Subhajit Dandapat

Curriculum Vitae

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About me

I am a final year Ph.D. candidate at the Tata Institute of Fundamental Research, Mumbai, India. I have been engaged in collaborative work with the Indian Pulsar Timing Array (InPTA), the International Pulsar Timing Array (IPTA), and the LIGO-Virgo-KAGRA Collaboration (LVK). My scientific interests include **nano and hecto-Hertz Gravitational Wave Astronomy, Pulsar timing, and modeling Gravitational Wave sources with Post-Newtonian approximation**.

Education

July 2019 - present
Doctor of Philosophy in Astrophysics, *Department of Astronomy & Astrophysics, Tata Institute of Fundamental Research, Mumbai, Maharashtra, India*

Thesis title: *Modeling Hecto and Nano-Hertz Gravitational Wave sources and their observational implications*

Advisor: Prof. A. Gopakumar

May 2014 - May 2019
BS-MS Dual Degree in Physics, Indian Institute of Science Education and Research, Bhopal, Madhya Pradesh, India

MS Thesis title: *Chiral Anomalies in Quantum Field Theory*

Studied: *Physics (Major), Mathematics, and Chemistry*

CGPA:8.89/10

Research Experience

My current research focuses on the efforts to detect and characterize gravitational wave (GW) events, relevant for both the LIGO, Virgo, and Kagra (LVK) and Pulsar Timing Array (PTA) consortia. I'm providing a summary of my previous and ongoing research work within both consortia.

Pulsar Timing Array

- Developing a detailed model of the PTA signals induced by encounters of Black Hole (BH) binaries in case of both unbound and bound orbits, with the help of Post Newtonian (PN) approximation to General Relativity.
- Implemented the PTA signals induced by hyperbolic encounters of supermassive BH binaries (SMBHB) that generate Burst with Memory (BWM) events with ENTERPRISE compatible `GW_hyp` package (Arxiv:2305.19318).
- Currently involved in pursuing very detailed injection studies and actual searches on various PTA datasets, mainly NANOGrav, using an improved version of my `GW_hyp` package.
- Adapted and Employed `tensiometer` package for the quantitative comparisons of various posteriors that arise from the detailed Bayesian noise modeling of individual pulsar timing residuals and stochastic GW background (SGWB) search. These efforts include the detailed comparison of EPTA+InPTA SGWB search posteriors along with very recent IPTA's main constituents (Arxiv:2309.00693).
- Utilized GWecc.jl package to search for isolated SMBHB in eccentric orbits within the simulated PTA dataset.
- Developing a ready-to-use characteristic strain expression to stochastic GW background from SMBHB in general relativistic eccentric orbits that explores the effects of pericenter advance on the existing characteristic strain spectrum.
- Searching for Ultra Light Dark Matter (ULDM) in PTA data-set.

LIGO-Virgo-KAGRA

- Developed a LIGO Algorithm Library (LAL) compatible highly 3PN accurate time domain waveform model, namely `HyperbolicTD` that computes the polarization states of the GWs emitted from hyperbolic encounters of stellar mass BH binaries (Arxiv:2305.19318).
- Currently conducting a detailed parameter estimation studies with our `HyperbolicTD` approximant and employing `PARALLEL BILBY` to recover the source characteristics of the fiducial synthetic GW signals from hyperbolic encounters within LVK data-set.

Other Theoretical Efforts

- Extended instantaneous contributions to the radiated GW Energy and Angular momentum arising from the hyperbolic passages of non-spinning compact objects to third post-Newtonian (3PN) order. We concluded that our expressions could be useful to model inspiral GWs from compact binaries in highly eccentric orbits as well (Arxiv:2111.00818).

Important Roles

2023 - present

- Co-leading the **IPTA Data Release 3 Search** for Gravitational Wave Burst with memory project.
- Co-led the quantitative comparisons of various posteriors that arose from the very recent three independent PTA efforts by the Australian, European, Indian, and North American PTA collaborations. This was very recent IPTA project that compared various aspects of the independent results on the nHz stochastic GW background search among three PTA (Arxiv:2309.00693).

2022 - 2023

- As the **Deputy Managing Leader (DML)** responsible for both the data reduction working group and the Data backup group within the InPTA collaboration, my duties involved overseeing the management of all processed *pinta* output files from the uGMRT dataset and ensuring their proper analysis. This involves conducting reviews of the backup procedures for the raw data as well.

Skills

Programming Languages	`Python, Wolfram Language, bash, C,` LaTeX
Computing Software	`MATHEMATICA, MAPLE`
Astrophysical Software	`ENTERPRISE, BILBY, TEMPO2, PINT`
Telescope Observations	Upgraded Giant Metrewave Radio Telescope
Data analysis	Bayesian inference, Data visualization

Research Publications

Peer-Reviewed Publications with Major Contribution

[1]* **Dandapat, S.**, Ebersold, M., Susobhanan, A., et al. (2023). Gravitational waves from black-hole encounters: Prospects for ground and galaxy-based observatories. Phys. Rev. D, 108, 024013. **DOI**:10.1103/PhysRevD.108.024013. arxiv:2305.19318 [gr-qc, astro-ph.GA]

[2]* Cho, G., **Dandapat, S.**, & Gopakumar, A. (2022). Third order post-newtonian gravitational radiation from two-body scattering: Instantaneous energy and angular momentum radiation. Phys. Rev. D, 105,084018. **DOI**: 10.1103/PhysRevD.105.084018. arxiv:2111.00818 [gr-qc]

Non-Peer-Reviewed Publications with Major Contribution

[3]* Agazie, G., ..., **Dandapat, S.**, et al. (2023). Comparing recent PTA results on the nanohertz stochastic gravitational wave background. arXiv:2309.00693 [astro-ph.HE]

Ongoing Publications with Major Contribution

[4]* **Dandapat, S.**, Susobhanan, A., Dey, L., Gopakumar, A., et al. 2023. An efficient prescription to search for Burst With Linear Memory Events in Pulsar Timing Array Data Sets (**To be submitted, by January 2024**). Accessible link of the draft is here.

Other Peer-Reviewed Publications

[5] Antoniadis, J., ..., **Dandapat, S.**, et al. (2023a). The second data release from the European Pulsar Timing Array II. Customised pulsar noise models for spatially correlated gravitational waves. Astronomy & Astrophysics 678 (2023): A49. **DOI**:10.1051/0004-6361/202346842. arXiv: 2306.16225 [astro-ph.HE]

[6] Antoniadis, J., ..., **Dandapat, S.**, et al. (2023b). The second data release from the European Pulsar Timing Array III. Search for gravitational wave signals. Astronomy & Astrophysics 678 (2023): A50. **DOI**: 110.1051/0004-6361/202346844. arXiv: 2306.16214 [astro-ph.HE]

[7] Srivastava, A. et al. (2023). Noise analysis of the Indian Pulsar Timing Array data release I. Phys. Rev. D, 108(2), 023008.**DOI**:10.1103/PhysRevD.108.023008. arXiv: 2303.12105 [astro-ph.HE]

[8] Chandra Joshi, B. et al. (2022). Nanohertz gravitational wave astronomy during SKA era: An InPTA perspective. J. Astrophys. Astron., 43(2), 98. **DOI**:10.1007/s12036-022-09869-w. arXiv: 2207.06461 [astro-ph.HE]

[9] Nobleson, K. et al. (2022). Low-frequency wideband timing of InPTA pulsars observed with the uGMRT. Mon. Not. Roy. Astron. Soc., 512(1), 1234–1243. **DOI**:10.1093/mnras/stac532. arXiv: 2112.06908 [astro-ph.IM]

[10] Tarafdar, P., ..., **Dandapat, S.**, et al. (2022). The Indian Pulsar Timing Array: First data release. Publ. Astron. Soc. Austral., 39, e053. **DOI**:10.1017/pasa.2022.46. arXiv: 2206.09289 [astro-ph.IM]

[11] Singha, J. et al. (2021). Evidence for profile changes in PSR J1713+0747 using the uGMRT. Mon. Not. Roy. Astron. Soc., 507(1), L57–L61. **DOI**:10.1093/mnrasl/slab098. arXiv: 2107.04607 [astro-ph.HE]

Non-Peer-Reviewed Publications

[12] Antoniadis, J., et al. (2023c). The second data release from the European Pulsar Timing Array IV. Search for continuous gravitational wave signals. arXiv: 2306.16226 [astro-ph.HE]

[13] Antoniadis, J. et al. (2023d). The second data release from the European Pulsar Timing Array: V. Implications for massive black holes, dark matter and the early Universe. arXiv: 2306.16227 [astro-ph.CO]

[14] Paladi, A. K. et al. (2023). Multi-band Extension of the Wideband Timing Technique. arXiv: 2304.13072 [astro-ph.IM]

[15] Kikunaga, Tomonosuke, et al. (2023). Low-frequency pulse-jitter measurement with the uGMRT I: PSR J0437 −4715. arXiv:2312.01875 [astro-ph.HE]

Fellowships

2023 **Sarojini Damodaran Fellowship** for international travel at TIFR

2022 **Pauli Center for Theoretical Studies visitor program Fellowship**, ETH and University of Zürich, July 15 - September 17, 2022

Seminars and Conference Presentations

2023
- **"Detection and Characterization of Burst with Linear Memory Events with Pulsar Timing Array and LIGO-Virgo-KAGRA Observatories"**; In person talk on Astrophysics group of Milan-Bicocca; December 5, 2023.
- **"Characterizing Burst with Linear Memory Events with LIGO-Virgo-KAGRA and Pulsar Timing Array Observatories"**; Amaldi15 virtual conference; July 17-21, 2023. [YouTube link]
- **"Searching Burst with memory event in IPTA dataset and Compairing PTA posteriors"**; IPTA Science meeting; 19-23 June, 2023.
- **"Comparing PTA posteriors"** IPTA GWA hackweek on 3P+ comparisons virtually on zoom; 6-8 March, 2023.

2022 **"Stochastic gravitational wave background spectrum due to supermassive black hole binaries in precessing eccentric orbits"**; Gravitational Wave Orchestra in-person held on UCLouvain, Belgium; Sep 8-9,2022.

2021
- **"Modeling GW burst with linear memory events"**; EPTA 2021 Winter meeting virtually on zoom Dec 6-8, 2021 and Astronomy Society of India meeting in-person held on **IIT Roorkee**; Mar 25-29, 2021.
- **"Effect of relativistic pericentre advance on the SGWB due to eccentric SMBH binaries"**; EPTA 2021 Summer meeting virtually on zoom; Apr 21-23, 2021.

Research Visits

2023
- Visited Prof. Alberto Sesana's B Massive group at Milano-Bicocca from **4 th December to 8th December, 2023** for IPTA collaborative work.
- Visited Prof. Jetzer's group at University of Zürich from **20 th November to 1st December, 2023** for LVK collaborative work.

2022 Visited Prof. Jetzer's group at University of Zürich from **15 th July to 30th September, 2022** for LVK collaborative work.

References

- **Prof. A. Gopakumar**
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- **Prof. P. T. Baker**
  Department of Physics and Astronomy,
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- **Prof. Maria Haney**
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