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Rajesh Singh

Curriculum Vitae

Research interests

Statistical physics | Soft matter | Numerical and computational methods | Biophysics

Present position

2018– Postdoctoral research associate in the group of Professor Michael E. Cates at the Department of Applied Mathematics and Theoretical Physics (DAMTP), University of Cambridge.

Education

2012–18 Ph.D. in Theoretical Physics, The Institute of Mathematical Sciences, Chennai, India
Title: Microhydrodynamics of active colloids | Advisor: Ronojoy Adhikari

2010–12 M.Sc. in Physics, Indian Institute of Technology Kanpur, India

2007–10 B.Sc. (Honours) in Physics, Hindu College, University of Delhi, India

Publications

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

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

Hydrodynamically interrupted droplet growth in scalar active matter
R. Singh, and M. E. Cates. Phys. Rev. Lett. 123(14), 148005, 2019.

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

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.

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

Complete list of publications

Preprints

Inference, prediction and optimization of non-pharmaceutical interventions using compartment models: the PyRoss library
R. Adhikari, *Et. Al.* arXiv:2005.09625, 2020.

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

Published

2020 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

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.

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

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

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

2019 Hydrodynamically interrupted droplet growth in scalar active matter
R. Singh, and M. E. Cates. Phys. Rev. Lett. 123(14), 148005, 2019.

Competing chemical and hydrodynamic effects in autophoretic colloidal suspensions
R. Singh, R. Adhikari, and M. E. Cates. J. Chem. Phys. 161, 044901, 2019.

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

Electrohydrodynamic assembly of ambient nanoparticles to nanosheets at liquid surfaces
D. Sarkar, **R. Singh**, *Et. Al.* J. Phys. Chem. C 122, 32, 2018.

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.

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

2017 Direct verification of the fluctuation-dissipation relation in viscously coupled oscillators
S. Paul, A. Laskar, **R. Singh**, *Et. Al.* Phys. Rev. E 96, 050102(R), 2017.

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.

Fast Bayesian inference of optical trap stiffness and particle diffusion
S. Bera, S. Paul, **R. Singh**, *Et. Al.* Sci. Rep. 7, 41638, 2017.

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

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

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

Software

Here is a list of scientific libraries that I have developed for my research.

PyStokes PyStokes is a numerical library for phoresis and Stokesian hydrodynamics in Python. 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 spheres with slip boundary conditions on their surfaces. The library has been used to model suspensions of microorganisms, synthetic autophoretic particles and self-propelling droplets. GitHub link.

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). Population processes are sampled exactly by the Doob-Gillespie algorithm or approximately by the tau-leaping algorithm while differential equations are integrated by both fixed and adaptive time-stepping. A hybrid algorithm transits dynamically between these depending on the magnitude of the compartmental fluctuations. 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. The library is freely available on GitHub.

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. The library is freely available on GitHub.

PyRitz PyRitz is a Python package using 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. The library is freely available on GitHub.

Scholarships, fellowships and prizes

2017 Newton International Fellowship

2012 JEST (Joint Entrance Screening Test for Ph.D. in India)

2011 Joint CSIR-UGC Junior Research Fellowship

2010 JAM - 2010 for Admissions in IITs for M.Sc. (Physics)

2010 National top 1% candidate at National Graduate Physics Examination

Conferences and seminars

Feb 2020 *Cambridge University, Cambridge* | Seminar

Jan 2020 *Edwards Centre Mini Conference, Cambridge* | Contributed talk

Dec 2019 *International Complex Fluid Conference (CompFlu-2019), Bhopal* | Invited talk

Oct 2019 *Fluid physics of life, Dresden* | Poster

Aug 2019 *The Institute of Mathematical Sciences, Chennai* | Seminar

June 2019 *International Soft Matter Conference, Edinburgh* | Poster

Jan 2019 *New Directions in Theoretical Physics, Edinburgh*

Dec 2018 *Indian Institute of Technology Madras, Chennai* | Seminar

Dec 2018 *Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru* | Seminar

Dec 2018 *International Conference on Complex Fluids and Soft Matter (CompFlu-2018), Roorke* | Contributed talk

Nov 2018 *Cambridge University, Cambridge* | Seminar

June 2018 *Cambridge University, Cambridge* | Seminar

Sep 2018 *3rd Edwards Symposium - New Horizons in Soft Matter, Cambridge* | Poster

Dec 2017 *International Complex Fluid Conference (CompFlu-2017), Chennai*

Aug 2017 *Stochastic Thermodynamics, Active Matter and driven systems, ICTS Bangalore*

Dec 2016 *International Conference on Soft Materials, ICSM-2016, Jaipur* | Poster

May 2016 *IASBS-ICTP School on Active Matter and Chemotaxis, Zanjan* | Contributed talk and poster

Feb 2016 *Indian Statistical Physics Community Meeting, ICTS, Bangalore* | Poster

Jan 2016 *International Complex Fluids Conference (CompFlu-2016), Pune* | Poster

Dec 2015 *Soft Matter Young Investigators Meeting - III, Puducherry*

July 2015 *Durham University, Durham* | Seminar

July 2015 *Oxford University, Oxford* | Seminar

July 2015 *24th International Conference on Discrete Simulation of Fluid Dynamics (DSFD-2015), Edinburgh* | Contrinbuted talk

Jan 2015 *Chennai Python Users Group, Chennai* | Invited talk

Dec 2014 *Eighth Symposium on Complex Fluids, Bangalore, India* | Poster

Dec 2014 *Soft Matter Young Investigators Meeting - II, Puducherry* | Poster

Jan 2014 *Soft Matter Young Investigators Meeting - I, Puducherry*

Dec 2013 *SERB School and Symposium on Complex Fluids - IIT Delhi, Delhi*

Apr 2013 *RRI school on Statistical Physics - RRI Bangalore*