

# Rajesh Singh

## Curriculum Vitae

DAMTP  
Centre for Mathematical Sciences  
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### Scientific positions and education

- April 2020– Postdoctoral research associate in the group of Professor Michael E. Cates at DAMTP, Centre for Mathematical Sciences, University of Cambridge
- March 2018– Newton International Fellow in the group of Professor Michael E. Cates at DAMTP, Centre  
March 2020 for Mathematical Sciences, University of Cambridge
- 2012–18 Ph.D. in Theoretical Physics, Institute of Mathematical Sciences-HBNI, Chennai, India  
Title: Microhydrodynamics of active colloids | Advisor: Ronjoy 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

### Research

Bibliometry [Google Scholar](#) | [Research Gate](#)

Interests Stochastic processes | Statistical Mechanics | Soft Matter | Fluid Mechanics | Mathematical Epidemiology | Mathematical Biology | Bayesian statistics | Active Matter

Selected Self-propulsion of active droplets without liquid-crystalline order  
publications **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**<sup>†</sup>, 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. 161, 044901, 2019](#).

Flow-induced phase separation of active particles is controlled by boundary conditions  
S. Thutupalli, D. Geyer, **R. Singh**<sup>†</sup>, 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](#).

<sup>†</sup> indicates the first author in theoretical contributions in a paper with experimentalists

## 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**<sup>†</sup>, 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**<sup>†</sup>, 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**<sup>†</sup>, 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**<sup>†</sup>, *et al.* [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.](#)

<sup>†</sup> indicates the first author in theoretical contributions in a paper with experimentalists

## 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. A summary of the selected libraries is given below.

- 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. [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). 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. [GitHub link.](#)
- 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](#).

## 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
- 2014 Organized two students seminars at IMSc, Chennai: (a) Statistical physics (b) Python programming in physics

## Scholarships, fellowships and prizes

- 2017 Newton International Fellowship, United Kingdom
- 2012 JEST (Joint Entrance Screening Test for Ph.D. in India). All India Rank - 6.
- 2011 Joint CSIR-UGC Junior Research Fellowship. All India Rank - 25.
- 2010 JAM - 2010 for Admissions in IITs for M.Sc. (Physics). All India Rank - 20.
- 2010 National top 1% candidate at National Graduate Physics Examination, India

## Conferences and seminars

- March 2021 *Tata Institute of Fundamental Research, Mumbai* | Seminar (Online)
- March 2021 *Indian Institute of Science Education and Research Mohali* | Seminar
- Dec 2020 *Complex Fluids 2020* | Contributed talk (Online)
- Dec 2020 *Edwards Centre Mini-Conference* | Contributed talk (Online)
- Oct 2020 *Microswimmers International Conference 2020, Jülich* | Poster (Online)
- 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 (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

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, Zanzibar* | Contributed talk

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* | Contributed 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, Puducherry* | Poster