# Sashwat Tanay

sashwat.tanay@obspm.fr

Laboratoire Univers et Theories (LUTH), Paris Observatory

5 place Jules Janssen, 92190 Meudon, France

sashwattanay.github.io/site

ORCID: 0000-0002-2964-7102

Google Scholar, LinkedIn

## EDUCATION

**Ph.D. (Physics)** University of Mississippi — 2016-2022
  **Advisor:** Prof. Leo C. Stein
  **Dissertation:** Post-Newtonian Dynamics of Eccentric, Spinning Binary
        Black Holes and the Associated Gravitational Waveforms

**B.Tech. (Mechanical Engineering)** Indian Institute of Technology Ropar — 2009-2013

## EMPLOYMENT

**Postdoctoral Fellow** LUTH, Paris Observatory - PSL University — 2023-2025

**Adjunct Instructor** University of Mississippi — 2022-2023

**Teaching and Research Assistant** University of Mississippi — 2016-2022

**Junior Research Fellow** Tata Institute of Fundamental Research, Mumbai — 2013-2015

## AWARDS & FELLOWSHIPS

PSL Postdoctoral Fellowship, Paris Observatory - PSL University — 2023-2025

FGSA Travel Award for Excellence in Graduate Research, APS ($500) — 2022

Graduate School Honors Fellowship, Univ. of Mississippi ($12,000 in total) — 2016-2020

Junior Research Fellowship, Tata Institute of Fundamental Research, Mumbai — 2013-2015

## RESEARCH INTERESTS

A total of 10 research papers (published and in prep.), plus 1 set of lecture notes, supplemented by computer codes on GitHub.

• Gravitational waves (GWs) • Post-Newtonian (PN) dynamics of binary black holes (BBHs) • Quasi-normal mode (QNM) ringdown of black holes (BHs) • Hamiltonian dynamical systems • Extreme mass ratio inspirals (EMRIs)

• Found closed-form solutions to the trajectories of spinning BBHs at 1.5PN and 2PN order • Discovered two new constants of motion for these systems at 2PN order • Constructed orbital solutions of non-spinning BBHs at 4PN and the associated GWs • Performed data-analysis oriented studies on non-spinning BBHs in the context of detectability of GWs emanating from them • Improved the computation of QNM frequencies of spinning BHs • Computed the action-angle variables (AAVs) and the associated frequencies for spinning PN BBHs and EMRI systems within Hamiltonian mechanics. • Discovered that the "orbit-averaged" 2PN spinning BBH system is an integrable Hamiltonian system; constructed its Hamiltonian and AAVs. • Located its separatrices and resonances using these AAVs.

## TEACHING EXPERIENCE

**Phys 211** Instructor of record          Summer 2023
(Adjunct Instructor, Univ. of Mississippi; course website here)
- Developed and taught a calculus-based undergraduate physics course
- Created course material, delivered lectures and assessed student performance

**Phys 221, 222, 223, 224** Undergrad physics lab courses      2016-2022
(Teaching Assistant, Univ. of Mississippi)
- Assisted in undergraduate physics lab courses
- Conducted lab sessions, and graded assignments

## MENTORING

Supervision of 3 mentees have resulted in 3 research papers (one published and two in prep.), and that of a 4th mentee into an undergrad thesis.

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|---|---|
| **Tom Colin** (postgrad, Ecole Normale Supérieure, Paris) led to Publication (1) | Oct 2023-present |
| **Manuel Alva** (undergrad, Universidad Nacional de Trujillo, Peru) led to Publication (1) | Nov 2023-present |
| **Rickmoy Samanta** (postdoc, ISI Kolkata) led to Publication (4) | Sep 2021-Sep 2022 |
| **Pranav Kasetty** (undergrad thesis co-advisor, IISc Bengaluru) | Oct 2021-Apr 2022 |

## SKILLS

- Numerical computing, analytical calculations, perturbative methods for approximate solutions of differential equations
- Data & machine learning with scikit-learn (GitHub portfolio)
- **Computer:** Mathematica (xAct), C/C++, Python, Fortran, Matlab, Jekyll (web development), Bash

## PROFESSIONAL SERVICE

**Referee** Physical Review & Physical Review Letters      Feb 2023-present

## INVITED TALKS & LECTURES

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| York University, Toronto (Department Colloquium) | Dec 2024 |
| Institut d'astrophysique de Paris (GReCO seminar) | Jan 2024 |
| IISER Pune (Physics Seminar) | Jan 2024 |
| Missouri University of Science and Technology (Department Colloquium) | Aug 2023 |
| Northwestern University | Jul 2023 |
| Univ. of Illinois Urbana-Champaign (lecture workshop; lecture notes here) | Jun 2022 |
| Montana State Univ. (Relativity, Astrophysics and Space Science Seminar) | Apr 2022 |
| Max Planck Inst. for Gravitational Physics Potsdam (ACR Seminar, *remote*) | Jun 2021 |
| Simon Fraser Univ. (Cosmology Seminar, *remote*) | Sep 2020 |

## OUTREACH & SERVICE

• Public Talk on Astronomy - Univ. of MS (2023) • Judge at The Speaker's Edge Competition 2022 - Univ. of MS • Organized STEM Summer Camp - Univ. of MS (2018, 19) • Organized Spooky Physics Night - Univ. of MS (2016, 17, 18) • Public talk in French (Journée du LUTH), Paris Observatory (2024) • YouTube videos on research and popular science

## LANGUAGES

**Fluent:** English, Hindi    **Elementary:** French (A1-A2)

## PUBLICATIONS AND RESEARCH ARTICLES

1. [*]T. Colin, **S. Tanay**, and L. Bernard. Solutions of spinning, eccentric binary black holes at 2$^{nd}$ post-Newtonian order, *in prep.* 2024

2. [†]T. Colin, **S. Tanay**, M. A. Morales, and L. Bernard. Orbit-averaged dynamics of spinning binary black holes in a Hamiltonian framework at 2$^{nd}$ post-Newtonian order, *in prep.* 2024

3. V. Witzany, V. Skoupý, L. C. Stein, and **S. Tanay**. Actions of spinning compact binaries: Spinning particle in Kerr matched to dynamics at 1.5 post-Newtonian order, 2024, arXiv:2411.09742 (submitted)

4. **S. Tanay**. Towards a more robust algorithm for computing the Kerr quasinormal mode frequencies, 2022, arXiv:2210.03657 (to be submitted)

5. R. Samanta, **S. Tanay**, and L. C. Stein. Closed-form solutions of spinning, eccentric binary black holes at 1.5 post-Newtonian order. *Phys. Rev. D*, 108(14):124039, 2023, arXiv:2210.01605

6. **S. Tanay**. Integrability and action-angle-based solution of the post-Newtonian BBH system (lecture notes), 2022, arXiv:2206.05799

7. **S. Tanay**, G. Cho, and L. C. Stein. Action-angle variables of a binary black hole with arbitrary eccentricity, spins, and masses at 1.5 post-Newtonian order. *Phys. Rev. D*, 107(26):103040, 2021, arXiv:2110.15351

8. G. Cho, **S. Tanay**, A. Gopakumar, and H. M. Lee. Generalized quasi-Keplerian solution for eccentric, nonspinning compact binaries at 4PN order and the associated inspiral-merger-ringdown waveform. *Phys. Rev. D*, 105(6):064010, 2022, arXiv: 2110.09608

9. **S. Tanay**, L. C. Stein, and J. T. Gálvez Ghersi. Integrability of eccentric, spinning black hole binaries up to second post-Newtonian order. *Phys. Rev. D*, 103(6):064066, 2021, arXiv: 2012.06586

10. **S. Tanay**, A. Klein, E. Berti, and A. Nishizawa. Convergence of Fourier-domain templates for inspiraling eccentric compact binaries. *Phys. Rev. D*, 100(6):064006, 2019, arXiv:1905.08811

11. **S. Tanay**, M. Haney, and A. Gopakumar. Frequency and time domain inspiral templates for comparable mass compact binaries in eccentric orbits. *Phys. Rev. D*, 93(6):064031, 2016, arXiv:1602.03081

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[*]We construct an analytical solution of the positions, and spin angular momenta as functions of time of the two black hole components in the binary black hole system at 2PN order.

[†]We • discover that the 2PN spinning orbit-averaged binary black hole system is an integrable Hamiltonian system; also give the Hamiltonian • construct its action-angle variable (AAV) and its AAV-based closed-form solution • locate its separatrices and resonances.