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Rajesh Singh

Curriculum Vitae

Scientific positions and education

03/18–date Postdoctoral research associate, DAMTP, University of Cambridge, United Kingdom

08/12–03/18 Ph.D. in Theoretical Physics, Institute of Mathematical Sciences-HBNI, Chennai, India
Title: Microhydrodynamics of active colloids | Advisor: Ronojoy Adhikari

08/10–06/12 M.Sc. in Physics, Indian Institute of Technology Kanpur, India

07/07–06/10 B.Sc. (Honours) in Physics, Hindu College, University of Delhi, India

Research

Bibliometry Google Scholar | ResearchGate

Interests Statistical Physics | Soft Matter | Fluid Dynamics | Bayesian Statistics | Active Matter

Selected publications

Self-propulsion of active droplets without liquid-crystalline order
R. Singh, E. Tjhung, and M. E. Cates. Phys. Rev. Research 2, 032024(R), 2020. Editors' Suggestion

Controlled optofluidic crystallization of colloids tethered at interfaces
A. Caciagli, **R. Singh**†, D. Joshi, R. Adhikari, and E. Eiser. Phys. Rev. Lett. 125(6), 068001, 2020. Editors' Suggestion | Featured in Physics

Hydrodynamically interrupted droplet growth in scalar active matter
R. Singh, and M. E. Cates. Phys. Rev. Lett. 123(14), 148005, 2019. Recommended with a commentary by the Journal Club for Condensed Matter Physics.

Competing chemical and hydrodynamic effects in autophoretic colloidal suspensions
R. Singh, R. Adhikari, and M. E. Cates. J. Chem. Phys. 151, 044901, 2019.

Flow-induced phase separation of active particles is controlled by boundary conditions
S. Thutupalli, D. Geyer, **R. Singh**†, R. Adhikari, and H. Stone. PNAS 115(21), 5403, 2018.

Fast Bayesian inference of the multivariate Ornstein-Uhlenbeck process
R. Singh, D. Ghosh, and R. Adhikari. Phys. Rev. E 98, 012136, 2018.

Universal Hydrodynamic Mechanisms for Crystallization in Active Colloidal Suspensions
R. Singh, and R. Adhikari. Phys. Rev. Lett. 117(22), 228002, 2016.

† indicates the first author in theoretical contributions in a paper with experimentalists

Awards and fellowships

2021 Leverhulme Early Career Fellowship, United Kingdom

2021 RAMP Early Career Investigator Award (RECIA), The Royal Society, United Kingdom

2017 Newton International Fellowship, The Royal Society, United Kingdom

2012 JEST (Joint Entrance Screening Test for Ph.D. in India). All India Rank - 6.

2011 Joint CSIR-UGC Junior Research Fellowship in Physical Sciences. All India Rank - 25.

2010 JAM - 2010 for Admissions in IITs for M.Sc. (Physics). All India Rank - 20.

2010 National Graduate Physics Examination, India (placed amongst top 25 candidates)

Teaching experience

Since 2018 Co-supervising the work of PhD and master/bachelor students at University of Cambridge

2020 Supervision for CATAM computational projects, University of Cambridge

2019 Supervision for Part II statistical physics, University of Cambridge

2012-18 Co-supervising the work of master/bachelor students at the Institute of Mathematical Sciences (IMSc) Chennai

2016 Teaching assistant: Statistical physics - I, IMSc Chennai

2015 Teaching assistant: Statistical physics - II, IMSc Chennai

2015 Teaching assistant: Statistical physics - I, IMSc Chennai

2014 Teaching assistant: Classical field theory, IMSc Chennai

2013-14 Organized two students seminars at IMsc, Chennai: (a) Statistical physics (b) Python programming in physics

Scientific software

I have developed state-of-the-art numerical libraries for my research in theoretical physics and applied mathematics. These open-source libraries are compliant with research software engineering (RSE) standards: easy to install, well-documented, reproducible, reusable, modular, admit continuous integration using automated unit tests and integration tests. My library, See my Github profile (https://github.com/rajeshrinet/) for a full list of open-source projects. A summary of the selected libraries follows.

PyStokes PyStokes is a numerical library for phoresis and Stokesian hydrodynamics in Python. The PyStokes library has been specifically designed for studying phoretic and hydrodynamic interactions in suspensions of active particles. It uses a grid-free method, combining the integral representation of Laplace and Stokes equations, spectral expansion, and Galerkin discretization, to compute phoretic and hydrodynamic interactions between spherical active particles with slip boundary conditions on their surfaces. The library has been used to model suspensions of microorganisms, synthetic autophoretic particles and self-propelling droplets. The current implementation includes unbounded volumes, volumes bounded by plane walls or interfaces, and periodic volumes. PyStokes, GitHub link, has more than 20 thousands downloads in the last year on GitHub.

PyRoss PyRoss is a numerical library that offers an integrated platform for inference, forecasts and non-pharmaceutical interventions in structured epidemiological compartment models. Generative processes can be formulated stochastically (as Markov population processes) or deterministically (as systems of differential equations). Bayesian inference on pre-defined or user-defined models is performed using model-adapted Gaussian processes derived from functional limit theorems for Markov population process. PyRoss, GitHub link, has been downloaded more than 18 thousands times in the last year and has over 125 stars on GitHub.

PyRitz PyRitz is a Python package, using the Ritz method, for computing transition paths and quasipotentials in Python. The most-probable path (instanton) is computed by minimizing the Freidlin-Wentzell action. Analysing the paths in a spectral basis of Chebyshev polynomial, nonlinear optimisation is used to obtain coefficients that give the least action from which the instanton is synthesised in the spectral basis. GitHub link.

PyGL PyGL is a numerical library for statistical field theory in Python. The library has been specifically designed to study field theories without time-reversal symmetry. The library can be used to study models of statistical physics of various symmetries and conservation laws. In particular, we allow models with mass and momentum conservations. The library constructs differentiation matrices using finite-difference and spectral methods. To study the role of momentum conservation, the library also allows computing fluid flow from the solution of the Stokes equation. GitHub link.

PyBISP PyBISP is a Python package for Bayesian Inference of Stochastic Processes. The library is constructed from a new $O(N)$ method for accurate and efficient inference of a stationary Gauss-Markov processes using four sufficient statistics matrices. GitHub link.

List of publications

Preprints

20. Efficient Bayesian inference of fully stochastic epidemiological models with applications to COVID-19
Y. I. Li, *et al.*, arXiv:2010.11783, 2020. [Joint 2nd author with 5 others (15 authors in total)]

19. Inference, prediction and optimization of non-pharmaceutical interventions using compartment models: the PyRoss library
R. Adhikari, *et al.* arXiv:2005.09625, 2020 [Alphabetic ordering of 18 authors].

18. Age-structured impact of social distancing on the COVID-19 epidemic in India
R. Singh, and R. Adhikari. arXiv:2003.12055, 2020.

Published

2020

17. Controlled optofluidic crystallization of colloids tethered at interfaces
A. Caciagli, **R. Singh**†, D. Joshi, R. Adhikari, and E. Eiser. Phys. Rev. Lett. 125(6), 068001, 2020. Editors' Suggestion | Featured in Physics

16. Ritz method for transition paths and quasipotentials of rare diffusive events
L. Kikuchi, **R. Singh**, M. E. Cates, and R. Adhikari. Phys. Rev. Research 2(3), 033208, 2020.

15. Self-propulsion of active droplets without liquid-crystalline order
R. Singh, E. Tjhung, and M. E. Cates. Phys. Rev. Research 2, 032024(R), 2020. Editors' Suggestion

14. PyStokes: phoresis and Stokesian hydrodynamics in Python
R. Singh, and R. Adhikari. J. Open Source Software 5(50), 2318, 2020.

13. Periodic orbits of active particles induced by hydrodynamic monopoles
A. Bolitho, **R. Singh**, and R. Adhikari. Phys. Rev. Lett. 124(8), 088003, 2020.

2019 12. Hydrodynamically interrupted droplet growth in scalar active matter
R. Singh, and M. E. Cates. Phys. Rev. Lett. 123(14), 148005, 2019. Recommended with a commentary by the Journal Club for Condensed Matter Physics.

11. Competing chemical and hydrodynamic effects in autophoretic colloidal suspensions
R. Singh, R. Adhikari, and M. E. Cates. J. Chem. Phys. 151, 044901, 2019.

2018 10. Fast Bayesian inference of the multivariate Ornstein-Uhlenbeck process
R. Singh, D. Ghosh, and R. Adhikari. Phys. Rev. E 98, 012136, 2018.

9. Electrohydrodynamic assembly of ambient nanoparticles to nanosheets at liquid surfaces
D. Sarkar, **R. Singh**[†], A. Som, C. Manju, M. Ganayee, R. Adhikari, and T. Pradeep. J. Phys. Chem. C 122, 32, 2018.

8. Flow-induced phase separation of active particles is controlled by boundary conditions
S. Thutupalli, D. Geyer, **R. Singh**[†], R. Adhikari, and H. Stone. Proc. Natl. Acad. Sci. 115(21), 5403, 2018.

7. Generalized Stokes laws for active colloids and their applications.
R. Singh, and R. Adhikari. J. Phys. Commun. 2, 025025, 2018.

2017 6. Direct verification of the fluctuation-dissipation relation in viscously coupled oscillators
S. Paul, A. Laskar, **R. Singh**, B. Roy, R. Adhikari, and A. Banerjee. Phys. Rev. E 96, 050102(R), 2017.

5. Fluctuating hydrodynamics and the Brownian motion of an active colloid near a wall
R. Singh, and R. Adhikari. Eur. J. Comp. Mech. 26, 78-97, 2017.

4. Fast Bayesian inference of optical trap stiffness and particle diffusion
S. Bera, S. Paul, **R. Singh**[†], D Ghosh, A Kundu, A Banerjee, and R Adhikari Sci. Rep. 7, 41638, 2017.

2016 3. Universal Hydrodynamic Mechanisms for Crystallization in Active Colloidal Suspensions
R. Singh, and R. Adhikari. Phys. Rev. Lett. 117(22), 228002, 2016.

2015 2. Many-body microhydrodynamics of colloidal particles with active boundary layers
R. Singh, S. Ghose and R. Adhikari. J. Stat. Mech. P06017, 2015.

2012 1. Phase-plane analysis of driven multi-lane exclusion models
V. Yadav, **R. Singh**, and S. Mukherji. J. Stat. Mech. P04004, 2012.

† indicates the first author in theoretical contributions in a paper with experimentalists