense quark matter
Neutron stars	Equation of state of neutron-star matter, physics of neutron-star mergers
In-medium field theory	Equation of state of dense/hot Quantum Chromodynamic matter, transport and energy loss in a dense/hot medium

Education

Doctor of Philosophy in Physics

Boulder, Colorado, USA

UNIVERSITY OF COLORADO BOULDER

Aug. 2011–Dec. 2016

- Supervisor: Prof. Paul Romatschke
- Thesis: “From pQCD to neutron stars: matching equations of state to constrain global star properties” (arXiv:1608.04358)

Master of Science in Physics

Boulder, Colorado, USA

UNIVERSITY OF COLORADO BOULDER

Aug. 2011– Dec. 2014

- 4.000 GPA

Bachelor of Science in Physics

New Brunswick, New Jersey, USA

RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY

Aug. 2007–May 2011

- Summa cum laude, 3.976 GPA
- Double major in Physics and Mathematics

Work Experience

Postdoctoral Researcher

Frankfurt, Germany

GOETHE UNIVERSITY FRANKFURT, INSTITUTE FOR THEORETICAL PHYSICS

Nov. 2023 - PRESENT

- Topics: QCD at high density, Physics of neutron-star mergers, Astrophysics of high-density QCD, Thermal field theory

Postdoctoral Researcher

Darmstadt, Germany

TU DARMSTADT, INSTITUTE FOR NUCLEAR PHYSICS

Sept. 2020 - Sept. 2023

- Topics: QCD at high density, Astrophysics of high-density QCD, Thermal field theory

Postdoctoral Researcher

Charlottesville, VA, USA

UNIVERSITY OF VIRGINIA

Aug. 2018 - Sept. 2020

- Topics: Thermal field theory, QCD at high density, Astrophysics of high-density QCD, Particle Propagation in a QCD medium

Postdoctoral Researcher

Helsinki, Finland

UNIVERSITY OF HELSINKI

Aug. 2016 - Aug. 2018

- Topics: Thermal field theory, QCD at high density, Astrophysics of high-density QCD, Particle cosmology

Research assistant

Boulder, Colorado, USA

UNIVERSITY OF COLORADO BOULDER

Oct. 2012–May 2016

- Topics: Thermal field theory, QCD at high density, Astrophysics of high-density QCD, AdS-CFT correspondence, collective flow in heavy-ion collisions

Mentoring & Supervision

Sofia Blomqvist MSc and PhD student. Official co-advisor

UNIVERSITY OF HELSINKI

Helsinki, Finland

June 2023 - PRESENT

Andreas Geißel PhD student. Advising and mentoring

TU DARMSTADT

Darmstadt, Germany

April 2023 - PRESENT

Oleg Komoltsev PhD student. Advising and mentoring

UNIVERSITY OF STAVANGER

Stavanger, Norway

Jan. 2022 - PRESENT

Saga Säppi MSc and PhD student. Advised and mentored

UNIVERSITY OF HELSINKI

Helsinki, Finland

Aug. 2016 - July. 2018

Eemeli Annala MSc and PhD student. Advised and mentored

UNIVERSITY OF HELSINKI

Helsinki, Finland

Aug. 2016 - July. 2018

Teaching Experience

Teaching Assistant

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Frankfurt, Germany

2024-2025

- General Relativity

Lectures on perturbative QCD at high temperatures and density

QCD MASTER CLASS 2023

Saint-Jacut-de-la-Mer, France

June 2023

- **10 hours of lectures** to advanced PhD students, postdocs, and permanent researchers on the formalism of perturbative QCD in medium
- Topics covered: (i) framework of relativistic thermal and high-density perturbation theory, (ii) infrared problems in thermal field theory and their resolution for the pressure, (iii) the general structure of the perturbative QCD pressure, and (iv) current status of theoretical calculations.

Lectures on Neutron Stars and the Equation of State of Dense Matter

DOKTORATSKOLLEG PARTICLES AND INTERACTIONS PH.D. RETREAT

Graz, Austria

May 2022

- **3 hours of lectures**, as part of a three-day retreat for doctoral students
- Topics covered: (i) General properties of neutron stars and their observation (ii) theoretical techniques for computing the thermodynamic properties of dense matter (iii) current status of astrophysical and theoretical constraints on the behavior of dense matter.

Lectures on Perturbative QCD at high densities

INSTITUTO GALEGO DE FISICA DE ALTAS ENERGIAS, UNIVERSITY OF SANTIAGO DE COMPOSTELA (ONLINE)

Santiago de Compostela, Spain

Nov. 2021

- **2 hours of lectures**, as part of course on Neutron-Star physics
- Topics covered: (i) framework of relativistic thermal and high-density perturbation theory, (ii) infrared problems in thermal field theory and their resolution for the pressure, (iii) the general structure of the perturbative QCD pressure, and (iv) current status of theoretical calculations.

Teaching Assistant

UNIVERSITY OF COLORADO BOULDER

Boulder, Colorado, USA

2011, 2014-2016

- Undergraduate introductory mechanics for majors
- Undergraduate introductory electromagnetism for majors
- Undergraduate introductory mechanics for non-majors
- Undergraduate introductory electromagnetism for non-majors

Presentations & Talks

In total: 2 colloquia, 15 plenary talks, 24 invited talks, 15 seminars, 8 contributed talks.

Recent or notable talks include:

The 3rd APCTP-Triumf Joint Workshop: From Nuclei to Neutron Stars

INVITED PLENARY TALK “Constraining strongly interacting matter at the highest densities with perturbative QCD”

Busan, South Korea

September 2024

New aspects of nuclear physics and nuclear astrophysics

INVITED PLENARY TALK “Quark matter in the cores of massive neutron stars”

Seoul, South Korea

September 2024

INT-24-89W: EOS Measurements with Next-Generation Gravitational-Wave Detectors

PLENARY TALK “Listening to the long ringdown”

Seattle, Washington

September 2024

Strong and Electro-weak Matter 2024

PLENARY TALK “Pressure and speed of sound in (two-flavor) color-superconducting quark matter at NLO”

Frankfurt, Germany

August 2024

CRC-TR 211 (Strong-interaction matter under extreme conditions) Meeting

INVITED PLENARY TALK “Listening to the long ringdown”

Frankfurt, Germany

July 2024

Heidelberg University

INVITED THEORY COLLOQUIUM “Constraining the behavior of strongly interacting matter at the highest densities”

Heidelberg, Germany

June 2024

ELEMENTS Annual Conference 2024

INVITED COLLOQUIUM “Constraining the behavior of strongly interacting matter at the highest densities”

Frankfurt, Germany

April 2024

Institute for Nuclear Theory

INVITED S@INT SEMINAR “Probing the behavior of strongly interacting matter at the highest densities”

Seattle, Washington

April 2024

University of Michigan

SEMINAR “Constraining the microphysics of high-density QCD”

Ann Arbor, Michigan

March 2024

Quark Matter 2023

INVITED PLENARY TALK, “Quark Matter and Nuclear Astrophysics”

Houston, Texas, USA

September 2023

Rencontres de Moriond: Gravitation

INVITED PLENARY TALK, “What multimessenger observations have told us about the EoS of NS matter”

La Thuile, Italy

Mar. 2023

Strong and Electro-weak Matter 2022

INVITED PLENARY TALK, “Bayesian constraints on the neutron-star equation of state with QCD input”

Saclay, France

June 2022

APS April Meeting (Session Q04: Mergers of Neutron Stars: Nuclear Physics from Gravitational Waves)

INVITED TALK, “High-Density Quark Matter in the Cores of Neutron Stars”

New York City, New York USA

Apr. 2022

Service

Astrocoffee Seminar Series Organizer

SEMINAR SERIES AT GOETHE UNIVERSITY ON RECENT DEVELOPMENTS IN ASTROPHYSICS, COSMOLOGY, AND ADJACENT TOPICS

Jan. 2024-PRESENT

Member of the IReNA Online Seminar Organizing Committee

INTERNATIONAL RESEARCH NETWORK FOR NUCLEAR ASTROPHYSICS

Sept. 2021-May 2022

Refereed Publications

VARIOUS JOURNALS

2018-PRESENT

- Physical Review Letters
- Physical Review D
- Physics Letters B
- Monthly Notices of the Royal Astronomical Society Letters
- Journal of High Energy Physics (JHEP)
- International Journal of Modern Physics A
- Universe
- European Physical Journal C

Founding member of the Graduate Liaison Committee

FOUNDED TO BETTER SUPPORT GRADUATE STUDENTS IN THEIR COMMUNICATION WITH THE PHYSICS DEPARTMENT

University of Colorado Boulder, USA

2014-2016

Coordinated Programs and Professional Societies

Member of the Collaborative Research Center TransRegio 211 (Strong-interaction matter under extreme conditions)

April 2022-PRESENT

COORDINATED PROGRAM BETWEEN BIELEFELD UNIVERSITY, TU DARMSTADT, AND GOETHE UNIVERSITY, TO DECISIVELY ADVANCE OUR UNDERSTANDING OF STRONG-INTERACTION MATTER UNDER EXTREME CONDITIONS OF TEMPERATURE AND DENSITY

Member of ELEMENTS: Exploring the Universe from Microscopic to Macroscopic Scales

April 2022-PRESENT

CLUSTER PROJECT BETWEEN GOETHE UNIVERSITY, TU DARMSTADT, JLU GIESSEN, AND GSI/FAIR TO ADDRESS THE QUESTION OF THE ORIGIN OF THE HEAVY CHEMICAL ELEMENTS, SUCH AS PLATINUM AND GOLD, IN OUR UNIVERSE.

Member of the American Physical Society

Feb. 2022-PRESENT

Outreach & Media Coverage

Helsingin Sanomat (largest newspaper in Finland), Phys.org, Universe Today, Space Daily articles about my work Phys. Rev. Lett. 133.7 (2024), 071901

Aug. 2024

Phys.org (2 articles), Yahoo News, Space.com, Universe Today, Sci.News articles about my work Nat Commun. 2023

Dec./Jan. 2023

PNAS article mentioning my work Nature Phys. 2020

Nov. 2020

Podcast Interview with The Cosmic Companion

June 2020

DISCUSSING EVIDENCE FOR QUARK-MATTER CORES IN MASSIVE NEUTRON STARS IN Nature Phys. 2020

Phys.org, Physicsworld, Medium, and IFLS articles

June 2020

MORE ARTICLES ABOUT MY WORK Nature Phys. 2020

Phys.org article about my work on the Two-Higgs-Doublet Model Phys. Rev. Lett. 121 191802 (2018)

Nov. 2018

Sky and Telescope article mentioning my work constraining the neutron-star-matter equation of state using gravitational waves Phys. Rev. Lett. 120 172702 (2018)

May 2018

APS Synopsis article on the same work Phys. Rev. Lett. 120 172702 (2018)

Apr. 2018

Software/Programming Experience

Programming Extensive experience with Mathematica and Python, and good working knowledge of C/C++

General IT \LaTeX (typesetting), GNU/Linux (operating system), Git (version control)

Languages

English Mother tongue

French Approximate Level B1

German Level A2.2

Publications

Summary of papers on [Inspire-HEP](#). As of 01 November 2024: 2,452, citations, h-index 19

Note that **alphabetical ordering** of authors is the community standard in theoretical high-energy physics

Peer-Reviewed Articles

- [31] A. Geißel, **T. Gorda**, and J. Braun. “Pressure and speed of sound in two-flavor color-superconducting quark matter at next-to-leading order”. *Phys. Rev. D* 110.1 (2024), 014034. arXiv: 2403.18010 [hep-ph].
- [30] C. Ecker, **T. Gorda**, A. Kurkela, and L. Rezzolla. “Listening to the long ringdown: a novel way to pinpoint the equation of state in neutron-star cores” (Mar. 2024). arXiv: 2403.03246 [astro-ph.HE]. (Accepted to Nature Communications).
- [29] J. Cruz Rojas, **T. Gorda**, C. Hoyos, N. Jokela, M. Järvinen, A. Kurkela, R. Paatelainen, S. Säppi, and A. Vuorinen. “Estimate for the Bulk Viscosity of Strongly Coupled Quark Matter Using Perturbative QCD and Holography”. *Phys. Rev. Lett.* 133.7 (2024), 071901. arXiv: 2402.00621 [hep-ph].
- [28] O. Komoltsev, R. Somasundaram, **T. Gorda**, A. Kurkela, J. Margueron, and I. Tews. “Equation of state at neutron-star densities and beyond from perturbative QCD”. *Phys. Rev. D* 109.9 (2024), 094030. arXiv: 2312.14127 [nucl-th].
- [27] G. D. Moore and **T. Gorda**. “Bounding the QCD Equation of State with the Lattice”. *JHEP* 12 (2023), 133. arXiv: 2309.15149 [nucl-th].
- [26] **T. Gorda**, R. Paatelainen, S. Säppi, and K. Seppänen. “Equation of State of Cold Quark Matter to $O(\alpha_s^3 \ln \alpha_s)$ ”. *Phys. Rev. Lett.* 131.18 (2023), 181902. arXiv: 2307.08734 [hep-ph].
- [25] **T. Gorda**, R. Paatelainen, S. Säppi, and K. Seppänen. “Soft gluon self-energy at finite temperature and density: hard NLO corrections in general covariant gauge”. *JHEP* 08 (2023), 021. arXiv: 2304.09187 [hep-ph].
- [24] E. Annala, **T. Gorda**, J. Hirvonen, O. Komoltsev, A. Kurkela, J. Nättilä, and A. Vuorinen. “Strongly interacting matter exhibits deconfined behavior in massive neutron stars”. *Nat Commun.* 14 (2023), 8451. arXiv: 2303.11356 [astro-ph.HE].
- [23] **T. Gorda**, O. Komoltsev, A. Kurkela, and A. Mazeliauskas. “Bayesian uncertainty quantification of perturbative QCD input to the neutron-star equation of state”. *JHEP* 06 (2023), 002. arXiv: 2303.02175 [hep-ph].
- [22] **T. Gorda**, K. Hebeler, A. Kurkela, A. Schwenk, and A. Vuorinen. “Constraints on Strong Phase Transitions in Neutron Stars”. *Astrophys. J.* 955.2 (2023), 100. arXiv: 2212.10576 [astro-ph.HE].
- [21] P. Arnold, **T. Gorda**, and S. Iqbal. “The LPM effect in sequential bremsstrahlung: incorporation of “instantaneous” interactions for QCD”. *JHEP* 11 (2022), 130. arXiv: 2209.03971 [hep-ph].
- [20] **T. Gorda**, J. Österman, and S. Säppi. “Augmenting the residue theorem with boundary terms in finite-density calculations”. *Phys. Rev. D* 106.10 (2022), 105026. arXiv: 2208.14479 [hep-th]. (**Editor’s suggestion**).
- [19] H. Schatz et al. “Horizons: nuclear astrophysics in the 2020s and beyond”. *J. Phys. G* 49.11 (2022), 110502. arXiv: 2205.07996 [nucl-ex].

- [18] **T. Gorda**, O. Komoltsev, and A. Kurkela. “Ab-initio QCD calculations impact the inference of the neutron-star-matter equation of state”. *Astrophys. J.* 950.2 (June 2023), 107. arXiv: 2204.11877 [nucl-th].
- [17] **T. Gorda**, A. Kurkela, J. Österman, R. Paatelainen, S. Säppi, P. Schicho, K. Seppänen, and A. Vuorinen. “Degenerate fermionic matter at N3LO: Quantum electrodynamics”. *Phys. Rev. D* 107.3 (2023), L031501. arXiv: 2204.11893 [hep-ph].
- [16] **T. Gorda**, A. Kurkela, J. Österman, R. Paatelainen, S. Säppi, P. Schicho, K. Seppänen, and A. Vuorinen. “Soft photon propagation in a hot and dense medium to next-to-leading order”. *Phys. Rev. D* 107.3 (2023), 036012. arXiv: 2204.11279 [hep-ph].
- [15] **T. Gorda** and S. Säppi. “Cool quark matter with perturbative quark masses”. *Phys. Rev. D* 105.11 (2022), 114005. arXiv: 2112.11472 [hep-ph].
- [14] P. Arnold, **T. Gorda**, and S. Iqbal. “The LPM effect in sequential bremsstrahlung: analytic results for sub-leading (single) logarithms”. *JHEP* 04 (2022), 085. arXiv: 2112.05161 [hep-ph].
- [13] E. Annala, **T. Gorda**, E. Katerini, A. Kurkela, J. Nättilä, V. Paschalidis, and A. Vuorinen. “Multimessenger Constraints for Ultradense Matter”. *Phys. Rev. X* 12.1 (2022), 011058. arXiv: 2105.05132 [astro-ph.HE].
- [12] **T. Gorda**, A. Kurkela, R. Paatelainen, S. Säppi, and A. Vuorinen. “Soft Interactions in Cold Quark Matter”. *Phys. Rev. Lett.* 127.16 (2021), 162003. arXiv: 2103.05658 [hep-ph].
- [11] **T. Gorda**, A. Kurkela, R. Paatelainen, S. Säppi, and A. Vuorinen. “Cold quark matter at N3LO: Soft contributions”. *Phys. Rev. D* 104.7 (2021), 074015. arXiv: 2103.07427 [hep-ph]. (**Editor’s suggestion**).
- [10] P. Arnold, **T. Gorda**, and S. Iqbal. “The LPM effect in sequential bremsstrahlung: nearly complete results for QCD”. *JHEP* 11 (2020), 053. arXiv: 2007.15018 [hep-ph].
- [9] E. Annala, **T. Gorda**, A. Kurkela, J. Nättilä, and A. Vuorinen. “Evidence for quark-matter cores in massive neutron stars”. *Nature Phys.* 16.9 (2020), 907–910. arXiv: 1903.09121 [astro-ph.HE].
- [8] **T. Gorda**, A. Helset, L. Niemi, T. V. I. Tenkanen, and D. J. Weir. “Three-dimensional effective theories for the two Higgs doublet model at high temperature”. *JHEP* 02 (2019), 081. arXiv: 1802.05056 [hep-ph].
- [7] **T. Gorda**, A. Kurkela, P. Romatschke, S. Säppi, and A. Vuorinen. “Next-to-Next-to-Next-to-Leading Order Pressure of Cold Quark Matter: Leading Logarithm”. *Phys. Rev. Lett.* 121.20 (2018), 202701. arXiv: 1807.04120 [hep-ph].
- [6] J. O. Andersen, **T. Gorda**, A. Helset, L. Niemi, T. V. I. Tenkanen, A. Tranberg, A. Vuorinen, and D. J. Weir. “Nonperturbative Analysis of the Electroweak Phase Transition in the Two Higgs Doublet Model”. *Phys. Rev. Lett.* 121.19 (2018), 191802. arXiv: 1711.09849 [hep-ph].
- [5] E. Annala, **T. Gorda**, A. Kurkela, and A. Vuorinen. “Gravitational-wave constraints on the neutron-star-matter Equation of State”. *Phys. Rev. Lett.* 120.17 (2018), 172703. arXiv: 1711.02644 [astro-ph.HE]. (**Featured in Physics, Editor’s suggestion**).
- [4] I. Ghisoiu, **T. Gorda**, A. Kurkela, P. Romatschke, S. Säppi, and A. Vuorinen. “On high-order perturbative calculations at finite density”. *Nucl. Phys.* B915 (2017), 102–118. arXiv: 1609.04339 [hep-ph].
- [3] **T. Gorda**. “Global properties of rotating neutron stars with QCD equations of state”. *Astrophys. J.* 832.1 (2016), 28. arXiv: 1605.08067 [astro-ph.HE].

- [2] **T. Gorda** and P. Romatschke. “Equation of state in two-, three-, and four-color QCD at nonzero temperature and density”. *Phys. Rev. D* 92.1 (2015), 014019. arXiv: 1412.6712 [hep-ph].
- [1] **T. Gorda** and P. Romatschke. “Precision studies of v_n fluctuations”. *Phys. Rev. C* 90.5 (2014), 054908. arXiv: 1406.6405 [nucl-th].

Preprints

- [1] A. Rajan, **T. Gorda**, S. Liuti, and K. Yagi. “Bounds on the Equation of State of Neutron Stars from High Energy Deeply Virtual Exclusive Experiments” (2018). arXiv: 1812.01479 [hep-ph].

Proceedings

- [6] **T. Gorda**. “Quark matter and nuclear astrophysics: recent developments”. Dec. 2023. arXiv: 2312.09967 [nucl-th].
- [5] S. Bogdanov et al. “Snowmass 2021 Cosmic Frontier White Paper: The Dense Matter Equation of State and QCD Phase Transitions”. *2022 Snowmass Summer Study*. Sept. 2022. arXiv: 2209.07412 [astro-ph.HE].
- [4] **T. Gorda**. “Improving the cold quark-matter pressure via soft interactions at N3LO”. *EPJ Web Conf.* 258 (2022), 05004. arXiv: 2111.11944.
- [3] P. Arnold, **T. Gorda**, and S. Iqbal. “The problem of overlapping formation times: A (nearly) complete result for QCD”. Vol. HardProbes2020. 2021, 181.
- [2] P. Arnold, **T. Gorda**, and S. Iqbal. “The Problem of overlapping formation times: In-medium virtual corrections for QCD”. Ed. by F. Liu, E. Wang, X.-N. Wang, N. Xu, and B.-W. Zhang. Vol. 1005. 2021, 121909.
- [1] E. Annala, **T. Gorda**, A. Kurkela, J. Nättilä, and A. Vuorinen. “Constraining the properties of neutron-star matter with observations”. *Proceedings: INTEGRAL 2019*. 2019. arXiv: 1904.01354 [astro-ph.HE].

Thesis

- [1] **T. Gorda**. “From pQCD to neutron stars: matching equations of state to constrain global star properties”. PhD thesis. Colorado U., 2016. arXiv: 1608.04358 [nucl-th].