Tangchao Liu

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Education

Universität Leipzig **10/2024 - 03/2025**
Free mover (visiting) student

École Polytechnique **09/2023 - 07/2024**
Master second year (M2) High Energy Physics *GPA: 14.43/20*
Main courses: **Cosmology**, **Gravitational Waves**, **Quantum Field Theory II&III**, Electroweak Theory, QCD

Université Paris-Saclay (joint Master 2 program with École Normale Supérieure) **09/2022 - 07/2023**
M2 International Centre for Fundamental Physics, Theoretical Physics track *GPA: 13.14/20*
Main courses: **General Relativity** (14.40/20), **Differential Geometry and Gauge Theory** (15.50/20), **Cosmology** (15.00/20), Quantum Field Theory I&II

Université Paris-Saclay **09/2021 - 07/2022**
Master first year (M1) General Physics *GPA: 17.945/20, ranking: 1/31*
Main courses: **General Relativity&Cosmology** (19.00/20), **Advanced Mathematics for Physicists** (19.65/20), Quantum Solid State Physics (17.75/20), Quantum Field Theory&Statistical Physics (18.67/20)

Huazhong University of Science and Technology (HUST) **09/2017 - 06/2021**
Bachelor of Science, school of Physics *GPA: 88.6/100* *ranking: 30/168*

Research & Internships

Green's function regularization for gravitational self-force of Kerr perturbations **11/2024 –**
Research assistant, Elementary Particle Theory Group, Institut für Theoretische Physik, Leipzig, Germany

- **Supervisor : Marc Casals**

- Objective: Calculating the regularized metric perturbation in radiation gauge and self-force of a point mass in Kerr background, by regularizing the Green's function solutions to the perturbation equations.

The first law of mechanics in General Relativity for spinning binary systems **03/2024 – 09/2024**
Master Thesis, Laboratoire Univers et Théories, l'Observatoire de Paris, Meudon, France *extended after defense*

- **Supervisor : Alexandre Le Tiec**

- Thorough investigation of extended test body in GR by multipoles developed by Dixon *et al*, and by Lagrangian formalism summarised by Marsat in *Class. Quantum Grav. 32 085008*. Non-relativistic correspondence is made.
- Familiarity of Wald's general method in *Phys. Rev. D 48, R3427(R)* is developed. The first law for dipolar binary system in *Phys. Rev. D 106, 044057* is re-derived. Preliminary results for quadrupole extensions are accomplished.
- Master thesis defended on July 19, 2024 as assessment. Overall score: **17.00/20**.
- Link to the master thesis.

Quantum noise reduction in new-generation gravitational wave detectors **04/2023 – 07/2023**
M2 internship, Laboratoire Astroparticule et Cosmologie, Université Paris Cité, Paris, France

- **Supervisors : Eleonora Capocasa & Matteo Barsuglia**

- Theoretical investigation of quantum noise and squeezed state. Analytic derivations are done for the quantum noise spectral density for Michelson interferometer with and without squeezing.
- Numerical optimization for Advanced Virgo+ and Einstein Telescope by Matlab and Python packages `MatGwinc` and `PyGwinc`. Quantitative improvement of sensitivity for AdV+ is found for detuned SR cavity with squeezing.
- Oral presentation given on July 4, 2023 as assessment. **Overall score: 16.00/20**.
- Link to the internship report.

Bound state in Dirac materials **04/2022 – 06/2022**
M1 internship, Laboratoire de Physique des Solides, Université Paris-Saclay, Orsay, France

- **Supervisors: Andrej Meszaros & Pascal Simon**

- Analytic calculations of Källén–Lehmann spectral density of gapped graphene with atomic impurity based on quantum many-body theory and Mathematica, reproducing the results of Dutreix *et al.* in *Nature 574, 219–222 (2019)*.
- Numerical computation by Python of tight-binding Hamiltonian spectrum for demonstrating the existence of a bound state and the study of its properties. Certain agreements with analytic methods are found.
- Oral presentation given on July 2, 2022 as assessment. **Overall score: 17.80/20**.
- Link to the internship report.

Primordial gravitational radiation from cosmological first order phase transition **06/2020 – 08/2020**

Summer Internship, Center for Gravitational Experiment, HUST, Wuhan, China *extended to Bachelor thesis*

- **Supervisor : Yiqiu Ma**
- Numerical simulation of field dynamics induced from Coleman's false vacuum decay in the internship stage. Confirmation of results established by Coleman, Kosowsky, Watkins and Turner around 1980s and 1990s.
- In the extension to (unpublished) Bachelor thesis from January to May 2021, generalisation to finite temperature field theory and energy conservation numerical test are achieved, as well as computation of GW power spectrum following the strategy by J. Garcia-Bellido *et al.* in *Phys.Rev.D 77, 043517 (2008)*.
- Bachelor thesis defended on May 30, 2021 as assessment. **Overall score: 94/100**.
- Link to simulation videos and descriptions.

Skills

Programming

- **Mathematica**: Computational tensor analysis and differential geometry in General Relativity. Ongoing practice by doing the exercises and calculations in the book *A Relativist's Toolkit: the Mathematics of Black Hole Mechanics* by Eric Poisson. Link to the notebooks and description.
- **Python**: Coding and solving the Hamiltonian in position space for gapped graphene with atomic impurity in 2022 internship. Numerical optimisation for GW detectors with package `PyGwinc` in 2023 internship.
- **Matlab**: During 2020 to 2021, numerical solution for Coleman's bounce solution was obtained in *Phys. Rev. D 15, 2929 (1977)*. Codes were written for generalising spatial 1D bounce solution to 3D vacuum bubble profile, for evolving the field dynamics by numerically solving PDEs, and for projecting out the transeverse-traceless metric perturbation. For results consult the link to simulation videos and descriptions.
- LaTeX: The only text editting tool since 2019. Experience with tikz for making visually appealing figures.

Languages: English (fluent, highest TOEFL score: 116/120), Chinese (mother tongue), French (intermediate), German (beginner).

Amateur interest: History of Science & Mathematics, football, swimming, badmiton.