# Dushmanta Sahu (Ph.D.)

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Orcid · Inspire HEP

## Education

**Ph.D.** | ***Experimental High Energy Physics*** — June 2019 – June 2024
Indian Institute of Technology Indore — Madhya Pradesh, India

**Master of Science** | ***High Energy Physics*** — August 2016 – April 2018
Sambalpur University, Burla — Odisha, India

**Bachelor of Science** | ***Major: Physics*** — August 2013 – May 2016
Trust Fund Degree College, Bargarh — Odisha, India

## Research Interest

- Relativistic heavy-ion and hadronic collisions experiments
- Heavy-ion phenomenology
- Heavy flavor and quarkonia
- Hadron resonance gas and quark-gluon plasma

## Publications

- Number of published articles in peer reviewed journals : 17
- Number of first author articles : 5
- Number of conference proceedings : 20

## Teaching Experience

**B.Tech lab (One semester TA)** — Autumn, 2019
IIT Indore — Indore, India

**Quantum Mechanics, B.Tech (One semester TA)** — Spring, 2020
IIT Indore — Indore, India

**B.Tech lab (Two semesters TA)** — Spring, Autumn, 2022
IIT Indore — Indore, India

## Skills

**Languages**: English, Hindi, Odia
**Operating systems**: MacOS, Ubuntu, Windwos
**Programming**: C++, Python
**Computational Tool**: Mathematica
**Event generators**: PYTHIA8, AMPT
**Plotting softwares**: Root, Xmgrace

## ACHIEVEMENTS

- PhD thesis: "Possible formation of QGP droplets in high-multiplicity events and measurement of $\psi$(2S) polarization in proton+proton collisions at $\sqrt{s}$ = 13 TeV with ALICE"
- Awarded best poster presentation in DAE Symposium on Nuclear Physics, 2019 at Lucknow University, India
- Qualified national level exam, GATE in PHYSICS in the year 2019

## STATEMENT OF RESEARCH

**Experiment**

I am broadly interested in heavy-ion physics. My research mainly focuses on the ALICE experiment at CERN. I was actively involved in the analysis of $\psi$(2S) polarization measurement in pp collisions at center of mass energy 13 TeV. The quarkonium polarization in high-energy hadronic collisions can provide tests for Quantum Chromodynamics. Currently, various theoretical models give contrasting results with the experimental data for charmonia polarization. Thus, a detailed study with a higher center of mass energy and higher statistics is necessary. Moreover, the $\psi$(2S) polarization study is important because the $\psi$(2S) signal is almost uncontaminated from the decays of higher charmonium states, giving a clear result of polarization. Thus, this study can act as a baseline for quarkonium polarization measurements in high multiplicity hadronic and heavy-ion collisions, where there can be a possibility of contribution from spin-orbit coupling, which is an indirect consequence of a thermalized deconfined medium formation. In the analysis, we extract the polarization parameters by studying the angular distribution of the two-body decay daughters of charmonia. Two specific frames of references are chosen in the $\psi$(2S) rest mass frame, namely the helicity and Colin-Soper frames. Finally, the polarization parameters are studied in these two reference frames as functions of transverse momentum. I mainly work with the Aliphysics framework, which was used for the data analysis of RUN 1 and RUN 2 data obtained by the ALICE collaboration. In addition to this, I am also involved in a service task to check the compatibility of RUN 2 converted data to the O2 framework, which is being used for the RUN 3 data analysis. I am also involved in and guiding new PhD students who are working on $\Upsilon$(nS) and $\phi$ polarization in dimuon channel with RUN3 data.

**Phenomenology**

On the phenomenological side, my work concerns with possible QGP droplet formation in high multiplicity proton-proton collisions. I work with QCD-inspired models, such as the color string percolation model (CSPM), which can provide useful information about the thermodynamics and transport properties of the matter formed in ultra-relativistic collisions. Our work suggests a threshold of charged particle multiplicity per pseudorapidity density of around 10-20, after which a possible deconfined medium formation can be expected. This makes the study of high multiplicity pp collisions very intriguing. I also work on non-extensive Tsallis statistics, which assumes a slightly off-equilibrium system to study various thermodynamic and transport properties of a hadronic medium. These studies can help us to characterize the matter formed in ultra-relativistic collisions. In addition, I am currently working with an interacting hadron resonance gas model to study various thermodynamic and transport properties by considering the effect of both an external magnetic field and rotation in the system. This also can be used to understand the conserved charge fluctuations in heavy-ion collisions. Recent studies on hyperon polarization in heavy-ion collisions have opened new avenues regarding the presence and effect of rotation in the medium. In accordance with the effect of vorticity, I am also exploring hyperon and quarkonium polarization studies in ultra-relativistic collisions by using various phenomenological models. Overall, the study of the QCD phase structure gets more interesting with the addition of extra dimensions such as magnetic field and rotation. I also explore the QCD phase diagram through the interacting hadron resonance gas model to try to constrain the location of both the QCD critical point and the liquid-gas critical point.

## Analysis Note

- D. Sahu and R. Sahoo, "$\psi$(2S) polarization measurement in pp collisions at $\sqrt{s}$ = 13 TeV", https://alice-notes.web.cern.ch/node/1472 (ALICE internal)

## Publications list

1. D. Sahu, S. Tripathy, G. S. Pradhan and R. Sahoo, "Role of event multiplicity on hadronic phase lifetime and QCD phase boundary in ultrarelativistic collisions at energies available at the BNL Relativistic Heavy Ion Collider and CERN Large Hadron Collider," Phys. Rev. C **101**, 014902 (2020).

2. D. Sahu, S. Tripathy, R. Sahoo and S. K. Tiwari, "Possible formation of a perfect fluid in $pp$, $p$–Pb, Xe–Xe and Pb–Pb collisions at the Large Hadron Collider energies: a color string percolation approach," Eur. Phys. J. A **58**, 78 (2022).

3. D. Sahu, S. Tripathy, R. Sahoo and A. R. Dash, "Multiplicity dependence of shear viscosity, isothermal compressibility and speed of sound in $pp$ collisions at $\sqrt{s}$ = 7 TeV," Eur. Phys. J. A **56**, 187 (2020).

4. D. Sahu and R. Sahoo, "Thermodynamic and transport properties of matter formed in pp, p-Pb, Xe–Xe and Pb–Pb collisions at the Large Hadron Collider using color string percolation model," J. Phys. G **48**, 125104 (2021).

5. D. Sahu and R. Sahoo, "Characterizing Proton-Proton Collisions at the Large Hadron Collider with Thermal Properties," MDPI Physics **3**, 207 (2021).

6. S. Deb, D. Sahu, R. Sahoo and A. K. Pradhan, "Bose-Einstein condensation of pions in proton–proton collisions at the Large Hadron Collider using non-extensive Tsallis statistics," Eur. Phys. J. A **57**, 158 (2021).

7. A. N. Mishra, D. Sahu and R. Sahoo, "Jet Transport Coefficient at the Large Hadron Collider Energies in a Color String Percolation Approach," MDPI Physics **4**, 315 (2022).

8. G. S. Pradhan, D. Sahu, S. Deb and R. Sahoo, "Hadron gas in the presence of a magnetic field using non-extensive statistics: a transition from diamagnetic to paramagnetic system," J. Phys. G **50**, 055104 (2023).

9. R. Scaria, D. Sahu, C. R. Singh, R. Sahoo and J. e. Alam, "Fluidity of the system produced in relativistic pp and heavy-ion collisions: Hadron resonance gas model approach," Eur. Phys. J. A **59**, 140 (2023).

10. K. K. Pradhan, D. Sahu, R. Scaria and R. Sahoo, "Conductivity, diffusivity, and violation of the Wiedemann-Franz Law in a hadron resonance gas with van der Waals interactions," Phys. Rev. C **107**, 014910 (2023).

11. K. Goswami, D. Sahu and R. Sahoo, "Understanding the QCD medium by the diffusion of charm quarks using a color string percolation model," Phys. Rev. D **107**, 014003 (2023).

12. B. Sahoo, C. R. Singh, D. Sahu, R. Sahoo and J. e. Alam, "Impact of vorticity and viscosity on the hydrodynamic evolution of hot QCD medium," Eur. Phys. J. C **83**, 873 (2023).

13. K. Goswami, K. K. Pradhan, D. Sahu and R. Sahoo, "Diffusion and fluctuations of open charmed hadrons in an interacting hadronic medium," Phys. Rev. D **108**, 074011 (2023).

14. B. Sahoo, K. K. Pradhan, D. Sahu and R. Sahoo, "Effect of a magnetic field on the thermodynamic properties of a high-temperature hadron resonance gas with van der Waals interactions," Phys. Rev. D **108**, 074028 (2023).

15. G. S. Pradhan, D. Sahu, R. Rath, R. Sahoo and J. Cleymans, "Role of chemical potential at kinetic freeze-out using Tsallis non-extensive statistics in proton-proton collisions at the Large Hadron Collider," Eur. Phys. J. A **60**, 52 (2024).

16. B. Sahoo, D. Sahu, S. Deb, C. R. Singh and R. Sahoo, "$J/\psi$ and $\psi$(2S) polarization in proton-proton collisions at the LHC energies using PYTHIA8," Phys. Rev. C **109**, 034910 (2024).

17. K. Goswami, D. Sahu, J. Dey, R. Sahoo and R. Stock, "Anisotropy of magnetized quark matter," Phys. Rev. D **109**, 074012 (2024).

## Communicated papers

1. K. K. Pradhan, D. Sahu, C. R. Singh and R. Sahoo, "Effect of Bose-Einstein condensation on the viscosity of a hot pion gas," [arXiv:2212.09288] (PRC under review).

2. K. K. Pradhan, B. Sahoo, D. Sahu and R. Sahoo, "Thermodynamics of a rotating hadron resonance gas with van der Waals interaction," [arXiv:2304.05190] (EPJC under review).

3. K. K. Pradhan, R. Scaria, D. Sahu and R. Sahoo, "Proton number cumulants in a modified van der Waals hadron resonance gas," [arXiv:2308.09337] (PLB under review).

## Conferenece proceedings

1. D. Sahu, S. Tripathy, G. S. Pradhan and R. Sahoo, "Hadronic Phase Lifetime and QCD Phase boundary in Ultra-relativistic Collisions at the RHIC and LHC: Collision System and Event Multiplicity Dependence," DAE Symp. Nucl. Phys. **64**, 754 (2019).

2. D. Sahu, A. N. Mishra and R. Sahoo, "Study of the jet transport coefficient at the Large Hadron Collider energies using Color String Percolation Model," PoS **LHCP2021**, 232 (2021).

3. D. Sahu and R. Sahoo, "Dissipative properties of the matter formed at the Large Hadron Collider energies using Color String Percolation Model," DAE Symp. Nucl. Phys. **65**, 626 (2021).

4. D. Sahu, S. Tripathy, R. Sahoo and S. K. Tiwari, "Multiplicity Dependence Study of Thermodynamic and Transport Properties of the Matter Formed in Ultra-Relativistic Collisions at LHC Using Color String Percolation Model," Springer Proc. Phys. **277**, 369 (2022).

5. D. Sahu, S. Tripathy, G. S. Pradhan and R. Sahoo, "Estimation of Hadronic Phase Lifetime and Locating the QGP Phase Boundary," Int. J. Mod. Phys. E **31**, 12 (2022).

6. K. K. Pradhan, D. Sahu, R. Scaria and R. Sahoo, "Electrical and thermal conductivities in a hadron resonance gas with van der Waals interactions," DAE Symp. Nucl. Phys. **66**, 853 (2023).

7. R. Scaria, D. Sahu, C. R. Singh, R. Sahoo and J. e. Alam, "Probing thermalization and system size effect on a hadron resonance gas for hydrodynamical study of hadronic phase," DAE Symp. Nucl. Phys. **66**, 948 (2023).

8. K. Goswami, D. Sahu and R. Sahoo, "Studying the diffusion of charm quarks in a deconfined medium using Color String Percolation approach," DAE Symp. Nucl. Phys. **66**, 936 (2023).

9. G. S. Pradhan, D. Sahu, S. Deb and R. Sahoo, "Insight into the magnetic response of hadron gas using non-extensive statistics," PoS **LHCP2022**, 327 (2023).

10. D. Sahu, S. Deb, A. Kumar Padhan and R. Sahoo, "Hint of pion condensation in proton-proton collisions at the LHC using non-extensive Tsallis statistics," PoS **LHCP2022**, 253 (2023).

11. R. Scaria, D. Sahu, C. R. Singh, R. Sahoo and J. e. Alam, "Fluid properties of hadron gas produced in relativistic hadronic and heavy-ion collisions," PoS **LHCP2022**, 332 (2023).

12. C. R. Singh, B. Sahoo, D. Sahu, R. Sahoo and J. e. Alam, "How do coupled viscosity, vorticity and magnetic field govern the QGP evolution?," DAE Symp. Nucl. Phys. **67**, 985 (2024).

13. B. Sahoo, K. K. Pradhan, D. Sahu and R. Sahoo, "Refractive index of the hadronic medium in presence of a magnetic field," DAE Symp. Nucl. Phys. **67**, 885 (2024).

14. G. S. Pradhan, D. Sahu, S. Deb and R. Sahoo, "Magnetic Field Effects in Hadron Gas: Non-Extensive Insights," DAE Symp. Nucl. Phys. **67**, 1063 (2024).

15. G. S. P. Pradhan, D. Sahu, R. Rath, R. Sahoo and J. Cleymans, "Decoding Chemical Potential Effects at the Kinetic Freeze-Out through Tsallis Non-Extensive Statistics at the LHC," DAE Symp. Nucl. Phys. **67**, 1065 (2024).

16. K. Goswami, K. K. Pradhan, D. Sahu and R. Sahoo, "Dynamics of charmed hadron in an interacting hadron gas," DAE Symp. Nucl. Phys. **67**, 883 (2024).

17. K. Pradhan, R. Scaria, D. Sahu and R. Sahoo, "Higher order proton number fluctuations in a modified van der Waals hadron resonance gas model," DAE Symp. Nucl. Phys. **67**, 887 (2024).

18. D. Sahu and R. Sahoo, "Is there a threshold in the final state charged particle multiplicity to form a plasma of quarks and gluons?," DAE Symp. Nucl. Phys. **67**, 1051 (2024).

19. B. Sahoo, S. Deb, D. Sahu, C. R. Singh and R. Sahoo, "Exploring J/$\psi$ and $\psi$(2S) polarization dynamics in pp collisions at the LHC energies with PYTHIA8," DAE Symp. Nucl. Phys. **67**, 1035 (2024).

20. D. Sahu, "Quarkonium polarization in pp and Pb-Pb collisions," DAE Symp. Nucl. Phys. **67**, 1053 (2024).

## Talks delivered

1. "Multiplicity dependence study of thermodynamic and transport properties of the matter formed in ultra-relativistic collisions at LHC using Color String Percolation Model", DAE-HEP, Lucknow University, Lucknow, 2020

2. "Dissipative properties of the matter formed at the Large Hadron Collider energies using Color String Percolation Model", DAE-NP, NISER, Bhubaneswar, 2021

3. "Estimation of hadronic phase lifetime and locating the QGP phase boundary", Hot QCD Matter Conference, IIT Goa, Goa, 2022

4. "Possibility of a QCD medium formation in LHC proton+proton collisions: A Color String Percolation Approach", DAE-BRNS CETHEP Symposium, VECC, Kolkata, 2022

5. "Quarkonium polarization in pp and Pb-Pb collisions with ALICE", Rencontres du Vietnam: Windows on the Universe, Quy Nhon, Vietnam, 2023 **(For the ALICE Collaboration)**

6. "Dynamics of open charmed hadrons in an interacting hadronic medium", Heavy Flavor Meet, IIT Goa, Goa, 2023 **(Invited talk)**

7. "Thermodynamics and statistical mechanics in heavy-ion collisions", Physics Club, IIT Indore, 2023

8. "Quarkonium polarization at the LHC energies", RDFP, Sambalpur University, 2024

9. "Quarkonium polarization in pp and Pb-Pb collisions with ALICE", ALICE India Collaboration Seminar, April, 2024

## Posters presented

1. ”Hadronic Phase Lifetime and QCD Phase boundary in Ultra-relativistic Collisions at the RHIC and LHC: Collision System and Event Multiplicity Dependence”, DAE-SNP 2019 **(Best Poster)**
2. ”Characterizing high energy pp collisions at the LHC using thermodynamic and transport properties”, DAE-HEP 2020
3. ”Study of the jet transport coefficient at the Large Hadron Collider energies using Color String Percolation Model”, LHCP 2021
4. ”Hint of pion condensation in proton-proton collisions at LHC using non-extensive Tsallis statistics”, LHCP 2022
5. ”Probing thermalization and system size effects on a hadron gas for a hydrodynamical study of the hadronic phase”, DAE-HEP, 2022
6. ”Transport properties of the deconfined medium by using the color string percolation model”, ICPAQGP, 2023
7. ”Is there a threshold in the final state charged particle multiplicity to form a plasma of quarks and gluons?”, DAE-SNP, 2023
8. ”Quarkonium polarization measurement in pp and Pb-Pb collisions”, DAE-SNP, 2023 **(For the ALICE Collaboration)**

## Extracurricular activities

- Core organizing member of DAE-SNP conference, 2023, IIT Indore
- Founding member of Physics Club, IIT Indore
- Core member of Literary Club, IIT Indore
- Written and published numerous articles in the IIT Indore literary magazines

## Referees

- **Prof. Raghunath Sahoo**
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  Department of Physics
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- **Dr. Sabyasachi Ghosh**
  Assistant Professor
  Department of Physics
  IIT Bhilai, Kutelabhata, Khapri
  District – Durg, Chhattisgarh – 491001, India
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- **Dr. Swatantra Kumar Tiwari**
  Assistant Professor
  Department of Physics, University of Allahabad
  Senate House Campus, University Road,
  Old Katra
  Prayagraj (Allahabad), Uttar Pradesh - 211002,
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