Manjunath Omana Kuttan

Frankfurt Institute for Advanced Studies,
3|204, Ruth-Moufang-Str 1, 60438, Frankfurt am Main
manjunath@fias.uni-frankfurt.de +49 6979847624 +49 1771846164
http://okmanjunath.github.io

Current Position

2023 – · · · · ***Postdoctoral Researcher,*** *High Energy Nuclear Physics & Artificial Intelligence*
Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany
Member at **KISS collaboration** (*BMBF projekt:* ***K****ünstliche* ***I****ntelligenz zur* ***S****chnellen* ***S****imulation 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
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
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
Grade: 83 %

Scientific Skills

Coding	C++, Python, QT, LaTeX (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 of scientific data.
- 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 Shram 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. 202 303, 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. 135 872, 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
Senior Fellow,
Frankfurt Institute for Advanced Studies,
Frankfurt am Main-Germany
stoecker@fias.uni-frankfurt.de

Dr. Jan Steinheimer
Research Fellow,
Frankfurt Institute for Advanced Studies,
Frankfurt am Main-Germany
steinheimer@fias.uni-frankfurt.de

Dr. Deepak Samuel
Associate Professor,
Central University of Karnataka,
Gulbarga, India
deepaksamuel@cuk.ac.in

Dr. Kai Zhou
Assistant Professor,
The Chineese University of Hong Kong,
Shenzhen
zhou@fias.uni-frankfurt.de