

Diptajyoti Mukherjee

PHD CANDIDATE · CARNEGIE MELLON UNIVERSITY

5000 Forbes Avenue, Pittsburgh PA 15213

✉ dipto@cmu.edu | 🏠 dipto4.github.io | 📄 github.com/dipto4

Education

Carnegie Mellon University

Pittsburgh, PA

PH.D. IN PHYSICS

Aug 2019 - present

- Thesis: Examining the swift mergers of massive black hole binaries in nuclear star clusters using N-body simulations
- Advisor: Prof. Hy Trac

Carnegie Mellon University

Pittsburgh, PA

M.S. IN PHYSICS

Aug 2019 - May 2021

Allegheny College

Meadville, PA

B.S. IN PHYSICS, *summa cum laude*

Aug 2015 - May 2019

- Minors in Economics and Computer Science
- Senior thesis advisor: Prof. Jamie Lombardi

Research Experience

Carnegie Mellon University

Pittsburgh, PA

DOCTORAL RESEARCHER

2019 - present

- Effects of nuclear star clusters surrounding massive black hole binaries on their dynamics and gravitational wave merger timescales
- Gravitational wave signatures of intermediate mass ratios embedded in dark matter spikes
- Optimization of the fast multipole method for the collisional N-body problem
- Geometric integration methods for separable and non-separable Hamiltonian problems

Los Alamos National Laboratory

Los Alamos, NM

CO-DESIGN SUMMER SCHOOL INTERN

2018

- Optimization of exascale computational fluid dynamics simulations using heterogeneous parallelization paradigms
- Machine learning as an alternative to memory intensive numerical algorithms

Leiden University

Leiden, Netherlands

LEAPS STUDENT

2017

- Evolution of the primordial solar system and formation of the Oort cloud in the solar birth cluster
- Astrophysical code coupling techniques using AMUSE

Skills

Programming Languages C++, Python, C, FORTRAN, CUDA, bash

Software Python stack (`numpy`, `scipy`, `matplotlib`, `pandas`), PyTorch, `scikit-learn`

Technical N-body simulations, high performance computing, symplectic integration techniques

Publications

FIRST OR PRIMARY AUTHOR (5)

MAGICS III. Seeds sink swiftly: nuclear star clusters dramatically accelerate seed black hole mergers

submitted to ApJ

MUKHERJEE, D., ZHOU, Y., CHEN, N., DI CARLO, U.N., & DI MATTEO, T.

[arxiv:2409.19095](https://arxiv.org/abs/2409.19095)

Examining the Effects of Dark Matter Spikes on Eccentric Intermediate Mass Ratio Inspirals Using N-body Simulations 2024, *MNRAS* 533(2)
MUKHERJEE, D., HOLGADO, A. MIGUEL, OGIYA, GO & TRAC, H. *arxiv:2312.02275*
Close encounters of the interstellar kind: exploring the capture of interstellar objects in near-Earth orbit 2023, *MNRAS* 525(1)
MUKHERJEE, D., SIRAJ, A., TRAC, H., & LOEB, A. *arxiv:2305.08915*
Evolution of massive black hole binaries in collisionally relaxed nuclear star clusters–Impact of mass segregation 2023, *MNRAS* 518(4)
MUKHERJEE, D., ZHU, Q., OGIYA, G., RODRIGUEZ, C. L., & TRAC, H. *arxiv:2205.12289*
Fast multipole methods for N-body simulations of collisional star systems 2021, *ApJ* 916(1), 9
MUKHERJEE, D., ZHU, Q., TRAC, H., & RODRIGUEZ, C. L. *arxiv:2012.02207*

SECOND AUTHOR (2+1 IN PREP)

Effect of initial fractality of young star clusters on population of supercanonical stars *in prep*
DI CARLO, U.N., & **MUKHERJEE, D.** *submitted to ApJ*
MAGICS II. The crucial role of tidal stripping for Seed Black Hole Binary evolution *arxiv:2409.19914*
ZHOU, Y., **MUKHERJEE, D.**, CHEN, N., DI MATTEO, T., & ET AL.
MAGICS I. The First Few Orbits Encode the Fate of Seed Massive Black Hole Pairs 2024, *OJAp*
CHEN, N., **MUKHERJEE, D.**, DI MATTEO, T., NI, Y., BIRD, S., & CROFT, R. *arxiv:2312.09183*

CONFERENCE PROCEEDINGS (1)

Optimizing Next Generation Hydrodynamics Code for Exascale Systems 2018, *proceedings of SC18*
AKHMETOVA, D., LAKSHMIRANGANATHA, S., **MUKHERJEE, D.**, OUELLET, F., PAYNE, P., STEGMEIER, N., ... & RAMAKRISHNAIAH, V.

Grants & Funding Awards

McWilliams Center visitor grant 2024
MCWILLIAMS CENTER FOR COSMOLOGY & ASTROPHYSICS
Recipient of \$1k funding to support research with external collaborators.
Pittsburgh supercomputing center seed grant 2023
PITTSBURGH SUPERCOMPUTING CENTER
Co-I on grant that includes 250k core hours on Bridges-2 and \$30k in monetary award.
Nordic winter school travel funding 2023
NEILS BOHR INTERNATIONAL ACADEMY
Partial travel funding to participate in Nordic winter school 2023.
Gateway award 2018
ALLEGHENY COLLEGE
To cover travel funding to the 2018 Division of Planetary Sciences meeting in Knoxville, TN.

Honors & Awards

| | | |
|------|---|--|
| 2019 | Phi Beta Kappa Richard L. Brown Award in Physics | <i>Allegheny College</i> <i>Allegheny College</i> |
| 2018 | Junior Major Award in Physics | <i>Allegheny College</i> |
| 2017 | Leaps Fellow | <i>Leiden University</i> |

2015-19 **Distinguished Alden Scholar**
Doane Scholar
International Scholarship

Allegheny College
Allegheny College
Allegheny College

Selected presentations

INVITED TALKS

Institute for Theory and Computation, Harvard University *Cambridge, MA*
EXPLORING CAPTURE OF INTERSTELLAR OBJECTS IN NEAR EARTH ORBIT *Oct 2023*

University of Helsinki *Helsinki, Finland*
EXPLORING MASSIVE BLACK HOLE BINARY MERGERS USING FAST MULTIPOLE METHODS *Apr 2023*

Allegheny College *Meadville, PA*
UNCOVERING THE SECRETS OF GALACTIC NUCLEI USING MASSIVE BLACK HOLE BINARIES *Sep 2022*

Los Alamos National Laboratory *Los Alamos, NM*
OPTIMIZING FLECSALE WITH EOSPAC FOR EXASCALE SYSTEMS *Aug 2018*

CONTRIBUTED TALKS

Galaxy group, Department of Astronomy, University of Michigan *Ann Arbor, MI*
EFFICIENT MERGERS OF SEED MBHS IN NUCLEAR STAR CLUSTERS *Apr 2024*

Fifth Neighborhood Workshop, Penn State University *State College, PA*
EVOLUTION OF MBH BINARIES IN COLLISIONALLY RELAXED NUCLEAR STAR CLUSTERS *Apr 2023*

Nordic Winter School for Gravitational Wave Astrophysics *Skeikampen, Norway*
EVOLUTION OF MBH BINARIES IN COLLISIONALLY RELAXED NUCLEAR STAR CLUSTERS *Jan 2023*

Challenges and Innovations in Computational Astrophysics (ChalCA) - IV *virtual*
EVOLUTION OF MBH BINARIES IN COLLISIONALLY RELAXED NUCLEAR STAR CLUSTERS *Nov 2022*

Cosmology From Home *virtual*
EVOLUTION OF MBH BINARIES IN COLLISIONALLY RELAXED NUCLEAR STAR CLUSTERS *Jun 2022*

Hernquist group, Center for Astrophysics, Harvard University *virtual*
ACCELERATING N-BODY SIMULATIONS USING FAST MULTIPOLE METHOD *Apr 2021*

Division of Planetary Sciences *Knoxville, TN*
EVOLUTION OF THE OORT CLOUD IN THE SOLAR BIRTH CLUSTER *Oct 2018*

LEAPS Symposium, Leiden University *Leiden, Netherlands*
PLANET-DISK INTERACTIONS IN THE SOLAR BIRTH CLUSTER *Aug 2017*

Teaching Experience

Fall 2021/23/24 **33-124 Introduction to Astrophysics**, Teaching Assistant, Guest instructor
Summer 2022 **Pennsylvania Governor's School for the Sciences**, Faculty
Summer 2020/21, Fall 2020/21 **33-142 Physics 2 for Engineering Majors**, Teaching Assistant
Fall 2019 **33-152 Matter and Interactions II**, Teaching Assistant

Mentoring

Jacques Moyer *2023-24*
UNDERGRADUATE STUDENT, CMU
Project: Examining the survivability and erosion of dark matter spikes

Jayanth Tumuluri *2023*
UNDERGRADUATE STUDENT, CMU
Project: Novel gravitational softening methods using symbolic regression

HIGH SCHOOL STUDENTS, PGSS

Project: The behavior of magnetic moments at low temperatures and simulating the Ising model using Metropolis-Hasting algorithm

Service, Outreach, & Professional Development

OUTREACH

Astronomy on Tap

2021-present

ORGANIZER

Pittsburgh, PA

- In association with the McWilliams Center & the University of Pittsburgh, restarted the Pittsburgh chapter of Astronomy on Tap.
- Organized 30+ public outreach talks on topics ranging from planetary astrophysics to theoretical cosmology over the course of 2 years at various Pittsburgh breweries.

Chandra X-ray telescope information session

2024

CO-ORGANIZER

Pittsburgh, PA

- Organized public information session about the importance of the Chandra telescope to X-ray astronomy.
- Organized public talks by 2 X-ray astronomers on how Chandra has shaped modern X-ray astronomy.

Telescope demonstration sessions

2022,23

DEMONSTRATOR

Carnegie Mellon University

- As a part of the Introduction to Astronomy class educated students about different telescope parts and how to use a telescope.

Astrophotography pilot project

2018-19

CO-CREATOR, PHOTOGRAPHER

Allegheny College

- Co-created and secured funding to begin a pilot astrophotography project at Allegheny college
- Took pictures of various astrophysics objects which were later incorporated into the Introduction to Astronomy class taught by Prof. Lombardi

Astronomy club

2017-19

CO-PRESIDENT

Allegheny College

- Led outreach activities for the campus community and the residents of Meadville.
- Organized stargazing and observing sessions, educating the campus community about visible objects in the night sky.
- In association with Prof. Lombardi, organized Planetarium shows for the campus community

Astronomy + art events

2016-18

CO-ORGANIZER

Meadville, PA

- As a part of the Astronomy Club, organized various STEAM (STEM + Art) oriented events demonstrating the intersection of art and astronomy.

SERVICE

2024 **Sophomore Seminar** Panelist

Carnegie Mellon University

2024 **Graduate Student Open House** Panelist

Carnegie Mellon University

2023 **Pittsburgh Regional Science & Engineering Fair** Qualified Scientist

Pittsburgh, PA

2022-2023 **Graduate Student Social Organizing Committee** Member

Carnegie Mellon University

2022 **Information Session for Incoming Students** Panelist

Allegheny College

2021-2023 **McWilliams Center Journal Club** Organizer

Carnegie Mellon University

2017-2019 **Astronomy Club** President

Allegheny College

WORKSHOPS

2023 **5th neighborhood workshop on cosmology**

Penn State University

2023 **Nordic winter school for gravitational wave astrophysics**

Skiekkampen, Norway

2020 **XSEDE summer bootcamp workshop**

XSEDE/PSC