Filippo Santoliquido

Postdoctoral Researcher

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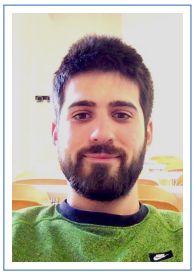

Work experience

Jan. 2023 - *ongoing* **Postdoc researcher**, *University of Padova*.
I am currently working in the DEMOBLACK group lead by Prof. Michela Mapelli. My main scientific focus is the prediction of gravitational-wave source properties across cosmic time.

Education

Oct. 2019 - *Expected Mar. 2023* **PhD student in Astrophysics**, *University of Padova*.
I submitted my PhD Thesis and expect to defend by the end of March 2023 . The PhD was fully funded by an **ERC** grant (PI and thesis supervisor: Prof. Michela Mapelli, DEMOBLACK project). Thesis title: *The evolution of compact objects and their host galaxies across cosmic time.*

Oct. 2017 - Sep. 2019 **Master Student in Astronomy**, *University of Padova*, *110/110*.
I graduated in Astronomy on September 26, 2019 with a thesis entitled *A data-driven model for the cosmic merger rate density of compact binaries*, supervised by Prof. Michela Mapelli.

Sep. 2014 - Sep. 2017 **Bachelor Student in Physics**, *University of Trento*, *104/110*.
I graduated in Physics on September 25, 2017 with a thesis entitled *Introduction to magnetohydrodynamic modelling of the solar wind*, supervised by prof. Bruno Giacomazzo.

Scientific visits

Feb. 1 - Jul. 31 2022 **Astroparticule et Cosmologie laboratory and Institute d'Astrophysique de Paris**, *Paris, France*.
I spent 6 months in Paris as a visiting researcher at the *Astroparticule et Cosmologie (APC)* laboratory, under the supervision of Dr. Stanislav Babak, and at the Institute d'Astrophysique de Paris (IAP), under the supervision of Dr. Irina Dvorkin. My research focused on new theoretical models for the detectability of merging binary black holes with third-generation gravitational-wave observatories.

May. 30 - Jun. 2 **Observatoire de la Côte d'Azur**, *Nice, France*.
I was invited for a four-day long scientific collaboration with Dr. Astrid Lamberts

Awards, Prizes and Grants

Oct. 2019 - now **Travel grants**, 1.2k euros.
In the next section, I mark with a * conferences and seminars for which I was assigned a travel grant or some sort of financial aid

Feb. 2022 - Jul. 2022 **Erasmus+ Trainee Programme**, *APC laboratory - CNRS - Paris*, 2.1k euros.
This scholarship helped the funding of the above-mentioned scientific missions

Jun. 2019 **Merit award**, *University of Trento*, 4k euros.
The university of Trento awards its best graduated students with a money prize. The amount of the prize depends on total time taken for graduating, average mark and periods abroad.

Feb. 2017 - Jul. 2017 **Erasmus+ Programme**, *University of Coimbra*, 2k euros.
I spent 5 months in Portugal as a mobility student. In order to receive the grant and graduate on time I had to take four exams abroad with average mark 18.25/20

Invited Colloquia and Seminars

Sep. 22, 2022 * **Invited speaker at University of Milano-Bicocca**.
My talk was part of the ongoing series of seminars in Astrophysics, hosted by the *Occhialini* Department of Physics.

Jun. 24, 2021 **Invited speaker at the Institut d'Astrophysique de Paris (IAP)**, *remote participation due to Covid-19 outbreak*, Paris.
Journal-club sessions for the high-energy research groups are organised every week at the *Institut d'Astrophysique de Paris* (IAP) in collaboration with the *Astroparticule et Cosmologie (APC)* laboratory

Apr. 13, 2021 **Invited speaker at SISSA Astrophysics Colloquium**, *remote participation due to Covid-19 outbreak*, SISSA, Trieste.
The Astrophysics Colloquium is a regular appointment of the Astrophysics and Cosmology group. I presented a talk entitled "The cosmic merger rate density of compact binaries".

Conferences and Workshops

Dec. 2022 * **Poster at GWPAW 22**, Melbourne Australia.
Gravitational Wave Physics and Astronomy Workshop 2022 (GWPAW). GWPAW is a leading workshop in Gravitational Wave Physics and Astronomy.

Jun. 27- Jul. 1, 2022 **Contributed Talk at EAS2022**, Valencia, Spain.
Annual meeting of the European Astronomical Society. I held a talk at the symposium: "Gravitational Wave and Multi-messenger Astronomy: current results and future perspectives".

Apr. 6-9, 2022 **Contributed Talk at APS meeting**, *remote participation due to Covid-19 outbreak*, New York City, New York, USA.
The American Physical Society's annual meeting brings together scientists and students from around the world to connect and collaborate across academia, industry, and major labs.

Jun. 20 - 24, 2022 * **Bayesian Deep Learning in Astrophysics**, Paris, France.
This workshop was intended for researchers that are familiar with machine learning and want to learn more about the advanced techniques related to Bayesian deep learning.

Dec. 2, 2021 **Contributed Talk at GWday**, *Sala consiliare di Palazzo Santo Stefano*, Padova, Italy.
The department of Physics and Astronomy of the University of Padova organised a workshop day where experts of gravitational waves could share their research and interact to prompt new collaboration. I volunteered to present my research topic.

Jul. 19-23, 2021 **Contributed Talk at Amaldi14**, *remote participation due to Covid-19 outbreak*, Melbourne, Australia.
Amaldi14 is the premier forum for the fields of gravitational wave science and gravitational wave detection. I presented a talk entitled "The cosmic merger rate density of compact binaries".

Jun. 28 - Jul. 2, 2021 **Poster at EAS2021**, *remote participation due to Covid-19 outbreak*, Leiden, Netherlands.
Annual meeting of the European Astronomical Society. I presented a poster at the symposium: "The Birth, Life, and Death of Black Holes".

May 24-28, 2021 **Contributed Talk at 3rd Workshop on Chemical Abundances in Gaseous Nebulae**, *remote participation due to Covid-19 outbreak*, Universidade do Vale do Paraíba, São José dos Campos, Brazil.
This 5-day workshop aims at bringing together scientists and students to extensively discuss about the crucial questions on chemical abundances in gaseous nebulae. I presented a talk titled "The cosmic merger rate density of compact binaries".

May 10-14, 2021 **#4 Gravitational Wave Open Data Workshop**, *remote participation due to Covid-19 outbreak*.
In order to facilitate the exploitation of the publicly available data, the LIGO and Virgo collaborations organised a workshops, intended for scientists who wish to learn about using gravitational-wave data and software, in order to conduct research of their own.

Mar. 30 - Apr. 1, 2021 * **Contributed Talk at The fourth assembly of the Groupement de Recherche *Ondes Gravitationnelles*** , *remote participation due to Covid-19 outbreak*, Institut Henri Poincaré, Paris.
This conference has been attached to the IHP programme "Gravitational waves: a new messenger to explore the universe". I presented a talk titled "The cosmic merger rate density of compact binaries".

Mar. 9-11, 2021 **Poster at 55th Rencontres de Moriond 2021**, *remote participation due to Covid-19 outbreak*.

Feb. 18, 2021 **Contributed Talk at annual TEONGRAV meeting**, *remote participation due to Covid-19 outbreak*.
TEONGRAV assembles the largest Italian collaboration of theoretical physicists and astrophysicists working on the theory of gravitational waves. I presented a talk titled "The cosmic merger rate density of compact binaries".

Jun. 29 - Jul. 3, 2020 **Poster at EAS2020**, *remote participation due to Covid-19 outbreak*, Leiden, Netherlands.
Annual meeting of the European Astronomical Society. I presented a poster at the symposium: "What have we learned from the observed population of gravitational wave sources?".

Mar. 10-13, 2020 **Invited talk at Mock Innsbruck**, *remote participation due to Covid-19 outbreak*.
The goal of this conference was to bring together leading researchers in computational studies of galaxy formation and cosmology. The participation at the conference was upon invitation. I presented a talk titled "The cosmic merger rate density of compact binaries".

Apr. 11-15, 2019 **Contributed Talk at Light of Tuscany 2019**, *Pisa and Firenze*.
It is a 4-day event organised by AISF (Associazione Italiana Studenti di Fisica). The common topic is the use of light in order to investigate new Physics. We visited, among other facilities, the European gravitational wave observatory Virgo. I was given the opportunity to held a presentation about my primary results of my master thesis.

Jun. 8, 2018 **ICYAA**, *University of Padova*.
During the one day long *International Conference of Young Astronomers and Astrophysicist* (ICYAA), both master students and PhD had the opportunity to share their research works.

Oct. 9-13, 2017 **Contributed Talk at PAPAP17**, *GSSI - L'Aquila*.
The *Particle and Astroparticle Autumn Program* (PAPAP) was an event organised by AISF. We visited the most important Italian laboratories which focus on the study of astroparticle physics. During last day, there was scheduled a student talk session at GSSI and my talk was awarded a prize.

Referee

Journal Referee, I am a scientific referee for the main astrophysical journals, on a regular basis.

Monthly Notices of the Royal Astronomical Society (MNRAS) .

The Astrophysical Journal (ApJ).

Teaching and Mentoring

Mar. 2022 **Co-supervisor of Lorenzo Merli's master thesis**.
The student looked at the evolution of the properties of population III stars that can be gravitational-wave sources at high redshift.

Dec. 2021 **Co-supervisor of Roberta Rufolo's master thesis**.
The student explored the impact of various models explaining the spin distributions of BBH detected by LIGO-Virgo. My main task was to guide her through the various functionalities of our codes.

Nov. 2021 **Physics Lab assistant**.
I supported students that learnt basic programming skills for data analysis in C++ (20 h/yr)

May - Jun. 2021 **Laboratory of Computational Astrophysics**.
I tutored a group of three students that completed a project starting from the code I developed during my PhD (12 h/yr)

Nov. 2020 **Physics Lab assistant**.
I supported students that learnt basic programming skills for data analysis in C++ (20 h/yr)

Affiliations, Memberships and Collaborations

Jun. 2022 **Einstein Telescope**, I am a member of the Observation Science Board of the Einstein Telescope (ET). ET is the European next-generation ground-based gravitational-wave detector. The Observation Science Board aims to identify the main scientific cases for the ET.

Apr. 2022 **AAS**, I am a member of the American Astronomical Society.

Apr. 2021 **EAS**, I am a member of the European Astronomical Society.

Oct. 2019 **INFN**, I am an associate of INFN (Istituto Nazionale di Fisica Nucleare), as a member of TEONGRAV group. The aim of this group is to gather experts around the theory of gravitational waves. Among the benefits it has to be part of INFN are travel funds and computing time at high computing facilities, for example CINECA.

May 2018 **SIF**, I am a fellow of the Italian Physics Society (Società Italiana di Fisica).

Dec. 2015 **AISF**, I am a fellow of the Italian Association of Physics Students (Associazione Italiana degli Studenti di Fisica). Further information are available on the official website http://ai-sf.it.

Public Outreach

Nov. 27, 2020 **Night of Researchers**, *remote participation due to Covid-19 outbreak*.
I gave an outreach talk at the 2020 Night of Researchers , followed by more than 500 people.

Oct. 2018 - Mar. 2020 **Guide for the Museum of History of Physics**, *University of Padova*.
In Fall 2018, I attended some educational lectures in order to become a guide for the Museum of History of Physics (Via Loredan 10, Padova). From January 2019, I regularly held visits at the museum for elementary and high school students

Technical Skills

Programming and scripting

Advanced Python, Jupyter notebooks

Intermediate MatLab®, R, C^{++}, SQL,BASH scripting

Other software

Advanced Latex

Intermediate Excel® or equivalently Numbers®,

Basic Parallel computing (CPUs)

Operating Systems

Advanced Linux, iOS, Windows

Versioning and Cloud

Intermediate Git (see ongoing public projects here), Google Drive

Main developer

COSMO$\mathcal{R}$ATE (Santoliquido et al. 2020) written in Python, COSMO$\mathcal{R}$ATE evaluates the astrophysical rates of compact object mergers and the evolution of their properties across cosmic time. It combines catalogues obtained through any formation channel with an observational-based prescription of the metallicity-dependent star formation rate. It is open source and available on GitLab at https://gitlab.com/Filippo.santoliquido/cosmo_rate_public

GALAXY$\mathcal{R}$ATE (Santoliquido et al. 2022) written in Jupyter Notebooks, GALAXY$\mathcal{R}$ATE is a unique tool for studying in an unravelled fast way the properties of host galaxies of compact object mergers with a minimal set of assumptions on observational scaling relations. It is available upon request.

HPC

Intermediate I usually run on High Performance Computing (HPC) machines using SLURM as a scheduler

Schools and Programs

Nov. 2022 **ML-INFN Hackathon: Advanced Level**, INFN Bari.
main topics: (1) Models constituted of multiple neural networks; (2) Models for data beyond tabular format; (3) Ongoing developments towards the future of Machine Learning

Oct. 2022 **Hands-on machine learning course with Python**, Padova Astronomical Observatory.
The course is organised by Dr. Lorenzo Spina (University of Padova). The course covers both supervised and unsupervised learning.

Jun. 7 - 9, 2021 **First ML-INFN Hackathon**, *remote participation due to Covid-19 outbreak*, INFN Firenze-Pisa-CNAF.
This three-day machine learning course was organised by INFN. The participation was closed to ~ 50 selected participants who had interest in applying ML in their research topics.

Jun. 1 - 5, 2021 **Summer School in Statistics for Astronomers XVI**, *remote participation due to Covid-19 outbreak*, Pennsylvania State University.
Penn State's Centre for Astrostatistics offered its week-long virtual Summer School in statistical methodology for astronomy.

Mar. 1 - Apr. 1, 2021 * **Gravitational waves: a new messenger to explore the universe**, *remote participation due to Covid-19 outbreak*, Institut Henri Poincaré, Paris.
The main goal of this programme is to bridge among all research areas in GW science, and foster interaction and communication. This 6-week program has been hosted by the *Institut Henri Poincaré* (IHP)

Feb. 1-5, 2021 **SIGRAV school**, *remote participation due to Covid-19 outbreak*, Rome.
The school, organised by the Italian Society of General Relativity and Gravitation (SIGRAV) aims at providing robust and deep knowledge of Physics and Astrophysics of the compact objects in the context of General Relativity and its possible modifications.

Jan. 14-23, 2020 **Multi Messenger Astrophysics School**, *Asiago astronomical observatory, Asiago (VI)*.
This school taught the cosmology and particle physics background needed to seriously approach multi-messenger astrophysics. It included key lectures, plus a series of topical lectures and seminars

Sep. 17-21, 2018 * **International School of Space Science**, *GSSI - L'Aquila*.
I attended this one-week summer school in L'Aquila on the topic: *The Polar Upper Atmosphere: From Science to Operational Issues*. The school was aimed for PhD students, and my presence was a welcome exception.

Languages

Italian	Native speaker
English	Excellent
French	Basic
Portuguese	Basic
Chinese	Extremely Basic

List of Publications

ADS See here for an interactive and most updated list of publications

ORCID https://orcid.org/0000-0003-3752-1400

Google Scholar

Summary of Publications

26 Total publications

4 Total publications as first author

21 Refereed publications

3 Refereed publications as first author

828 Total number of citations

150 Total number of citations as first author

14 h-index

3 h-index as first author

Data from ADS taken on January 24, 2022

First-author peer-reviewed publications

[1] **Santoliquido, Filippo**, Michela Mapelli, Yann Bouffanais, Nicola Giacobbo, Ugo N. Di Carlo, Sara Rastello, M. Celeste Artale, and Alessandro Ballone. The Cosmic Merger Rate Density Evolution of Compact Binaries Formed in Young Star Clusters and in Isolated Binaries. *ApJ*, 898(2):152, August 2020.

[2] **Santoliquido, Filippo**, Michela Mapelli, M. Celeste Artale, and Lumen Boco. Modelling the host galaxies of binary compact object mergers with observational scaling relations. *MNRAS*, 516(3):3297–3317, November 2022.

[3] **Santoliquido, Filippo**, Michela Mapelli, Nicola Giacobbo, Yann Bouffanais, and M. Celeste Artale. The cosmic merger rate density of compact objects: impact of star formation, metallicity, initial mass function, and binary evolution. *MNRAS*, 502(4):4877–4889, April 2021.

Other peer-reviewed publications

[4] Michela Mapelli, **Santoliquido, Filippo**, Yann Bouffanais, Manuel Arca Arca Sedda, Maria Celeste Artale, and Alessandro Ballone. Mass and Rate of Hierarchical Black Hole Mergers in Young, Globular and Nuclear Star Clusters. *Symmetry*, 13(9):1678, September 2021.

[5] S. Ronchini, M. Branchesi, G. Oganesyan, B. Banerjee, U. Dupletsa, G. Ghirlanda, J. Harms, M. Mapelli, and **Santoliquido, F.** Perspectives for multimessenger astronomy with the next generation of gravitational-wave detectors and high-energy satellites. *aap*, 665:A97, September 2022.

[6] Barbara Patricelli, Maria Grazia Bernardini, Michela Mapelli, Paolo D'Avanzo, **Santoliquido, Filippo**, Giancarlo Cella, Massimiliano Razzano, and Elena Cuoco. Prospects for multimessenger detection of binary neutron star mergers in the fourth LIGO-Virgo-KAGRA observing run. *MNRAS*, 513(3):4159–4168, July 2022.

[7] Carole Périgois, **Santoliquido, Filippo**, Yann Bouffanais, Ugo N. Di Carlo, Nicola Giacobbo, Sara Rastello, Michela Mapelli, and Tania Regimbau. Gravitational background from dynamical binaries and detectability with 2G detectors. *prd*, 105(10):103032, May 2022.

[8] Rosalba Perna, M. Celeste Artale, Yi-Han Wang, Michela Mapelli, Davide Lazzati, Cecilia Sgalletta, and **Santoliquido, Filippo**. Host galaxies and electromagnetic counterparts to binary neutron star mergers across the cosmic time: detectability of GW170817-like events. *MNRAS*, 512(2):2654–2668, May 2022.

[9] Michela Mapelli, Yann Bouffanais, **Santoliquido, Filippo**, Manuel Arca Sedda, and M. Celeste Artale. The cosmic evolution of binary black holes in young, globular, and nuclear star clusters: rates, masses, spins, and mixing fractions. *MNRAS*, 511(4):5797–5816, April 2022.

[10] Alessandro A. Trani, Sara Rastello, Ugo N. Di Carlo, **Santoliquido, Filippo**, Ataru Tanikawa, and Michela Mapelli. Compact object mergers in hierarchical triples from low-mass young star clusters. *MNRAS*, 511(1):1362–1372, February 2022.

[11] Marco Dall'Amico, Michela Mapelli, Ugo N. Di Carlo, Yann Bouffanais, Sara Rastello, **Santoliquido, Filippo**, Alessandro Ballone, and Manuel Arca Sedda. GW190521 formation via three-body encounters in young massive star clusters. *MNRAS*, 508(2):3045–3054, December 2021.

[12] Yann Bouffanais, Michela Mapelli, **Santoliquido, Filippo**, Nicola Giacobbo, Ugo N. Di Carlo, Sara Rastello, M. Celeste Artale, and Giuliano Iorio. New insights on binary black hole formation channels after GWTC-2: young star clusters versus isolated binaries. *MNRAS*, 507(4):5224–5235, November 2021.

[13] Sara Rastello, Michela Mapelli, Ugo N. Di Carlo, Giuliano Iorio, Alessandro Ballone, Nicola Giacobbo, **Santoliquido, Filippo**, and Stefano Torniamenti. Dynamics of binary black holes in low-mass young star clusters. *MNRAS*, 507(3):3612–3625, November 2021.

[14] Yann Bouffanais, Michela Mapelli, **Santoliquido, Filippo**, Nicola Giacobbo, Giuliano Iorio, and Guglielmo Costa. Constraining accretion efficiency in massive binary stars with LIGO -Virgo black holes. *MNRAS*, 505(3):3873–3882, August 2021.

[15] Michela Mapelli, Marco Dall'Amico, Yann Bouffanais, Nicola Giacobbo, Manuel Arca Sedda, M. Celeste Artale, Alessandro Ballone, Ugo N. Di Carlo, Giuliano Iorio, **Santoliquido, Filippo**, and Stefano Torniamenti. Hierarchical black hole mergers in young, globular and nuclear star clusters: the effect of metallicity, spin and cluster properties. *MNRAS*, 505(1):339–358, July 2021.

[16] Ugo N. Di Carlo, Michela Mapelli, Nicola Giacobbo, Mario Spera, Yann Bouffanais, Sara Rastello, **Santoliquido, Filippo**, Mario Pasquato, Alessandro Ballone, Alessandro A. Trani, Stefano Torniamenti, and Francesco Haardt. Binary black holes in young star clusters: the impact of metallicity. *MNRAS*, 498(1):495–506, October 2020.

[17] Sara Rastello, Michela Mapelli, Ugo N. Di Carlo, Nicola Giacobbo, **Santoliquido, Filippo**, Mario Spera, Alessandro Ballone, and Giuliano Iorio. Dynamics of black hole-neutron star binaries in young star clusters. *MNRAS*, 497(2):1563–1570, September 2020.

[18] Ugo N. Di Carlo, Michela Mapelli, Yann Bouffanais, Nicola Giacobbo, **Santoliquido, Filippo**, Alessandro Bressan, Mario Spera, and Francesco Haardt. Binary black holes in the pair instability mass gap. *MNRAS*, 497(1):1043–1049, September 2020.

[19] M. Celeste Artale, Yann Bouffanais, Michela Mapelli, Nicola Giacobbo, Nadeen B. Sabha, **Santoliquido, Filippo**, Mario Pasquato, and Mario Spera. An astrophysically motivated ranking criterion for low-latency electromagnetic follow-up of gravitational wave events. *MNRAS*, 495(2):1841–1852, June 2020.

[20] M. Celeste Artale, Michela Mapelli, Nicola Giacobbo, Nadeen B. Sabha, Mario Spera, **Santoliquido, Filippo**, and Alessandro Bressan. Host galaxies of merging compact objects: mass, star formation rate, metallicity, and colours. *MNRAS*, 487(2):1675–1688, August 2019.

[21] Michela Mapelli, Nicola Giacobbo, **Santoliquido, Filippo**, and Maria Celeste Artale. The properties of merging black holes and neutron stars across cosmic time. *MNRAS*, 487(1):2–13, July 2019.

Other publications

[22] Carole Périgois, Michela Mapelli, **Santoliquido, Filippo**, Yann Bouffanais, and Roberta Rufolo. Binary black hole spins: model selection with GWTC-3. *arXiv e-prints*, page arXiv:2301.01312, January 2023.

[23] Biswajit Banerjee, Gor Oganesyan, Marica Branchesi, Ulyana Dupletsa, Felix Aharonian, Francesco Brighenti, Boris Goncharov, Jan Harms, Michela Mapelli, Samuele Ronchini, and **Santoliquido, Filippo**. Detecting VHE prompt emission from binary neutron-star mergers: ET and CTA synergies. *arXiv e-prints*, page arXiv:2212.14007, December 2022.

[24] Giuliano Iorio, Guglielmo Costa, Michela Mapelli, Mario Spera, Gastón J. Escobar, Cecilia Sgalletta, Alessandro A. Trani, Erika Korb, **Santoliquido, Filippo**, Marco Dall'Amico, Nicola Gaspari, and Alessandro Bressan. Compact object mergers: exploring uncertainties from stellar and binary evolution with SEVN. *arXiv e-prints*, page arXiv:2211.11774, November 2022.

[25] **Santoliquido, Filippo**. The evolution of compact object mergers and their host galaxies across cosmic time. In *APS April Meeting Abstracts*, volume 2022 of *APS Meeting Abstracts*, page D15.008, April 2022.

[26] Michela Mapelli, **Santoliquido, Filippo**, Yann Bouffanais, Manuel Arca Arca Sedda, Maria Celeste Artale, and Alessandro Ballone. Mass and Rate of Hierarchical Black Hole Mergers in Young, Globular and Nuclear Star Clusters. *Symmetry*, 13(9):1678, September 2021.