Mahammad Mustakim

CURRICULUM VITAE

PERSONAL DETAILS

Present Address : *School of Physical Sciences*
National Institute of Science Education and Research (NISER)
Bhubaneswar, Khurda, Odisha, India-752050

Date of Birth : 16 January, 1990
Nationality : India

Email ID : mustakim@niser.ac.in
mustakimz@gmail.com
Mobile : +91-8637204050
Google Scholar : https://scholar.google.com/citations?user=X6UGfy0AAAAJ&hl=en
Researchgate : https://www.researchgate.net/profile/Mahammad-Mustakim

PhD THESIS

Thesis Title : *Structure and Dynamics of Binary colloids in an External potetial: Role of Depletion Interaction*

Thesis Advisor : Dr. A. V. Anil Kumar
School of Physical Sciences
National Institute of Science Education and Research (NISER)
Bhubaneswar, Odisha, India – 752050

ACADEMICS

2014 – 2022 **Ph.D. in Physics**
School of Physical Sciences
National Institute of Science Education and Research (NISER)
Bhubaneswar, Odisha, India – 752050

2011 - 2013 **Master of Science (M.Sc.), Physics (First Class)**
Jamia Millia Islamia, Central University
New Delhi, India - 110025

2008 - 2011 **Bachelor of Science(B.Sc.), Physics Honors (First Class with Distinction)**
Ravenshaw University, Cuttack
Odisha, India - 753003

RESEARCH INTERESTS

Thesis Work:

I have been working on the computational modeling of the binary colloidal mixture. My thesis work concentrates on the Molecular Dynamics (MD) simulations study of the influence of depletion interaction on the structure and transport properties of a binary colloidal mixture of soft spheres in the presence of an external potential. A few key findings of my research during my Ph.D. are:

1. In the presence of an external potential (Gaussian form), at low densities, the temperature dependence of diffusivity of larger components of the binary mixture follows sub-Arrhenius behavior. The smaller particles follow Arrhenius behavior and show dynamics similar to supercooled liquids manifested in the plateau formation in the MSD curve at intermediate times. In literarture there is a consensus that sub-Arrhenius behavior is a quantum phenomena; however, we reported a sub-Arrhenius behavior in a classical system, where the depletion interaction between the larger particles and the barrier makes the activation energy temperature dependent and causes sub-Arrhenius diffusion of larger particles over the barrier at low temperature regimes.

2. At higher densities, still less than the freezing volume fraction of the single component system, the large particle rich phase forms the domain of fcc crystal in the region of the external barrier; while the smaller particles remain in fluid phase away from the barrier, owing to the depletion interaction between the larger particles and the barrier. The crystal structure diffuses as a whole perpendicular to the barrier. It is intriguing to find such moving crystal in an equilibrium system, which are generally observed in a non-equilibrium system. Because of the crystallization process, the diffusion of larger particles reduces sharply at low temperatures and high volume fractions leading to a cross over from sub-Arrhenius dynamics to super-Arrhenius dynamics as we increase the volume fraction.

3. In the presence of an asymmetric Gaussian potential, we have found that, at a low volume fraction, the diffusivity of the larger particles exhibits a crossover from sub-Arrhenius to super-Arrhenius behavior as the asymmetry in the external potential increases, while the smaller particles show normal Arrhenius behavior for all asymmetry parameters and temperatures. The depletion attraction of asymmetric barrier with larger particles increases as the asymmetry increases, causes transient caging at the asymmetric side of the potential, hence leads to super-Arrhenius diffusion. This reveals that the depletion interaction can be manipulated to achieve crystallization even at lower volume fractions.

Future directions and research interests:

Having trained in the computational modeling of soft matter systems such as binary colloidal mixtures using molecular dynamics simulations, I would be happy to get an opportunity to contribute to the theoretical and the computational studies of different soft matter systems such as colloidal systems, polymers, liquid crystals, active matter, living matter, etc. by implementing the simulation techniques. I am eager to learn and develop computational methods required to study such systems.

Broadly I would be happy to be part of any of the following research domains:
Equilibrium or non-equilibrium statistical physics, Theoretical and computaional modeling of soft matter systems, Fluid in confinement, Transport phenomena, Glassy dynamics, Phase transitions, Barrier crossing problems, Active matter system, Biophysics.

PUBLICATIONS

1. Sub-Arrhenius diffusion in a classical system: Binary colloidal mixture in an external potential.
   Mahammad mustakim and A.V. Anil Kumar, *Physica A*, **2021**, 563, 125462

2. Super-Arrhenius diffusion in a binary colloidal mixture at low volume fraction: an effect of depletion interaction due to an asymmetric barrier.
   Jalim Singh, **Mahammad Mustakim** and A.V. Anil Kumar, *Journal of Physics: Condensed Matter*, **2021**, 33, 125101

3. Depletion induced demixing and crystallization in a binary colloids subjected to external potential barrier.
   Mahammad Mustakim and A.V. Anil Kumar, *J. Phys. Chem. B*, **2022**, 126, 1, 327–335

4. Dynamics of the binary colloidal mixture over a potential barrier: system size scaling and its break down.
   Mahammad mustakim and A.V. Anil Kumar (under preparation)

CONFERENCES/ SCHOOLS

1. 11 December - 13 December 2019, “Recent Topics in Statistical Mechanics (RTSM–2019)”, National Institute of Science Education and Research (NISER) Bhubaneswar, India. **Poster –** Mahammad Mustakim, “Dynamics of binary colloids in the influence of an externla potential”

2. 3 June - 7 June 2019, “International Soft Matter Conference (ISMC)”, held at University of Edinburgh, Edinburgh , UK. **Poster –** Mahammad Mustakim,“Sub-Arrhenius diffusion in a binary colloidal system”.

3. 6 March - 10 March 2019, workshop and symposium on “Advanced Simulation Methods: DFT, MD, and Beyond” held at Indian Institute of Technology (IIT) Delhi, India. **Poster –** Mahammad Mustakim, “Dynamics of binary colloids in a periodic potential”.

4. 8 February - 11 Frbruary 2018, “Recent Advances in Molecular Simulations”, held at SSCU, organized by Thematic unit of Excellence in Computational Material Sciences, Indian Institute of Science (IISc) Bangalore, India. **Poster –** Mahmmad Mustakim, “Dynamics of binary colloids in an external repulsive potential”

5. 18 december - 20 december 2017, International conference on complex fluid and soft matter “CompFlu – 2017”, organized by Indian Institute Of Technology (IIT) Madras, India. **Poster –** Mahammad Mustakim,“Dynamics of binary colloidal mixture in a periodic potential”

6. 31 October - 3 November 2017, National conference on “Recent Trends in Condensed Matter Physics (RTCMP-2017)” organized by Bose Institute , Kolkata, India. **Poster –** Mahammad Mustakim,“Dynamics of binary colloids in a periodic potential”

7. 1 July - 15 July 2016, “Bangalore school on Statistical Mechanics-VII” held at International Center for Theoretical Sciences (ICTS), Bangalore, India.

TEACHING EXPERIENCES

- **Teaching Assistant** : *Electrodynamics* — Even Semester 2017
  NISER, Bhubaneswar, India
- **Teaching Assistant** : *Statistical Mechanics* — Odd Semester 2016
  NISER, Bhubaneswar, India
- **Teaching Assistant** : *Mathematical Methods* — Odd Semester 2015
  NISER, Bhubaneswar, India

AWARDS AND FELLOWSHIPS

- INSPIRE fellow of DST, India, Scholarship for Higher Education(SHE) (2007 - 2012)
- Joint Entrance Screening Test (2014) cleared (All India Rank - 344, Percentile - 92)
- Junior Research Fellow at NISER Bhubaneswar (2014 - 2016)
- Senior Research Fellow at NISER Bhubaneswar (2016 - 2022)

COMPUTATION AND SOFTWARE

- **Operating System**: Linux/Unix, Windows
- **Languages**: FORTRAN, C/C++, High Performance Computing, Shell scripting, Mathematica
- **Useful Sofwares**: Gnuplot, Xmgrace, LATEX, GIMP, Inkspace
- **Techniques**: Numerical Methods, Molecular Dynamics simulations, Monte Carlo simulations

ACADEMIC REFEREES

Dr. A. V. Anil Kumar (Thesis Advisor)
National Institute of Science Education and Research
School of Physical Sciences
Bhubaneswar, Khurda, Odisha, India-752050
Email: anil@niser.ac.in
Phone No. +91 674-2494287

Dr. Sumedha
National Institute of Science Education and Research
School of Physical Sciences
Bhubaneswar, Khurda, Odisha, India - 752050
Email: sumedha@niser.ac.in
Phone No. +91 674-2494241

Dr. Joydeep Bhattacharjee
National Institute of Science Education and Research
School of Physical Sciences
Bhubaneswar, Khurda, Odisha, India - 752050
Email: jbhattacharjee@niser.ac.in
Phone No. +91 674-2494282