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PERSONAL STATEMENT

I have a strong interdisciplinary background in biophysics, statistical mechanics, polymer modeling, and computational biology, with a particular focus on understanding genome architecture from a physical and mechanistic perspective. My research combines the methods of physics, chemistry, and computer science with experimental data, such as Hi-C, to develop quantitative models that explain how molecular factors manipulate genome structure. This is exemplified by a series of studies where I integrated molecular dynamics and DNA statistical mechanics with experimental findings to uncover the role of SMC proteins in genome organization (PNAS 2019; Science 2021; NAR 2022; bioRxiv 2024). These efforts contribute to our broader understanding of how the forces exerted by collective activity of molecular factors shape large-scale genome architecture and influence its functional dynamics, ultimately aiming to define the physical principles governing genome structure.

RESEARCH EXPERIENCE

Post-doctoral Associate, Rice University 2018 - present
Supervisor: Prof. José N. Onuchic
Research keywords: Molecular Dynamics Simulations, Machine Learning, Statistical Mechanics, Computational biology, Hi-C data, Epigenetics, genome architecture, chromatin mechanics, transcription, SMC proteins.

Graduate Researcher, Northwestern University 2013-2018
Supervisor: Prof. John F. Marko
Research keywords: Statistical Mechanics, Single-molecule DNA biophysics, chromosome structure.

EDUCATION

Ph. D. Physics, Department of Physics and Astronomy, Northwestern University 2013-2018
M. Sc. Physics, Department of Physics, Indian Institute of Technology Mumbai 2011-2013
B. Sc. Physics, Hindu College, University of Delhi 2008-2011

PUBLICATIONS (* = shared authorship; # = highlights)

Link to all publications: https://scholar.google.com/citations?user=uIbiYcIAAAAJ&hl=en&authuser=1

[1] # S Brahmachari, S Tripathi, JN Onuchic, and H Levine. Nucleosomes play a dual role in regulating transcription dynamics. **Proc. Natl. Acad. Sci. USA.** 121 (28) (2024).

[2] # S Brahmachari, T Markovich, FC MacKintosh, and JN Onuchic. Temporally Correlated Active Forces Drive Segregation and Enhanced Dynamics in Chromosome Polymers. **PRXLife** 2 (2024).

[3] # [Preprint] S Brahmachari, AB Oliveira, MF Mello, VG Contessoto, and JN Onuchic. Compaction-mediated segregation of partly replicated bacterial chromosomes. **bioRxiv** (2024).

[4] [Preprint] J Hwang, C Lee, S Brahmachari, et al. DNA supercoiling-mediated G4/R-loop formation tunes transcription by controlling the access of RNA polymerase. **Research Square** (2024).

[5] E Dodero-Rojas, MF Mello, S Brahmachari, et al. PyMEGABASE: Predicting cell-type-specific structural annotations of chromosomes using the epigenome. **J. Mol. Biol.** 435 (15), p168180 (2023).

[6] BS Ruben, S Brahmachari, VG Contessoto, et al. Structural reorganization and relaxation dynamics of axially stressed chromosomes. **Biophys. J.** 122 (9) p1633-1645 (2023).

[7] # S Brahmachari, VG Contessoto, M Di Pierro, and JN Onuchic. Shaping the genome via lengthwise compaction, phase separation, and lamina adhesion. **Nucl. Acids Res**. 50, p4258-4271 (2022).

[8] S Tripathi, S Brahmachari, JN Onuchic, and H Levine. DNA supercoiling-mediated collective behavior of co-transcribing RNA polymerases. **Nucl. Acids Res.** 50 (3), p1269-1279 (2022).

[9] C Hoencamp*, O Dudchenko*, AMO Elbatsh*, S Brahmachari* et al. 3D genomics across the tree of life reveals condensin II as a determinant of architecture type. **Science** 372, p984-989 (2021).

[10] PR Desai, S Brahmachari, JF Marko, et al. Coarse-grained modelling of DNA plectoneme pinning in the presence of base-pair mismatches. **Nucl. Acids Res.** 48 (19), p10713-10725 (2020).

[11] # S Brahmachari and JF Marko. Chromosome disentanglement driven via optimal compaction of loop-extruded brush structures. **Proc. Natl. Acad. Sci. USA.** 116, p24956-24965 (2019).

[12] S Brahmachari, A Dittmore, Y Takagi, et al. Defect-facilitated buckling in supercoiled double-helix DNA. **Phys. Rev. E** 97 (2), p022416 (2018).

[13] A Dittmore, S Brahmachari, Y. Takagi, J. F. Marko, and K. C. Neuman. Supercoiling locates mismatches. **Phys. Rev. Lett.** 119, 147801 (2017).

[14] S Brahmachari*, KH Gunn*, RD Giuntoli, et al. Nucleation of multiple buckled structures in intertwined DNA double helices. **Phys. Rev. Lett.** 119, 188103 (2017).

[15] S Brahmachari and JF Marko. Torque and buckling in stretched intertwined double-helix DNAs. **Phys. Rev. E** 95 (5), p052401 (2017).

[16] [Book chapter] S Brahmachari and JF Marko. DNA mechanics and topology. **Biomechanics in Oncology**, Advances in Experimental Medicine and Biology, vol 1092. Springer, Cham. (2018).

AWARDS AND FELLOWSHIPS

- Robert A. Welch Postdoctoral Fellow, Rice University 2018-2022
- Shirley Chan student travel grant sponsored by DBIO, APS 2017
- Molecular Biophysics Training Program Fellow, Northwestern University 2014-2016
- Innovation in Science Pursuit for Inspired Research (INSPIRE) scholarship, sponsored by the Department of Science and Technology, Government of India 2008-2013

PROFESSIONAL SERVICE

- Member of the American Physical Society (2017 to present).
- Peer-reviewed for PLOS One, iScience, Journal of Royal Society Interface, Clinical and Translational Medicine, and eLife.

MENTORING AND OUTREACH

- Mentored multiple undergraduate (Benjamin Ruben) and graduate students (Shubham Tripathi, Esteban Dodero-Rojas, Matheus F. Mello) leading to multiple publications

- Mentor for the NSF sponsored Frontiers in Science (FIS) program at Rice University. This program provides summer research opportunities in biological physics for undergraduate students from underserved communities in the Houston area.
- Organized an invited workshop on genome modeling at the NSF Genome organization meeting in Boston (July 2024). This workshop was aimed at exposing early career trainees (post bacs and graduate students) to the methods of data-driven polymer modeling.
- Organizer of the DBIO-sponsored focus session: DNA Mechanics and Gene Expression, at the American Physical Society March Meetings (2023 onwards).
- Organized workshop on Quantitative Approaches to Modeling Biological Systems (January 2023) hosted by the Center for Theoretical Biological Physics, Rice University.

TEACHING EXPERIENCE

2017 Teaching Assistant (Northwestern University) for Quantitative Biology (IBiS-410)
2016 Teaching Assistant (Northwestern University) for Quantum Mechanics II (Phys 412-2)
2015 Teaching Assistant (Northwestern University) for Quantum Mechanics III (Phys 412-3)
2014 Teaching Assistant (Northwestern University) for General Physics Laboratory (Phys 136-1)

SELECTED PRESENTATIONS

2024 Invited talk at Tata Institute of Fundamental Research Hyderabad, India (Sep)
Invited talk at the Dept. of Bioengineering, Indian Institute of Sciences, Bengaluru, India (Sep)
Invited talk at Interdisciplinary challenges in non-equilibrium physics, MPIKS, Germany (April)
Contributed talk at APS March meeting, Minneapolis, US (March)
Invited talk at Department of Physics, Georgia Tech, Atlanta, Georgia (March)
Invited talk at Department of Physics, University of Alberta, Edmonton, Canada (March)
Invited talk at Dept. of Molecular Biology, Colorado State U., Fort Collins, Colorado (March)
Invited talk at Department of Physics, University of Florida, Gainesville, Florida (February)
2023 Invited talk at the International Plant and Animal Genome Conference, Perth, Australia (Sep)
Invited talk at Indian Institute of Technology Bombay (IITB), Mumbai, India (Sep)
Invited talk at Jawaharlal Nehru Center for Advanced Scientific Research, Bengaluru, India (Sep)
Invited talk at International Center for Theoretical Sciences (ICTS), Bengaluru, India (Sep)
Invited talk at National Center for Biological Sciences (NCBS), Bengaluru, India (Sep)
Invited talk at the American Physical Society (APS) March Meeting, Las Vegas, US (March)
2022 Contributed talk at the American Physical Society March Meeting, Chicago, US (March)
2020 Contributed talk at the Genome Organization Workshop, held virtually at MIT, US (June)
2019 Contributed talk at APS March meeting, Boston, US (March)
Poster at Gordon Research Conference on Chromosome Dynamics, Newry, US (June)
Poster at Genome Architecture Meeting, Varna, Bulgaria (July)
2018 Contributed talk at the APS March meeting, Los Angeles, US (March)
2017 Contributed talk at the APS March meeting, New Orleans, US (March)
Poster at Chromosome segregation and structure meeting, Cold Spring Harbor Lab, US (June)

REFERENCES

- **Prof. José N. Onuchic** (Postdoc adviser)
  Rice University
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  Email: jonuchic@rice.edu
  Contact number: +1 713-348-4197

- **Prof. John F. Marko** (PhD adviser)
  Northwestern University
  Evanston, IL, USA 60028
  Email: john-marko@northwestern.edu
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- **Prof. Herbert Levine** (Collaborator)
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- **Prof. Fred C. MacKintosh** (Collaborator)
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- **Dr. Keir C. Neuman** (Collaborator)
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