

Manjunath Omaha Kuttan

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Current Position

- 2023 – … ■ **Postdoctoral Researcher, High Energy Nuclear Physics & Artificial Intelligence**
Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany
Member at **KISS consortium** (BMBF projekt: *Künstliche Intelligenz zur Schnellen Simulation von wissenschaftlichen Daten*)

RESEARCH INTERESTS:

- Deep Learning (DL) methods to analyse experimental data.
- DL and Bayesian methods for inverse problems in nuclear & particle physics.
- Artificial Intelligence (AI) for fast simulations.
- Properties, evolution & measurements of high density QCD matter in Heavy-ion Collisions (HIC) through model calculations & detector simulations.

Education

- 2019 – 2023 ■ **Ph.D in physics (Dr. phil. nat.)**,
Johann Wolfgang Goethe-Universität, Frankfurt am Main, Germany
QM magna cum laude Advisor: Prof. Dr. Dr. h.c. mult. Horst Stoecker
Dissertation: *Artificial intelligence in heavy-ion collisions: bridging the gap between theory and experiments.*
Member at HGS-HIRe for FAIR
Member at Frankfurt International Graduate School for Science
- 2017 – 2019 ■ **M.Sc. Physics, Central University of Karnataka**, Karnataka, India
QM Grade: 80 % Advisor: Dr. Deepak Samuel
Thesis: *Deep Learning techniques for muon momentum reconstruction for the INO-ICAL detector.*
- 2014 – 2017 ■ **B.Sc. Physics, Government College Kasaragod**, Kerala, India
QM Grade: 83 %

Scientific Skills

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|---------------|---|
| Coding | ■ C++, Python, QT, L ^A T _E X (6+ YEARS); Fortran (1 YEAR) |
| Libraries | ■ Tensorflow, Pytorch, Scikit-learn, Keras, (5+ YEARS) |
| HEP softwares | ■ Geant4, ROOT, (3 YEARS) |
| Data analysis | ■ Using Python and ROOT (5 YEARS) |
| HIC models | ■ UrQMD, Hydrodynamic models, MC-Glauber (4+ YEARS) |
| Detectors | ■ Development, testing and characterization of RPCs (3 MONTHS) |
| Big data | ■ Physics analysis for HIC simulations and experiments(5 YEARS) |

Research Experience

- 2023–  **Current Research.** Deepthinkers group: *Dr. Jan Steinheimer, Dr. Kai Zhou*
- Focusing on AI for fast simulations in high energy and nuclear physics.
 - First use of deep generative methods for heavy-ion collision event generation.
- Drafts under preparation:
-  Accelerating heavy-ion collision (HIC) simulations with deep generative models for next generation experiments.
 -  Pointcloud diffusion for event-by-event simulation of HIC.
- 2019–2023  **Doctoral Research.** Advisor: *Prof. Dr. Dr. h.c. mult. Horst Stoecker*
- Developed advanced AI methods to infer the underlying physics governing the dense nuclear matter created in heavy-ion collisions.
- This includes several works that explored:
- ✓ Bayesian constraints on the high density QCD Equation of State
 - ✓ Accurate, online event-by-event centrality meter for CBM experiment.
 - ✓ Dynamical time evolution in transport and fluid dynamical models.
 - ✓ DL for identifying first order phase transitions at CBM experiment.
 - ✓ Uncertainties in MC-Glauber modelling at SIS-18 energies.
 - ✓ DL for noise cluster filtering (online) in CERN-NA61 experiment.
 - ✓ DL for participant nucleon determination in HADES & STAR experiments.
- OTHER ACTIVITIES:
- Mentor for Master's students (AI-analysis for PANDA & NA61 experiments).
 - Local organiser for *MAGIC23: Workshop on QCD EoS in dense matter HIC & Astrophysics*, Kovalam, Kerala, India, March 2023.
 - Local organiser: *XF-IJRC AI4Science workshop*, Frankfurt am Main, Sep 2023.
- 2018–2019  **Master's Research.** Advisor: *Dr. Deepak Samuel*
- Developed DL algorithm was developed to reconstruct the muon momentum in the ICAL detector which studies neutrino oscillations at the India based Neutrino Observatory (INO).
 - Contributed to the development of ML methods to identify the charge and direction of cosmic muons at mini-ICAL (prototype detector for INO).
- 2018  **Summer Intern, India based Neutrino Observatory, IICHEP** Activities:
- Fabrication of Resistive Plate Chambers (RPC)
 - Setting up test experiments for RPCs
 - Installation of mini-ICAL detector at Tata Institute of Fundamental Research (TIFR) field station, Madurai.
 - Analysis of cosmic muon data

Achievements and Skill development

Awards

- 2024  **Giersch Award**, for outstanding doctoral thesis.
- 2023  **Stefan Shramm Award**, for best presentation, MAGIC2023: Workshop on QCD EoS in dense matter HIC and astrophysics, Kovalam.
- 2021  **Giersch-Excellence-Grant**, for outstanding scientific work in the past years.
- 2020  **Giersch-Excellence-Grant** for outstanding scientific work in the past years.

Softskill courses

- 2022  **HGS-HIRe Basic Course II:** Leading Teams in a Research Environment.
- 2021  **HGS-HIRe Basic Course I:** Making an Impact as an Effective Researcher.

Online courses (credited)

- MITX  **Quantum Information Science -I**, Prof. P. Shorr & Prof. I. Chuang, MIT, 2018.
- NPTEL  **Physics of Semiconductors**, Prof. H. C. Verma, IIT Kanpur, 2017.

Online profiles

- Google scholar  <https://scholar.google.com/citations?user=cZe18xwAAAAJ>
Articles: 12; Citations: 140; (As of Oct 15 2024)
- INSPIRE-HEP  <https://inspirehep.net/authors/1823113>
- ORCID  <https://orcid.org/0000-0003-1432-9643>

Selected Publications

- 1 **M. Omana Kuttan**, J. Steinheimer, K. Zhou, and H. Stoecker, “QCD Equation of State of Dense Nuclear Matter from a Bayesian Analysis of Heavy-Ion Collision Data,” *Phys. Rev. Lett.*, vol. 131, no. 20, p. 202303, 2023.  DOI: 10.1103/PhysRevLett.131.202303,  **Highlighted as cover for the Volume 131, Issue 20, 2023**  **Recommended as Editor's suggestion**.
- 2 **M. Omana Kuttan**, A. Motornenko, J. Steinheimer, H. Stoecker, Y. Nara, and M. Bleicher, “A chiral mean-field equation-of-state in UrQMD: effects on the heavy ion compression stage,” *Eur. Phys. J. C*, vol. 82, no. 5, p. 427, 2022.  DOI: 10.1140/epjc/s10052-022-10400-2.
- 3 **M. Omana Kuttan**, J. Steinheimer, K. Zhou, A. Redelbach, and H. Stoecker, “A fast centrality meter for heavy-ion collisions at the CBM experiment,” *Phys. Lett. B*, vol. 811, p. 135872, 2020.  DOI: 10.1016/j.physletb.2020.135872.
- 4 **M. Omana Kuttan**, K. Zhou, J. Steinheimer, A. Redelbach, and H. Stoecker, “An equation of state meter for CBM using PointNet,” *JHEP*, vol. 21, p. 184, 2020.  DOI: 10.1007/JHEP10(2021)184.
- 5 **M. Omana Kuttan**, J. Steinheimer, K. Zhou, M. Bleicher, and H. Stoecker, “Model dependence of the number of participant nucleons and observable consequences in heavy-ion collisions,” *Eur. Phys. J. C*, vol. 83, no. 9, p. 792, 2023.  DOI: 10.1140/epjc/s10052-023-11968-z.

Selected Conferences and Workshops

- SQM2024 **Strangeness in Quark Matter; Strasbourg, France;** June 2024; *Talk: Bayesian constraints on the high density QCD EoS from Heavy-ion collision data.*
- EuCAIFCon24 **European AI for Fundamental Physics Conference; Amsterdam, Netherlands;** April 2024 *Talk: AI-driven exploration of strongly interacting nuclear matter under extreme conditions.*
- ML4JETS23 **ML for Jets Workshop; Hamburg, Germany;** Nov 2023; *Talk: ParticleGrow: Event-by-event simulation of HIC via autoregressive point cloud generation.*
- INT workshop **Dense Nuclear Matter EoS from Heavy-Ion Collisions; Seattle, USA;** Dec 2022; *Talk: The EoS of dense nuclear matter from Bayesian analysis of heavy-ion collision data.*
- QM2022 **International Conference on Ultra-relativistic Nucleus-Nucleus Collisions; Krakow, Poland;** April 2022; *Poster: Deep Learning the physics of heavy-ion collisions at the CBM experiment using PointNet.*
- NA61/SHINE **Collaboration meeting; CERN, Geneva;** Feb 2020; *Talk: Deep learning for fast TPC data processing.*

References

Prof. Dr. Dr. h.c. mult. Horst Stoecker

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Dr. Jan Steinheimer

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Dr. Deepak Samuel

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