

Taj Jankovič

Curriculum vitae

Center for Astrophysics and Cosmology
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Research profile

My interest is focused on simulations of high-energy astrophysics phenomena, including stellar tidal disruption events (TDEs). I am proficient in the hydrodynamics of TDEs in general relativity and modelling stars with realistic density profiles. I significantly contributed to the understanding of debris evolution after the stellar disruption, specifically the return rate of the debris and the effect of the black hole's rotation on the subsequent debris evolution. Due to this, I am on track to becoming an internationally recognized researcher in this field. During PhD, I developed strong proficiency in numerical codes, especially those based on the smoothed-particle-hydrodynamics method that incorporates general relativistic hydrodynamics.

Education

- 2019-2023 **Ph.D. in Astrophysics**, *University of Nova Gorica*, Nova Gorica, Slovenia (final grade: 9.7/10)
Thesis: "Relativistic Tidal Disruptions of Realistic Stars by Supermassive Black holes"
Supervisor: Prof. A. Gomboc (University of Nova Gorica, Nova Gorica, Slovenia)
Co-supervisor: Asst. Prof. C. Bonnerot (University of Birmingham, Birmingham, UK)
Successfully defended on: August 24th, 2023
- 2016-2019 **M.Sc. in Physics**, *University of Ljubljana*, Ljubljana, Slovenia (final grade: 9.7/10)
Thesis: "On the Fate of Stars After a Tidal Disruption Event"
Advisor: Prof. A. Gomboc (University of Nova Gorica, Nova Gorica, Slovenia)
Awarded on: September 12th, 2019
- 2012-2016 **B.Sc. in Physics**, *University of Ljubljana*, Ljubljana, Slovenia (final grade: 7.8/10)
Thesis seminar: "Space-time ripples"
Advisor: Prof. A. Gomboc (University of Nova Gorica, Nova Gorica, Slovenia)
Awarded on: September 20th, 2016

Research experience

- 2023-present **Research assistant**, Center for Astrophysics and Cosmology, School of Science, *University of Nova Gorica*, Nova Gorica, Slovenia
- 2019-2023 **PhD student**, School of Science, *University of Nova Gorica*, Nova Gorica, Slovenia

Memberships

- 2023-present **Member of the European Astronomical Society**, an intergovernmental organisation of 22 member states dedicated to the exploration of space
- Member of the WG1 of GWverse COST Action**, a collaboration focusing on super massive black holes, relativistic numerical relativity of astrophysical gas and plasma, and observations of transients

Grants and exchanges

- 09/2021 **STSM funded by the COST Action CA16104: GWverse**
I was awarded funding for a visit to the Niels Bohr Academy (Copenhagen, Denmark) as the Short Term Scientific Mission. This visit made possible the start of the collaboration with Dr. Bonnerot.
- 2017 **Erasmus exchange, Astronomy department, Stockholm University, Sweden**
During a 4-month exchange, I significantly improved my knowledge in astrophysics, including hydrodynamics by successfully completing the course Astrophysical Gas Dynamics (lecturer Prof. Stephan Rosswog).

Numerical expertise

- Methods Expertise in Lagrangian general relativistic-hydrodynamics codes (Phantom) and stellar evolution codes (MESA, MESA2HYDRO)
- Languages Fortran 90, Mathematica, Python, and Latex

Outreach and media activities

- 09/2022 **Presentation** titled “Center for astrophysics and cosmology” to elementary school students at the University of Nova Gorica, Ajdovščina, Slovenia
- 08/2022 **Presentation** titled “Black holes and tidal disruption events” to high school students at the GoChile summer school, Ajdovščina, Slovenia
- 03/2021 **Interview** titled “[Virus ne gane črnih lukenj](#)” for the Slovenian national newspaper *Delo*
- 01/2021 **Presentation** titled “Black holes and tidal disruption events” to high school students at the Informativa Fair, online
- 11/2020 **Presentation** titled “Black holes, stellar tidal disruption events and other points of interest in astronomy” to general public at the European researcher’s night, online
- 09/2020 **Interview** titled “[Iskanje življenja onkraj Zemlje](#)” for the Slovenian national radio station *RTV*
- 05/2019 **Presentation** titled “On the fate of stars after a tidal disruption event” to students at the First meeting of the CEEPUS network, Vipava, Slovenia

Teaching and supervision

- 2022-present **Supervision** of a master-level student Martina Larma
In December 2022, I began supervising the student in the context of TDE simulations with the Phantom code. The work is focused on determining the effect of different stream properties on the outflow from the self-crossing region.
- 2023-present **Supervision** of a PhD student Mario Andrés Osvaldo Aguilar Faúndez
In April 2023, I began supervising the student in the context of TDE simulations with the Phantom code, where stars are constructed with the MESA code. Currently, the work is focused on the student developing the necessary skills to efficiently use both codes, which will be later used to study open questions in TDEs.
- 2023-present **Supervision** of a bachelor student Aleksej Jurca
In August 2023, I began supervising the student, with the initial goal to model realistic stars with the code MESA.
- 2019-present **Teaching assistant** for the bachelor-level course “Stellar astrophysics 2”
- 2020-2023 **Teaching assistant** for the bachelor-level course “Stellar astrophysics 1”

Publications

3. **Jankovič, T., Bonnerot, C., Gomboc, A.**, “[Spin-induced offset stream self-crossing shocks in tidal disruption events](#)”, 2023, submitted to MNRAS

After a star is disrupted, the returning stream may collide with itself, leading to a self-crossing shock that launches an outflow part of which can circularize into an accretion disc. If the black hole rotates, the additional Lense-Thirring precession induces an offset between these two colliding components, which can affect the outcome of the interaction. I studied the effect of the black hole’s spin by locally simulating collisions between two offset streams. I determined the properties of the outflow and studied the consequences on the later debris evolution as well as characterized potentially observable features that hold the promise of constraining the black hole spin from tidal disruption events.

- Code and data:

HEALPix maps of the outflow obtained from the simulations and the code to extract mass flux for given values of the stream offset and the direction. The code and data are available at: <https://github.com/tajjankovic/Spin-induced-offset-stream-self-crossing-shocks-in-TDEs>

- Movies of simulations: <https://www.youtube.com/channel/UCcfg9AxruBie2pjTt0w34CA>

2. **Jankovič, T., Gomboc, A.**, “[The mass fallback rate of the debris in relativistic stellar tidal disruption events](#)”, 2023, ApJ, 946, 25

The debris fallback rate is the rate at which the bound debris returns to the proximity of the supermassive black hole after the disruption and is often assumed to be directly related to the observed light curve of TDEs. For this purpose, I simulated disruptions of stars with realistic stellar profiles constructed with the code MESA, for different stellar and orbital parameters as well as varying the black hole spin and calculated the fallback rate. By considering both general relativity and realistic stellar structure this work is currently the most accurate study of the debris fallback rate.

- Code and data:

MESA inlist files are available on Zenodo: <https://zenodo.org/record/7428262>

1. **Jankovič, T.**, “[Space-time ripples](#)”. Matrika: selected topics in modern physics and mathematics, 2017, Vol. 4, Issue 1, 10 pages

A review paper where the Einstein equation is introduced to describe gravitational waves and ascertain their properties. Additionally, possible astrophysical sources are presented as well as the first directly and indirectly detected events.

Talks and posters

- 09/2023 **Talk “Spin-induced offset stream self-crossing shocks in tidal disruption events”**, LSST Conference: “[Towards LSST science, together!](#)”, Poreč, Croatia
I was selected to present my work at the LSST conference, providing me an opportunity to further expand my understanding of transient observations.
- 03/2023 **Talk “Spin-induced offset stream self-crossing shocks in tidal disruption events”**, Mini TDE Workshop, Columbia University, New York, USA
I was selected to present my work at the Workshop, where I also engaged in discussions with prominent researchers, including Prof. Brian Metzger, Prof. James Stone, Prof. Andrew MacFadyen, Dr. Matteo Cantiello, Dr. Wenbin Lu, and Dr. Itai Linial.
- 11/2022 **Talk “The mass fallback rate of the debris in relativistic stellar tidal disruption events”**, [12th Slovenian conference on basic research in physics](#), Terme Čatež, Slovenia
The “Slovenian conference on basic research in physics” is the most prestigious annual Slovenian physics conferences. Due to my outstanding accomplishments, I was selected to present my work at the conference.
- 10/2022 **Talk “The mass fallback rate of the debris in relativistic stellar tidal disruption events”**, [Transient sky with Gaia: MW-Gaia WG2-WG4 Workshop](#), University of Coimbra, Coimbra, Portugal
I was selected to present my work at the conference attended by experts in TDEs, including Prof. Łukasz Wyrzykowski and Dr. Thomas Wevers, enabling me to increase my knowledge in observations of transients.

- 06/2022 **Virtual poster presentation “Relativistic tidal disruptions of stars with realistic density profiles”**, [European Astronomical Society EAS 2021: Annual Meeting](#), Leiden, The Netherlands,
- 01/2020 **Poster presentation “Bound debris in stellar TDEs”**, [Tidal disruptions in Kyoto: confronting theory with observations](#), Kyoto University, Kyoto, Japan
During a 2-week long combination of a conference and a workshop, I presented a poster, significantly improved my knowledge in TDEs, and interacted with several prominent TDE experts, including Dr. Nicholas Stone, Dr. Michael Kesden, Dr. Wenbin Lu, and Dr. Clément Bonnerot.