# SHASHWAT **SINGH**

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I am currently a Ph.D. student at the University of Glasgow and working on probing massive and supermassive black holes using LISA - a future space-based gravitational-wave detector.

## Academic Qualifications

2023 – 2027 | **University of Glasgow, School of Physics and Astronomy, PhD**
Thesis title : Revealing the family of massive black holes with LISA
Supervisors : Dr. Christopher Berry and Dr. John Veitch
Gravitational Waves | LISA | Super/Massive Black Holes | Population Inference

2022 – 2023 | **l'Observatoire de Paris, Université PSL (Paris Sciences & Lettres), M2 – International Research Track**
Program combined with courses and research in laboratories.
General-relativity | Data-analysis | Magneto-hydrodynamics | High-performance-computing

2021 – 2022 | **Sciences et Ingénierie, Sorbonne Université, M1 – Paris Physics Masters**
Program targetted towards fundamental courses and compulsory lab-work.
Advanced quantum mechanics | Statistical mechanics | Astrophysics & Cosmology | Numerical-methods

2017 – 2021 | **Sardar Vallabhbhai National Institute of Technology, B. Tech, Mechanical Engineering**
Four-year program combined with theoretical and experimental work.
Data-analysis | Fluids - mechanics &dynamics | Machines and rigid body motion

## Research Experience

January 2023 – July 2023 | **Max-Planck-Institut für Gravitationsphysik, (Albert-Einstein-Institut), Supervisor : Dr. M. Zumalacárregui**
Master Thesis : Probing Fuzzy dark matter using lensed gravitational waves detected by LISA.
Master Thesis | Gravitational-Wave-Lensing | Fuzzy Dark-Matter

September 2022 – January 2023 | **l'Observatoire de Paris, Lab Insertion Unit, Supervisor : Dr. A. Hees (SYRTE) & Dr. N. Korsakova (APC)**
Waveform compression of Extreme-Mass-Ratios-Inspirals (EMRIs) using Singular Valued Decomposition.
Gravitational-Waves | EMRI | Waveform-modeling

April 2022 – July 2022 | **Max-Planck-Institut für Gravitationsphysik, (Albert-Einstein-Institut), Supervisor : Dr. A. H. Nitz**
Prospects of premerger detections & skylocalization of gravitational waves (GWs), using higher modes.
Internship | Gravitational-Waves | Higher-modes | Premerger-detection | Multi-Messenger Astronomy (MMA) | PyCBC

June 2020 – September 2020 | **Max-Planck-Institut für Gravitationsphysik, (Albert-Einstein-Institut), Supervisor : Dr. A. H. Nitz**
Build a prototype analysis for massive binary blackhole (MBH) mergers using the LISA.
Internship | Gravitational-Waves | LISA | PyCBC | Simulation

May 2019 – July 2019 | **Dept. of Mechanical Engineering, Indian Institute of Technology Indore, Supervisor : Dr. S. K. Sahu**
- Developed numerical method to study heat transfer effects of synthetic jet on different materials in the shape of a 2D plate.
- Developed C++ code for allowing mesh motion within the model in Ansys Fluent.

Internship | Synthetic-jet | Ansys Fluent | Computational-Fluid-Dynamics (CFD) | C++

May 2019 – August 2020 | **Dept. of Physics, SVNIT Surat, Under supervision of Dr. K. N. Pathak**
Worked on several projects especially targeted towards the use of deep learning
- estimating parameters of GWs (Convolutional neural networks)
- sequence-prediction of galaxy mergers (Long-short term memory neural networks)

Gravitational-Waves | Galaxy mergers | Sequence-prediction | Machine Learning (ML)

## Publications

- "**Estimating dynamical parameters of two interacting galaxies using Deep Learning**", Mahor, A., Reddy, J., Singh, A., **Singh, S.**, Monthly Notices of the Royal Astronomical Society, Volume 521, Issue 3, May 2023, Pages 3441–3450, https://doi.org/10.1093/mnras/stad700
- "**Deep learning for estimating parameters of gravitational waves**", **Singh, S.**, Singh, A., Prajapati, A., Pathak, K. N., Monthly Notices of the Royal Astronomical Society, Volume 508, Issue 1, November 2021, Pages 1358–1370, https://doi.org/10.1093/mnras/stab2417
- "**Lindblad Evolution and Quantum to Classical Transition of Rabi Oscillation in Single Quantum Dot**" Prajapati, A., **Singh, S.** AIP Conference Proceedings 2220, 020122 (2020); https://doi.org/10.1063/5.0001258
- "**Experimental and Numerical Investigation of Thermal Performance of Synthetic Jet Impingement**" Singh, P. K., Kothar, R., Sahu, S., Upadhyay, P.K., **Singh, S.**, ICONE2020-16775, V001T03A020; 6 pages, https://doi.org/10.1115/ICONE2020-16775
- "**Experimental and numerical investigation of the thermal performance of impinging synthetic jets with different waveforms**" Singh, P. K., Sahu, S., Upadhyay, P.K., **Singh, S.**, Experimental Heat Transfer, 10.1080/08916152.2021.1984341
- "**Decoherence Control via Pumping of Electromagnetic Energy in Open Quantum System**" Prajapati, A., **Singh, S**. presented at The 5th International Conference on Atomic, Molecular, Nano-physics with Application (CAMNP-2019).
- P. K. Singh, A. Kumar, A. Shah, A. Kishor, S. K. Sahu, P. K. Upadhyay, **S.Singh**,"**Flow and Heat Transfer analysis of an axisymmetric Impinging Synthetic Jet for Electronic Cooling**" Proce of Int Conf on Innovation and Thermo-Fluid Eng and Sci [ICITFES – 2020] NIT Rourkela, India, 10-12 February [Paper ID : 13754]

## Conference contributions† and attendance

- SUPA Cormack Astronomy Meeting - Glasgow, UK, December 2023.
- Cosmology from Home, July 2023. *Probing Fuzzy dark matter with lensed Gravitational waves.*†
- 3rd International Conference on Condensed Matter and Applied Physics (ICC) - Bikaner, India, October 2019. *Lindblad Evolution and Quantum to Classical Transition of Rabi Oscillation in Single Quantum Dot.*†
- 9th International Conference on Gravitation and Cosmology (ICGC) - IISER Mohali, India, December 2019. *Clustering and Predicting Astrophysical events using GW.*†

## Workshops & Summer School organized† and attendance

- Python for HPC Workshop by Max Planck Computing and Data Facility (MPCDF), July 2023
- $2^{nd}$ MaNiTou Summer School on Gravitational Waves : A new window to the Universe - Nice, France, July 2023.

## Preprints and Reports

- "**Unveiling the Hidden Cosmos : Lensing of Gravitational Waves by Fuzzy Dark Matter with LISA.**," **Singh S.** (2023). Master (M2) thesis; supervisor Dr. Miguel Zumalacárregui
- "**Prospects of detection of gravitational waves using higher harmonics.**" **Singh S.** (2022). Internship report. Supervisor : Dr. Alexander H. Nitz
- "**Predicting future astronomical events using deep learning**" **Singh, S.**, Prajapati, A., Pathak, K.N. - https://arxiv.org/abs/2012.15476
- "**Prospects of detection of lensed gravitational wave signals.**" **Singh S.** (2022). Zenodo. https://doi.org/10.5281/zenodo.7029226

## Mentorship

Undergraduate° and master's* students

- 2021, Adarsh Mahor° & Janvita Reddy°, SVNIT, Surat (via Bose.X), *Co-authored a paper; Application of ML in astronomy*.
- 2023, Nancy Sharma° Nancy Jikarda°, SVNIT, Surat (via Bose.X), *Writing in progress; Gravitational-Wave Lensing*.
- 2023, Nancy Sharma° & Sree Suswara*, SVNIT, Surat (via Bose.X), *Gravitational-Wave Lensing*.

## Technical Skills

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| Python | ●●●●● |
| C++/C | ●●●●○ |
| MATLAB | ●●●○○ |
| Mathematica | ●●●○○ |
| LaTeX, Pack Office | ●●●●● |
| JS, HTML, CSS | ●●●○○ |

## Libraries worked on

- Astropy, GWpy, PyCBC, IBM Quiskit - Python
- Scikit, Pytorch, Keras - Python
- Managing HDF5, FITS files

## Awards and Recognition

2023 University of Glasgow Graduate School scholarship.
2023 Received Erasmus+ funding (EU's program to support education, training, youth and sport in Europe)
2022 Université PSL fellowship for higher education (M2).
2022 Received IPIASMUS grant (IPI Initiative « Physique des Infinis ») towards carrying out an internship at Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut).
2020 Received honorarium by the Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) for a three-month internship.

## Public Libraries

**AEI - lensing library** 2023
Code not yet public
Contributed to the GW lensing library
Internship | gravitational-waves | lensed-gravitational-waves | PyCBC

**Inclusion of higher-modes for Parameter estimation of Gravitational waves in PyCBC** 2022
github.com/SSingh087/pycbc/tree/conmodel
A recovery model that allows extracting mode-by-mode information while performing parameter estimation.
Internship | gravitational-waves | higher-modes | premerger-detection | multi-messenger astronomy | PyCBC

**LensGW for generating gravitationally lensed signals** 2021
github.com/SSingh087/lensGW
Python library for generating lensed gravitational waves and uses PyCBC for waveform generation so that all analysis can be done using tools provided by PyCBC.
gravitational-waves | lensed-gravitational-waves | PyCBC

**lensGW-PyCBC-plugin** 2021
github.com/SSingh087/lensGW-PyCBC-plugin
Plugin for allowing waveforms to be recognized by PyCBC and perform parameter estimation
gravitational-waves | lensed-gravitational-waves | PyCBC

**LISA - Module** 2020
github.com/gwastro/pycbc/commits/master/pycbc/detector.py?author=SSingh087
Prototype for analysis of MBH GWs signals using LISA space-based GW observatory.
The module consists of a simplified LISA orbit and detector response towards a GW signal.
Internship | gravitational-waves | LISA | PyCBC

## Certifications

2018 Secured top 4th candidate from all over India in "DECOHERENCE - Pravega" held at Indian Institute of Sciences (IISc), Bangalore.
2013 Participated in "10th INTERNATIONAL COMPUTER OLYMPIAD 2013"; achieved rank 118 in state; international rank 919.
2013 Participated in "5th INTERNATIONAL OLYMPIAD OF SCIENCE 2013"; achieved state rank within 500; international rank under 5000
2013 Participated in "6thINTERNATIONAL MATHEMATICS OLYMPIAD 2013"; achieved state rank within 500; international rank under 5000.
2010 Participated in "INTERNATIONAL OLYMPIAD OF SCIENCE 2010"; achieved rank 421 in state; international rank under 5000.

## Extracurricular Activities

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| BOSE.X, Co-Founder : | Independent research organization targeted to promote multidisciplinary research; since 2019. (bosex.org). |
| GRA-WITTY, Founder : | Outreach program; since 2023. (gra-witty) |
| CHRD Club, SVNIT : | Ex-member of the Centre of Human Resource Development (CHRD, SVNIT) Music and Photography club. |
| Astronomy : | Successfully completed "Asteroid Data Challenge 2020" - organized by IASC supported by NASA. |
| Sport : | Basketball (professional), Badminton & Cycling (leisure) |
| 2018 - | Silver medal in Inter Year Basketball Tournament. |
| 2018 - | Gold medal in IGNIS SVNIT's Annual Sports Meet 2018. |
| 2019 - | Participated in Dhirubhai Ambani Institute of Information and Communication Technology Sports Tournament. |

## References


Prof. Alexander H. Nitz

*Assistant Professor*, Syracuse University - College of Arts and Science, NY, USA

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Dr. Miguel Zumalacárregui

*Group Leader - Astrophysical and Cosmological Relativity*, Max-Planck-Institut für Gravitationsphysik, Potsdam, Germany

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