

# Saurabh

## Curriculum Vitae

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*"Everything happens for a reason and that reason is always good!"*

### Objective

To create interest among the youngsters in the field of Science, especially in the field of Physics and Astronomy and to develop creative and enquiring learning mind committed to lifelong learning and get acquainted with the fun along learning.

### Education

- 2017–2020 **B.Sc Honours (Physics)**,  
*Department of Physics, Dyal Singh College, University of Delhi, India.*
- 2017 **Higher Secondary Education**,  
Manav Rachna International School, Charmwood Village, Faridabad, India (82%).
- 2015 **Matriculation Examination**,  
Manav Rachna International School, Charmwood Village, Faridabad, India (CGPA 8.4).

### Scholastic and Curricular Achievements

- 2017-present Member of the College Physics Society - Cosmos
- 2017 Founded **Stellar Universe** - A student organisation for every astronomy and physics enthusiast to work and learn collectively while providing a platform to grow in the field by doing activities such as research/learning projects, seminars, webinars, lectures , interactive sessions, etc. and organising interactive sessions every weekend.
- 2015-2017 Member of the Student council as Vice-House Captain (2015-16) and House-Captain (2016-17))
- 2015 AIR - 100 in National Astronomy Olympiad organised by Orange Organisation
- 2014-2017 Won several awards and top positions while representing the school in inter(intra)-school competitions (Dance Drama (1st), Mono-acting(3rd), Debate, Volleyball, Basketball,Cricket etc.)

### Coursework

- Core Courses Mechanics, Mathematical Physics (I, II, III), Electromagnetism, Waves and Optics, Thermodynamics, Digital Systems and Applications, Analog Systems and Applications, Modern Physics, Solid State Physics\*, Quantum Mechanics and Applications\*, Electromagnetic Theory\*\*, Statistical Mechanics\*\*

Lab Courses Mathematical Physics Labs (I,II,III) and Advanced Mathematical Physics Lab\* - Numerical Methods and their applications in Physics using C++ and Scilab, Solving Schrodinger Equations for various potentials and systems using Scilab and C++, Digital and Analog Electronics, Thermodynamics.

## Awards

- 1 1st Prize for Presentation/Seminar Presentation, 2020 at Dyal Singh College, University of Delhi, Topic: Shadows cast by compact and ultracompact objects
- 2 1st Prize, Astronomy Quiz during SKA-Outreach at Vigyan Samagam, New Delhi.

## Technical Skills

Programming PYTHON (SCIPY, NUMPY, MATPLOTLIB, ASTROPY, EINSTEINPY), C++, SCILAB, FORTRAN, BASH  
Software MATHEMATICA, CASA (COMMON ASTRONOMY SOFTWARE APPLICATION), LATEX

## Libraries

EinsteinPY (Contributor), ShadowPY (Under Development)

## Research Interests

General Relativity, Relativistic Ray Tracing, Radio Astronomy and Synthesis Imaging, Gravitational waves

## Responsibilities

- (1) Stellar Universe - Student's organisation for astronomy and astrophysics enthusiasts.  
Position Founder
- (2) BOSE-X - Bose.X is an independent multidisciplinary research organization  
Position Associate Mentor & Project Lead
- (3) INTERTA Jounal of SciRox, Guru Nank Dev University, Amritsar.  
Position Reviewer

## Work Experience

- (1) Indian School of Robotics (ISRRBOTICS): Paid part-time work  
Position Technical Educator  
Teaching Massive Online Open Course (MOOC) Astronomy and Machine learning to Kids.

## Mentoring Experience

- (1) Mentor-Mentee Program, 2020 organised by SciRox, Guru Nanak Dev University, Amritsar, India  
(a) Geodesics around Static Black holes - 3 Students  
(b) Shadows cast by Static Black holes - 3 Students

## **Research Internships**

- (1) Summer Research Internship Program - 2019  
Mentor Prof. Pankaj Joshi  
Topic Shadows of Black Holes and Naked Singularities  
Institution International Centre for Cosmology (ICC), CHARUSAT University, Gujarat  
Duration 1 Month
- (2) Summer Internship - 2019  
Mentor Dr. Himanshu Kumar  
Topic Twin Paradox Studies and Simulations in General Relativity  
Institution Dyal Singh College, University of Delhi  
Duration 15 Days

## **Projects Undertaken**

### Completed

- (1) Twin Paradox around Black Hole (Resinner-Nordstrom Spacetime)
- (2) Timelike and Null Geodesics in spherically symmetric static and stationary Space-times.(Naked Singularities, Black Holes, Wormholes)[Reading Project].
- (3) Data Analysis (Timing) of VELA PULSAR (data taken from Ooty Radio Telescope.)
- (4) Measuring angular diameter of the sun using hand-made Solar Projector.
- (5) Measuring angular diameter of the Moon using modified version of Cross-Staff (Observations taken during Lunar eclipse, 31st Jan,2018 and compared results to normal day.)

### Ongoing

- (1) Programming Beamformer system on *Raspberry Pi* for the SWAN system.
  - (2) Making a Horn antenna for radio astronomical observations.
  - (3) Imaging and Simulations of Shadows cast by Compact objects such Black Holes.
- (a) **Imaging Non-Kerr Black Holes with Event Horizon Telescope:**  
**Supervisor :** Dr.Sourabh Nampalliwar (University of Tübingen)  
*Recent observations from the EHT of the center of the M87 galaxy have opened a whole new era for testing general relativity using black hole images. Normally, the astrophysical black holes are thought to be described by the Kerr metric from General relativity, but theories beyond general relativity predict black holes that deviate from the Kerr solution. To test the Kerr hypothesis and hence GR, we are developing a framework that can perform theory-independent tests of general relativity by analyzing black hole images. The process includes modeling the black hole neighborhood, building and comparing black hole images, and using Bayesian analysis on the EHT data to estimate the deviation parameters that characterize deviations from the Kerr solution.*

- (b) **Identifying Dark Matter by analysing Black hole images.** :
- Supervisor** : Dr. Kimet Jusufi (Physics Department, State University of Tetovo)  
*We are studying the possibility of identifying dark matter in the galactic center from the physical properties of the electromagnetic radiation emitted from a optical-thin disk region described by gas in a radial free fall around the static and spherically symmetric black hole. Due to the effect of dark matter on the spacetime geometry, we find that the dark matter can increase or decrease the intensity of the electromagnetic flux radiation depending on the dark matter model. We are considering two models for the dark matter: Firstly, we analyze the case of a total mass function which consists by a black hole with mass ' $m$ ', surrounded by the dark matter having mass ' $M$ ' along with a thickness  $\delta r_s$ . In the second model, we explore the scenario of a phantom perfect fluid dark matter surrounding the black hole. We show that in order to have significant effect of dark matter on the intensity of the electromagnetic flux radiation, a high energy density of dark matter near the Black hole is needed. On the other hand, with the increase of dark matter thickness the effect becomes very small*
- (c) **Observational features of Black Hole vs Naked Singularity pierced by a Cosmic String :**
- Supervisor** : Prof. Pankaj Joshi (ICC and Charusat University)  
**Co-Supervisor** : Dr. Dipanjan Dey (ICC and Charusat University)  
*We study the timelike and lightlike geodesics in the Schwarzschild and Janis-Newman-Winicour (JNW) naked singularity spacetimes pierced by an infinity thin cosmic string. We derive an orbit equation to understand how massive particles move in these spacetimes and find the change in the perihelion shift of a particle due to the deficit angle. We do the simulations taking into effect when a cosmic string is pierced through the spacetimes. The size of the shadow cast by these spacetimes will be change and that depends on the deficit angle parameter  $\beta$ , and we compare our results with that of standard spherically symmetric and static, Schwarzschild and JNW spacetimes for the condition  $\beta = 0$ .*
- (4) **Radio Interferometry and Synthesis Imaging with SWAN**  
 (SKY WATCH ARRAY NETWORK)[Raman Research Institute]:  
*While cm and mm wave studies of radio sources have been possible at angular resolutions of even sub-arc-second level, meter-wave studies have not yet been possible at any comparable resolution. There is a need thus for such a very long baseline array, particularly in India, complementing the capabilities of the GMRT at the low radio frequencies. The proposed Indian-SWAN will extend our capabilities for studies at these frequencies in both sensitivity and angular resolution, by significant factors. The proposed competitive coordinated network (with nominally 1000 sq. m array area at each location and operation spanning a decade in frequency; 50-500 MHz) will be developed. In the beginning phase, a moderate setup will be attempted for realizing and demonstrating the essential features*

## Conferences & Workshops

- (1) Organised Mini-Astro Workshop Series of talks and hands-on session by early graduate and PhD students in collaboration with BOSE-X (SVNIT) & PAE.
- (2) Sixth Southern Regional Meeting, Research in Astronomy: Opportunities and Challenges, Sponsored by IUCAA, 2020

- (3) 23rd Capra Meeting on Radiation Reaction in General Relativity, University of Texas at Austin
- (4) Black Hole Perturbation Toolkit (BHPToolkit) Spring 2020 Workshop
- (5) Cosmology Summer School 2020 (University of Michigan)
- (6) International Workshop on Astrophysics and Cosmology organised by International Centre for Cosmology (ICC), Charusat University, Gujarat, India
- (7) 30th Indian Association for General Relativity and Gravitation Meet (IAGRG) at BITS Pilani Hyderabad Campus.
- (8) Co-hosted and Participated in Astronomy Boot Camp organised by Nehru Planetarium (2019)
- (9) Astronomy Code Camp organised by Nehru Planetarium (2018)
- (10) Research Assistant at One-Day RAD Workshop (ODRAW) at St. Stephens College, Delhi University organised by RAD@HOME
- (11) RAD@HOME Discovery Camp (2018)
- (12) International Capsule Workshop organised by Indian Astro-Biology Research Center

## Participations

- (1) Organised Astro Retreat 2020, an online/virtual meet for talks and poster presentations in collaboration with SciRox (Science Club, Guru Nanak Dev University, Amritsar).
- (2) Organising a free certificate course on 'Special and General Theory of Relativity' in Collaboration with Scienteen Edt. Pvt. Ltd., Ramanujan Research Institute and Nehru Planetarium.
- (3) Volunteer at LIGO-India booth (One week) at Vigyan Samagam, Delhi
- (4) SWAN Imaging Challenge (Creating a 100 Sq.degree Image of any part of sky with observations from SWAN).
- (5) Attended lecture by Prof. Kip Thorne at ICTS, Bangalore
- (6) Co-organised and attended Lecture by Dr. Bharat Ratra at Nehru Planetarium, New Delhi.
- (7) Regular participation in lectures organised in the Colleges and Universities.

## Talks and Poster presentation

- (1) Talk - '*Theory-Independent tests of General Relativity by analysing Black hole images*' during Undergrad Symposium, Precision'20, Presidency College, Bangalore, India.
- (2) Lightning Talk - '*Theory-Independent tests of General Relativity by analysing Black hole images*' during Sixth Southern Regional Meeting, Research in Astronomy: Opportunities and Challenges, Sponsored by IUCAA
- (3) Poster Presentation - '*The ageing problem of twins in Reissner–Nordström spacetime*' during International Workshop on Astrophysics and Cosmology, ICC, Gujarat, India
- (4) Talk - '*Shadows cast by compact and ultracompact objects*' during Presentation/Seminar Presentation, Dyal Singh College, University of Delhi

- (5) Talk - 'Timing of Vela Pulsar using Python (Data taken from Ooty Radio Telescope)' as Student-Coordinator during SKA-Outreach Week, Vigyan Samagam, New Delhi

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## Publications

### First Author

- (1) **Saurabh** & Kimet Jusufi, 'Imprints of Dark Matter on Black Hole Shadows using Spherical Accretions', 2020 [arXiv:2009.10599]
- (2) **Saurabh** & Himanshu Kumar, 'The ageing problem of twins in Reissner–Nordström spacetime', *Mod. Phy. Lett. A*, 2019, 10.1142/S021773232050008X

### Co-Author

- (3) Shubham Kala, **Saurabh**, Hemwati Nandan, 'Deflection of light and Shadow cast by a Dual Charged Stringy Black Hole', *Int. Jour. of Mod. Phy. A*, 2020, 10.1142/S0217751X20501778 [arXiv:2010.03615]
- (4) Shreyas Bapat, (34 authors), **Saurabh**, (15 authors), 'EinsteinPy: A Community Python Package for General Relativity', 2020 [arXiv:2005.11288]