Francesco Iacovelli

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FrancescoIacovelli
CosmoStatGW

Languages

Italian (Native),
English (Fluent),
French (Intermediate).

Programming Languages

Advanced level:
C, C++, R,
Python, MATLAB,
Microsoft Office, LaTeX.
Intermediate level:
Visual Basic,
Arduino, Wolfram
Mathematica,
FORTRAN, CSS.

Skills and Knowledge

Cosmology and
Gravity, Simulations
and Data Analysis,
Responsibility, Team
working, Leadership,
Flexibility, Teaching.

Hobbies

Percussion
instruments,
photography,
tennis, hiking.

Education

2020–current **Ph.D.** in Theoretical Physics — University of Geneva, Geneva, Switzerland

Gravitational waves, Cosmology, Modified Gravity and Computing. On November 1, 2020, I moved to Geneva to complete my education, under the supervision of Prof. M. Maggiore. The core focus of my current research activity is the theoretical study of the new and promising field of gravitational waves. To be specific I am focusing on the possibility of using them for cosmological purposes and to test modifications of the theory of General Relativity. Also, being member of the Observational Science Board, I am working on forecasting the capabilities of the Einstein Telescope. Moreover, I am an assistant, thus I am becoming much more proficient in teaching and understanding the other's various points of view. In 2022 I was awarded the Istituto Svizzero "Milano Calling" fellowship, which allowed me to visit the University of Milano-Bicocca from October 2022 to April 2023. During this experience I worked with the group of Prof. D. Gerosa, mainly focusing on Astrophysical aspects related to gravitational waves and data analysis.

2018–2020 **Master's Degree** in Astronomy and Astrophysics — Sapienza University, Rome, Italy

General Relativity, Physical and Theoretical Cosmology, Stellar and High Energy Astrophysics, Relativistic Quantum Mechanics. Different topics linked to Astrophysics and High Energy Physics examined in-depth with particular focus on theoretical aspects of Gravity and Cosmology. In February 2019 I became part of the *Excellence Programme* and researched material linked to Inflation and Effective Field Theory under the supervision of Prof. F. Riccioni. I graduated with honors on October 1, 2020, writing my thesis under the supervision of Prof. M. Maggiore and Prof. A. Melchiorri about cosmological model testing via gravitational waves and galaxy clustering observation.

2015–2018 **Bachelor's Degree** in Physics — Sapienza University, Rome, Italy

Classical, Statistical and Quantum Mechanics, Electromagnetism and Optics, Computational Physics, Statistics, Real, Complex and Functional Analysis. I learned the foundations of both theoretical and experimental physics, as well as the mathematics behind them. I graduated with honors on October 22, 2018, my thesis was about dark matter evidences from gravitational microlensing, the supervisor was Prof. P. de Bernardis.

Experience

2021-current **Teaching assistant** — University of Geneva, Geneva, Switzerland

Since arriving in Geneva, I have been a teaching assistant for Thermodynamics, Mathematical Methods for Physics, and Electrodynamics II courses. This greatly improved my teaching and organisational skills and allowed me to understand better how to share my knowledge arousing interest in the students.

2022–2023 **Maturity exam jury member** — Geneva, Switzerland

In 2022 (Collège de Saussure) and 2023 (Collège Rousseau, Collège Sismondi, CEC André-Chavanne) I have been a jury member during the Swiss maturity exams, for the subjects of "Physics and Applications of Mathematics" and "Mathematics". As such, I participated in the correction of the written tests and oral examinations. This improved my ability in testing and evaluating students knowledge.

2019 **Collaboration Scholarship** — Sapienza University, Rome, Italy

Organisational, teaching and problem solving skills. I set up instrumentation both for Mechanics, Thermodynamics and Electromagnetism Laboratory experimental classes and helped younger students during data taking and report writing.

2015–2018 **Private Tutor** — Rome, Italy

Teaching to high school students Mathematics, Physics, Biology and Chemistry. I improved my flexibility, teaching skills, and learned to understand different points of view.

Research interests

Einstein Telescope science
Einstein Telescope (ET) is the proposed European third-generation ground-based gravitational wave detector. As a member of the ET Observational Science Board, I extensively worked on different aspects of ET's science. In particular, together with the Geneva group, I developed `gwfast`, one of the few public Fisher-matrix codes capable of simulating how ET will reconstruct the parameters of the huge number of compact binary events it will detect. I am actively involved in the analysis and strengthening of the ET science case, in particular regarding compact binary mergers observation and prospects of their impact on astrophysics (e.g. compact objects populations), cosmology (e.g. primordial black holes) and fundamental physics (e.g. neutron star equation of state).

Gravitational-wave cosmology
Gravitational waves emitted by coalescing binary systems are ideal candidates to measure how the universe expands, giving direct access to the luminosity distance to the source. Also, gravitational waves could be the only way to test gravity models that modify GR on cosmological scales. I have worked on different ways of extracting cosmological information from GW events (e.g. correlating GWs and galaxy catalogs) and to test modified propagation (e.g. from quadruply lensed gravitational-wave events), and keep working on extending previous analyses, as well as in finding new ways to observe deviations from GR.

Multimessenger astrophysics
Gravitational wave signals emitted by the coalescence of two objects, if there is at least a neutron star, can trigger a burst of electromagnetic radiation. From the combination of the two observables we can better constrain e.g. the neutron star structure, the physical processes giving rise to the observed electromagnetic emission or the expansion history of the Universe. I have worked on the prospects of using joint gamma-ray burst polarimetry and GW measurements to obtain constraints on the burst emission model and, more recently, I am working with a group of leading experts to forecast the prospects of observing electromagnetic counterparts from neutron star-black hole coalescences both at current and future detectors.

Publications

Publications: **9** papers published in major peer–reviewed journals, **1** paper accepted for publication in a in major peer–reviewed journal, **1** paper in submission stage, **2** public codes, **5** proceedings.

Total number of citations: 247 [iNSPIRE] – 240 [NASA/ADS]

h-index: 6

Alphabetical order is the standard publication policy in Theoretical Cosmology, regardless of the actual contribution of the authors, and the group where I am working during my Ph.D. usually adopts such practice. I will therefore add a brief summary of my contribution to each paper I am not the first author of.

Links to publication list: iNSPIRE, NASA/ADS, Scholar

Published papers

[10] **F. Iacovelli**, M. Mancarella, et al. "Nuclear physics constraints from binary neutron star mergers in the Einstein Telescope era". 2023. arXiv: 2308.12378 [gr-qc]. *To appear in Phys. Rev. D*.

[9] G. Franciolini, **F. Iacovelli**, M. Mancarella, M. Maggiore, P. Pani and A. Riotto. "Searching for Primordial Black Holes with the Einstein Telescope: impact of design and systematics". In *Phys. Rev. D* . 108, 043506 (2023). DOI: 10.1103/PhysRevD.108.043506. arXiv: 2304.03160 [gr-qc].

My contribution can be considered as first author. I had a major role in the theoretical development and writing of the paper, and I also produced many of the reported results.

[8] M. Branchesi, M. Maggiore, et al. (incl. **F. Iacovelli**). "Science with the Einstein Telescope: a comparison of different designs". In *JCAP* 07 (2023) 068. DOI: 10.1088/1475-7516/2023/07/068. arXiv: 2303.15923 [gr-qc].
I took part in the development of various sections of the work, producing in particular most of the results in the "Coalescence of compact binaries" section, and participating in the "Nuclear physics", "Population studies" and "Cosmology" sections.

[7] M. Mancarella, **F. Iacovelli**, D. Gerosa. "Inferring, not just detecting: metrics for high-redshift sources observed with third-generation gravitational-wave detectors". In *Phys. Rev. D* . 107, L101302 (2023). DOI: 10.1103/PhysRevD.107.L101302. arXiv: 2303.16323 [gr-qc].
I participated in the theoretical development and writing of the paper, also producing part of the reported results (in particular the 'inference horizon').

[6] M. Kole, **F. Iacovelli**, M. Mancarella, N. Produit. "Adding Gamma-ray Polarimetry to the Multi-Messenger Era". In *Astron. Astrophys.* 669 (2023) A77. DOI: 10.1051/0004-6361/202245205. arXiv: 2211.12403 [astro-ph.HE].
I produced the results and plots of the gravitational wave part, also participating in the theoretical development of the paper.

[5] **F. Iacovelli**, M. Mancarella, S. Foffa, M. Maggiore. "Forecasting the detection capabilities of third-generation gravitational-wave detectors using GWFAST". In *Astrophys. J.* 941 (2022) 2, 208. DOI: 10.3847/1538-4357/ac9cd4. arXiv: 2207.02771 [gr-qc].

[4] **F. Iacovelli**, M. Mancarella, S. Foffa, M. Maggiore. "GWFAST: A Fisher Information Matrix Python Code for Third-generation Gravitational-wave Detectors". In *Astrophys. J. Supp.* 263 (2022) 1, 2. DOI: 10.3847/1538-4365/ac9129. arXiv: 2207.06910 [astro-ph.IM].

[3] A. Finke, S. Foffa, **F. Iacovelli**, M. Maggiore, and M. Mancarella. "Modified gravitational wave propagation and the binary neutron star mass function". In: *Phys. Dark Univ.* 36 (2022) 100994. DOI: 10.1016/j.dark.2022.100994. arXiv: 2108.04065 [gr-qc].
I produced most of the results results, figures, and code, developing also a useful data visualization technique.

[2] A. Finke, S. Foffa, **F. Iacovelli**, M. Maggiore, and M. Mancarella. "Probing modified gravitational wave propagation with strongly lensed coalescing binaries". In: *Phys. Rev. D* 104.8 (2021), p. 084057. DOI: 10.1103/PhysRevD.104.084057. arXiv: 2107.05046 [gr-qc].
I produced most of the results results and figures within this paper, wrote the necessary code, and also contributed to the development of the theoretical framework.

[1] A. Finke, S. Foffa, **F. Iacovelli**, M. Maggiore, and M. Mancarella. "Cosmology with LIGO/Virgo dark sirens: Hubble parameter and modified gravitational wave propagation". In: *JCAP* 08 (2021), p. 026. DOI: 10.1088/1475-7516/2021/08/026. arXiv: 2101.12660 [astro-ph.CO].
This work is part of my Master's thesis, and I contributed writing parts of the accompanying code, studying in depth and handling the problem of the completeness of galaxy catalogs, as well as producing most of the figures and results.

Papers under review

[1] A. Colombo, R. Duqué, et al. (incl. **F. Iacovelli**). "Multi-messenger prospects for black hole – neutron star mergers in the O4 and O5 runs". 2023. arXiv: 2310.16894 [astro-ph.HE].
I took care of the gravitational wave modelling aspects of the paper, writing the relative part and producing the results of the gravitational wave observational prospects.

Public softwares

[2] **F. Iacovelli**, M. Mancarella. GWFAST: a Fisher information matrix Python package for GW detector networks. ascl: 2212.001. Git: https://github.com/CosmoStatGW/gwfast.

[1] **F. Iacovelli**. WF4Py: Gravitational waves waveform models in pure Python language. ascl: 2301.003 Git: https://github.com/CosmoStatGW/WF4Py.

Proceedings

[5] **F. Iacovelli**, M. Mancarella., S. Foffa, M. Maggiore. "GWFAST: A tool to explore the capabilities of Third-generation Gravitational-wave Interferometers". In *Proceedings, PUMA22*. 2022. *Genova*

University Press "Probing the Universe with Multimessenger Astronomy" p.68. e-ISBN: 978-88-3618-218-3.

[4] M. Mancarella, N. Borghi, S. Foffa, E. Genoud-Prachex, **F. Iacovelli**, M. Maggiore, M. Moresco, M. Schulz. "Gravitational-wave cosmology with dark sirens: state of the art and perspectives for 3G detectors". In *PoS ICHEP2022 127*. 2022. arXiv: arXiv:2211.15512 [gr-qc].

[3] **F. Iacovelli**, A. Finke, S. Foffa, M. Maggiore, M. Mancarella. "Modified gravitational wave propagation: information from strongly lensed binaries and the BNS mass function". In *Proceedings, 56th Rencontres de Moriond on Gravitation*. 2022. arXiv: arXiv:2203.09237 [gr-qc].

[2] M. Mancarella, A. Finke, S. Foffa, E. Genoud-Prachex, **F. Iacovelli**, M. Maggiore. "Cosmology and modified gravity with dark sirens from GWTC-3". In *Proceedings, 56th Rencontres de Moriond on Gravitation*. 2022. arXiv: arXiv:2203.09238 [gr-qc].

[1] A. Finke, S. Foffa, **F. Iacovelli**, M. Maggiore, and M. Mancarella. "Constraining the Hubble constant and modified GW propagation with LIGO/Virgo dark sirens". In: *Proceedings, 55th Rencontres de Moriond on Cosmology*. 2021.