

## Contact Information

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## Professional Experience

**Marie S. Curie Fellow, Padua Observatory, Italy, 01/09/2017- current** My project leverages machine learning to find intermediate-mass black holes in star clusters (ARTificial Intelligence Search for Intermediate-mass black holes in star Clusters - *ARTISTIC*). I use deep learning on mock images from star cluster simulations as well as more conventional machine learning techniques. Host: Prof. Raffaele Gratton.

**Senior Data Analyst, Kvadro-M, Ukraine, 01/06/2017 – 31/08/2017** Kvadro-M is a leading wholesaler of dental supplies in Ukraine. The company recently moved into the retail space, opening an e-commerce website (<http://kvadro-m.com>). I analyzed web marketing performance indicators in R and Tableau, and worked with Google tools e.g. Search Console, Analytics, Adwords, and 3rd party SEO tools (Semrush).

**Postdoctoral fellow, Yonsei University, Korea, 01/10/2012 – 31/05/2017** I developed my own computational astronomy research program with a focus on star-cluster dynamics and intermediate-mass black holes. Run and analyzed large sets of direct N-body simulations (with the NBODY6 code on GPUs). Between 30/06/2012 and 01/10/2012 I took some time off to prepare for moving to Korea, including a period to familiarize myself with the Korean language and culture.

**Postdoctoral researcher, Bologna University, Italy, 01/07/2011 – 30/06/2012** Performed the simulation groundwork for Ferraro et al. 2012, a Nature paper on the formation mechanism of blue straggler stars in GCs. We reproduced their bimodal distribution with mass segregation of a pure binary population.

**Contract Consultant, Pisa, Italy 27/01/2011 – 30/04/2012** I was registered as a professional in the field of education support activities for the period indicated (overlapping my first postdoc), with VAT number 01994790507. I provided training in statistics and exact sciences, either on an individual or company level.

## Education

**Ph.D., Astrophysics, Pisa University, Italy, 01/01/2007 – 07/12/2010** Full, merit-based scholarship and tuition waiver. Thesis: *Globular clusters and intermediate-mass black holes: a model-free, non-parametric approach, between simulations and observations* - Advisor: Prof. G. Bertin (Milan University). During my Ph.D. course I visited the European Space Agency ESTEC facility (Noordwijk, The Netherlands June 2009; expenses fully paid by ESA) and was a summer intern at Space Telescope Science Institute (Baltimore, USA, June-August 2008; expenses fully paid by STScI).

**M.Sc., Physics Scuola Normale Superiore, Italy, 01/10/2001 – 01/10/2006** Full, merit-based scholarship and tuition waiver. Grade 70/70, summa cum laude.

**M.Sc., Astrophysics Pisa University, Italy, 16/10/2004 – 26/09/2006** Grade: 110/110, Thesis: *The fundamental manifold of globular clusters*, Advisor: Prof. G. Bertin (Milan University)

**B.Sc., Physics Pisa University, Italy, 12/10/2001 – 15/10/2004** Grade: 110/110, Thesis: *Stochastic resonance and its applications to biology*, Advisor: Prof. R. Mannella (Pisa University)

## Grants, awards, memberships, and other achievements

**Member of the Italian National Institute for Nuclear Physics (INFN), Padua chapter, 2018-current**

**Astrofit2 MSCA-COFUND action, grant agreement No. 664931, 01/09/2017** Grant awarded for project ARTificial Intelligence Search for Intermediate-mass black holes in star Clusters (*ARTISTIC*). Value ~200 k\$.

**Grant N. 2017018587 by the National Research Foundation (NRF) of Korea, 02/06/2017** Awarded for project *Machine-learning search for intermediate-mass black holes*. The grant amounted to 250'000'000 Korean Won (about 250 k\$) over a period of 3 years. Declined.

**Member of the technical-scientific committee of the Italian Embassy in Korea, 2015-2017** I served as an evaluator for travel grant proposals within the framework *Grants to Explore Science and Technology*

*Opportunities in South Korea (GESTO-SK)* by the Italian Embassy in Korea.

**Member of the Korean Astronomical Society 2013-2016**

**PI of three Italian Super Computing Resource Allocation C-class projects** CLUSTERS, 50k core-hours (Bologna, 2011); DLSCHIMB, 200k hours (Padua, 2018); DISSM67, 400k hours (Padua, 2019)

**Confucius institute scholarship, Nankai University, China, 01/08/2011 – 31/08/2011** I was selected to receive a full immersion course in Chinese language at Nankai University in Tianjin, China. Living expenses fully paid by the ministry of education of the People's Republic of China

**Teaching qualification exam, Italy, 22/11/2007** Participated in the regional selection for teaching qualification for secondary education (*Scuola di Specializzazione all'Insegnamento Secondario*; SISS).

Admitted, top applicant in ranking for Tuscany (the selection used to take place on a regional basis).

**Admitted to Scuola Normale Superiore, Italy, 01/10/2001** Scuola Normale Superiore, similarly to the French *École Normale Supérieure*, grants admission yearly to a very limited number of students (about 50 between sciences and humanities, of which only ~10 for Physics) based solely on a written and oral examination. Students receive free board and lodging and a monthly stipend.

## Outreach activities

**European Researchers Night, Padua Astronomical Observatory, Italy, 27/09/2019** gave a 'Young Researcher' talk on *Astronomy and Artificial Intelligence*

**Outreach talk at Padua Planetarium, Italy, 06/04/2019** I gave a talk on *Artificial Intelligence in Astronomy* to a paying audience at the Planetarium of Padua

**European Researchers Night, Padua Astronomical Observatory, Italy, 28/09/2018**

**European Researchers Night, Padua Astronomical Observatory, Italy, 27/09/2017**

**Member of the Jury, Wiki Science Competition 2017, 01/11/2017 - 19/02/2018** Wiki Science competition is a competition for scientific photography held by the Wikimedia Foundation. I sat in the national jury for Italy, rating pictures submitted by the public in the capacity of expert in astrophysics.

**Interview by ScienceNews, Kissimmee, US, 12/01/2016** I was interviewed by the US magazine ScienceNews ([sciencenews.org](http://sciencenews.org)) while attending the 227th American Astronomical Society Meeting. My interview is featured in the article *Red giants map how the Milky Way grew* by Andrew Grant

**Outreach program staff, Pisa, Ludoteca Scientifica 02/04/2007 – 25/05/2007** Ludoteca Scientifica ([ludotecascientifica.it](http://ludotecascientifica.it)) is a spinoff of Pisa University. It is best described as a 'scientific playroom', a collection of hands-on games, tools and experiments in physics, chemistry and other sciences. I guided visitors through the exhibit, interacting with them during hands-on activities.

## Teaching

**Optics Laboratory, Padua University, Italy 06/05/2019 – 26/06/2019** Official name of the course: *Esperimentazioni di fisica II*. Undergraduate course for astronomers, shared with Prof. Davide de Salvador, my part accounting for 36 hours of teaching, including grading of student tests. Course language: Italian. I was selected for teaching this course again in the spring semester of 2020.

**Machine learning for astronomy, Padua University, Italy 15/02/2017 – 22/02/2017** Graduate course for astronomers, total of 10 hours of teaching. I devised the course syllabus and materials from scratch, and submitted it for dean approval. This was the first dedicated machine learning course taught to graduate students of the department, consisting entirely of hands-on activities in R. Course language: English.

**Computational Astronomy, Yonsei University, Korea 20/02/2014 - 15/06/2014** Taught a semester course in computational astronomy, with my own materials and tests. Graded written examinations. Other 3 postdocs shared equally the teaching load, divided in four independent modules. I focused mainly on solving ordinary differential equations of astrophysical interest numerically, in Python. Course language: English.

**Croatian black hole school, Trpanj, Croatia 21/05/2010 – 25/06/2010** Invited lecture on black holes from an astrophysical perspective (the school was attended mainly by theoretical physicists), in particular on intermediate mass black holes.

**Teaching assistant – Pisa University Italy 01/03/2010 – 22/07/2010** Served as teaching assistant for analog electronics laboratory. This included grading written tests and performing oral examinations, assisting students with equipment, troubleshooting. Course language: Italian.

## Mentoring

### Ph.D. students

**José Schiappacasse, Padua University, Italy, currently ongoing** Ph.D. student on the *Chilean scholarship for doctoral studies abroad (Becas Chile para doctorado en el extranjero)* program; co-supervised with Dr. Sara Lucatello of Padua Observatory. José is working with me for over 50% of his time on predicting star cluster properties (age, [Fe/H], distance...) from HR diagrams using machine learning.

**Stefano Torniamenti, Padua University, Italy, currently ongoing** Ph.D. student co-supervised with Prof. Michela Mapelli. Stefano is working with me for 25% of his time on applying neural generative models (GANs, VAEs) to generate synthetic outputs of star-cluster formation simulations run by Prof. Mapelli.

### Master's

**Erica Greco, Padua University, Italy, currently ongoing** Masters student, Preliminary thesis title: *Unsupervised machine learning for chemical tagging of open cluster stars*. Expected defense date in July 2020.

**Tobia Peruzzi, Padua University, Italy, currently ongoing** Masters student, Preliminary thesis title: *Visualizing AGN spectra with t-SNE*. Expected defense date in March 2020.

**Piero Trevisan, Padua University, Italy, 07/03/2019** Masters student, Thesis title: *Deep Convolutional Neural Networks in Astrophysics: a case study for gas turbulence*, Grade: 110/110 summa cum laude

**Hyunwoo Kim, Yonsei University, Korea, 15/06/2018** Masters student, Thesis title: *Kinematic Signature of Core Collapse in N-Body Simulations of Globular Clusters*, Grade: Pass

### Bachelor's

**Erica Greco, Padua University, Italy, 14/12/2017** Bachelors student, Thesis title: *Formation and dynamical evolution of black hole binaries* (Official title in Italian: *Evoluzione e formazione dinamica di binarie di buchi neri*), Grade: 99/110; note that final grade for bachelors students is mostly based on course grades.

### Other

**Ugo Niccolò di Carlo, Insubria University, Italy** Ph.D. student, recently co-authored the paper *Radial Dependence of the Proto-Globular Cluster Contribution to the Milky Way Formation* working with me on the simulation part. **This is his first paper not to involve his Ph.D. supervisor Prof. Francesco Haardt.**

**Founder of the Students & postdocs Original Journal club about the Universe (S.O.J.U.), Yonsei University, Korea, 27/02/2013** SOJU, the first regular journal club of Yonsei University's dept. of astronomy open to all students, was founded by me and three other postdocs to give students a way to practice public speaking while keeping updated on the most recent astro-ph preprints.

## Skills and assets

### Programming Languages

R - fluent (code sample: most repositories in <https://gitlab.com/mariomario>)

Python - working knowledge (code sample using Keras: <https://gitlab.com/mariomario/jellyfishng>)

C - working knowledge (code sample: <https://gitlab.com/mariomario/quesodish>)

### Machine learning

Unsupervised learning in R: t-SNE and UMAP for dimensionality reduction (libraries *tsne*, *umap*), clustering with DBSCAN (library *dbscan*) and hierarchical and partitioning methods (library *cluster*). Supervised learning with traditional (not deep learning) tools in R such as SVM (library *e1071*), k-nearest neighbor (library *FNN*), trees and random forests (libraries *C5.0*, *party*, *randomForest*). Neural networks in R using the *h2o* library. Supervised learning with deep convolutional neural networks on images using *Keras* on top of *Tensorflow* in Python. Took part in several competitions on the kaggle.com platform, with results in the top 5% out of thousands of users. Selected competitions: Africa Soil Property Prediction Challenge **top 5%**; Prudential Life Insurance Assessment top 23%, awarded silver medal for kernels; Driver Telematics Analysis (sponsored by AXA insurance company) top 34%; Diabetic Retinopathy Detection top 46%.

### Astronomy specific computing skills

Codes for star-cluster dynamics: NBODY 6 and MOCCA (I have access to the source code and to the MOCCA Survey Database I library of simulations through my collaboration with Prof. M. Giersz at the Copernicus Center for Astronomy in Warsaw, Poland). Planning and deploying large simulations, including on GPU clusters, using the relevant Unix/GNU- Linux and HPC tools (shell scripting, schedulers, performance monitors...). Writing, debugging and optimizing scripts for data processing, model fitting, plotting, and visualization both in R (using *ggplot2*) and in Python (using *astropy*, *matplotlib*, *seaborn*). Some experience with SAOImage DS9, topcat

## Other computing skills

Version control with git. LaTeX and BibTeX (also on Overleaf.com). Jupyter notebooks. Some exposure to SQL. Working knowledge of HTML and CSS (e.g. site I made from scratch: <http://dentalight.com.ua>) and CMS systems such as Wordpress (e.g. my site <http://www.mariopasquato.com>). Experience with proprietary tools for search engine optimization (SEMRush). Dataviz with Tableau (portfolio: <https://public.tableau.com/profile/mario.pasquato>). Bash scripting. Rapidminer data science platform.

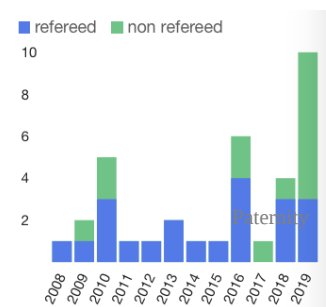
## Natural languages and soft skills

Able to communicate scientific results in fluent English (CEFR C2 level), both in written form and orally. Native speaker of Italian, working knowledge of German (B1), spoken Korean (B1), and Ukrainian (A2). Public speaking. Teamwork. Large network of collaborations. Scientific writing, grant writing. Ready to adapt to different cultural environments, eager to interact with the scientific community worldwide.

## Publications

### Metrics

Publications in peer-reviewed journals	29	Citations	509
Submitted	4	Median number of coauthors	3
Published + Accepted	25	h-index	11
1 <sup>st</sup> author; 2 <sup>nd</sup> author	14; 4	First author h-index	5
Without Ph.D. superv.	27	Publications/yr of post-Ph.D. activity	3



Data obtained from the Astrophysics Data System ([adsabs.harvard.edu](https://adsabs.harvard.edu)) on 08/09/2019. I am not part of large collaborations (see the median number of coauthors) and I am 1<sup>st</sup> author in ~half of my publications. The apparent hiatus in research output in 2017 is due to a short period of work outside academia and to paternity.

### Submitted (draft available upon request if not on astro-ph)

1. *Mass and star formation rate of the host galaxies of compact binary mergers across cosmic time*, Artale M. C., Mapelli M., Bouffanais, Y., Giacobbo, N., Spera, M., Pasquato M. 2019, MNRAS Submitted, astro-ph:1910.04890
2. *Detecting IMBHs with machine learning: I. feature-based supervised classification on MOCCA-SURVEY Database I simulations*, Pasquato, M., Mapelli, M., Askar, A., Giersz, M. 2019, A&A Submitted
3. *Towards a theory of the dynamical clock - Evolution of the A+ indicator in Plummer models*, Pasquato, M. 2019, A&A Submitted
4. *Multiple Stellar Populations in NGC 2808: a Case Study for Cluster Analysis*, Pasquato, M. & Milone, A. 2019, ApJ Submitted, astro-ph:1906.04983

### Accepted

1. *Further properties of the dynamical clock A+ indicator in a toy model of pure dynamical friction*, Pasquato, M. 2019, RevMexAA Accepted, astro-ph:1907.11965
2. *Analytical solutions for the dynamical clock A+ indicator in a toy model of pure dynamical friction*, Pasquato, M. 2019, RevMexAA Accepted, astro-ph:1907.11964
3. *Clustering clusters: unsupervised machine learning on globular cluster structural parameters*, Pasquato, M. & Chung, C. 2019, MNRAS Accepted, astro-ph:1901.05354

### Published

1. *Radial Dependence of the Proto-Globular Cluster Contribution to the Milky Way Formation*, Chung, C., Pasquato, M., Lee, S.-Y., Di Carlo, U.N., An, D., Yoon, S.-J., Lee, Y.-W. 2019 *ApJL* 883, L31
2. *Extended halo of NGC 2682 (M 67) from Gaia DR2*, Carrera, R., Pasquato, M., Vallenari, A., Balaguer-Núñez, L., Cantat-Gaudin, T., Mapelli, M., Bragaglia, A., Bossini, D., Jordi, C., Galadí-Enríquez, D., Solano, E. 2019, *A&A*, 627, A119
3. *Finding Black Holes with Black Boxes - Using Machine Learning to Identify Globular Clusters with Black Hole Subsystems*, Askar, A., Askar, A., Pasquato, M. & Giersz, M. 2019, *MNRAS*, 485, 5345
4. *Merging black holes in young star clusters* Di Carlo, U. N., Giacobbo, N., Mapelli, M., Pasquato, M., Spera, M., Wang, L. & Haardt, F. 2019, *MNRAS*, 487, 2947
5. *Weighing the IMBH candidate CO-0.40-0.22\* in the Galactic Centre*, Ballone, A., Mapelli, M. & Pasquato, M. 2018, *MNRAS*, 480, 4684
6. *Blue Straggler Bimodality: A Brownian Motion Model* Pasquato, M., Miocchi, P. & Yoon, S.-J. 2018, *ApJ*, 867, 163
7. *Science with e-ASTROGAM. A space mission for MeV-GeV gamma-ray astrophysics*, de Angelis, A., [...], Pasquato, M., [...], & E-Astrogam Collaboration 2018, *JHEAp*, 19, 1
8. *Reversed Trend of Radial Distribution of Subpopulations in the Globular Clusters NGC 362 and NGC 6723*, Lim, D., Lee, Y.-W., Pasquato, M., Han, S.-I. & Roh, D.-G. 2016, *ApJ*, 832, 99
9. *Globular Clusters Hosting Intermediate-Mass Black Holes: No Mass-Segregation Based Candidates*, Pasquato, M., Miocchi, P., Won, S. B. & Lee, Y.-W. 2016, *ApJ*, 823, 135
10. *Merged or monolithic? Using machine-learning to reconstruct the dynamical history of simulated star clusters*, Pasquato, M. & Chung, C. 2016, *A&A*, 589, A95
11. *On the use of the number count of blue horizontal branch stars to infer the dominant building blocks of the Milky Way halo* Chung, C., Lee, Y.-W. & Pasquato, M. 2016, *MNRAS*, 456, L1
12. *Probing the Role of Dynamical Friction in Shaping the BSS Radial Distribution. I. Semi-analytical Models and Preliminary N-body Simulations*, Miocchi, P., Pasquato, M., Lanzoni, B., Ferraro, F. R., Dalessandro, E., Vesperini, E., Alessandrini, E. & Lee, Y.-W. 2015, *ApJ*, 799, 44
13. *Stellar Encounter Driven Red-giant Star Mass Loss in Globular Clusters*, Pasquato, M., de Luca, A., Raimondo, G., Carini, R., Moraghan, A., Chung, C., Brocato, E. & Lee, Y.-W. 2014, *ApJ*, 789, 28
14. *Star Count Density Profiles and Structural Parameters of 26 Galactic Globular Clusters*, Miocchi, P., Lanzoni, B., Ferraro, F.R., Dalessandro, E., Vesperini, E., Pasquato, M., Beccari, G., Pallaanca, C. & Sanna, N. 2013, *ApJ*, 774, 151
15. *Core collapse and horizontal-branch morphology in Galactic globular clusters*, Pasquato, M., Raimondo, G., Brocato, E., Chung, C., Moraghan, A. & Lee, Y.-W. 2013, *A&A*, 554, A129
16. *Dynamical age differences among coeval star clusters as revealed by blue stragglers*, Ferraro, F. R., Lanzoni, B., Dalessandro, E., Beccari, G., Pasquato, M., Miocchi, P., Rood, R. T., Sigurdsson, S., Sills, A., Vesperini, E., Mapelli, M., Contreras, R., Sanna, N. & Mucciarelli, A. 2012, *Nature*, 492, 393
17. *The Binary Fraction in the Globular Cluster M10 (NGC 6254): Comparing Core and Outer Regions* Dalessandro, E., Lanzoni, B., Beccari, G., Sollima, A., Ferraro, F. R. & Pasquato, M. 2011, *ApJ*, 743, 11
18. *The Dynamical State of the Globular Cluster M10 (NGC 6254)* Beccari, G., Pasquato, M., De Marchi, G., Dalessandro, E., Trenti, M. & Gill, M. 2010, *ApJ*, 713, 194
19. *On the fundamental line of galactic and extragalactic globular clusters*, Pasquato, M. & Bertin, G. 2010, *A&A*, 512, A35
20. *Tidal Disruption, Global Mass Function, and Structural Parameter Evolution in Star Clusters*, Trenti, M., Vesperini, E. & Pasquato, M. 2010, *ApJ*, 708, 1598
21. *Mass Segregation in NGC 2298: Limits on the Presence of an Intermediate Mass Black Hole* Pasquato, M., Trenti, M., De Marchi, G., Gill, M., Hamilton, D. P., Miller, M. C., Stiavelli, M. & van der Marel, R. P. 2009, *ApJ*, 699, 1511
22. *On the Fundamental Plane of the Galactic globular cluster system*, Pasquato, M. & Bertin, G. 2008, *A&A*, 489, 1079

### **Selected proceedings and other non-peer reviewed publications**

*Kinematics of Globular Cluster: new Perspectives of Energy Equipartition from N-body Simulations*, Kim, H., Pasquato, M. & Yoon, S.-J. 2018, *AAS Meeting Abstracts* 231, 448.02

*Building blocks of the Milky Way halo* Chung, C., Lee, Y.-W. & Pasquato, M. 2016, *MMSAI*, 87, 681.

*Detecting intermediate mass black holes in globular clusters with machine learning*, Pasquato, M. 2016, *MMSAI*, 87, 571

*Croatian Black Hole School 2010 lecture notes on IMBHs in GCs*, Pasquato, M. 2010, *astro-ph:1008.4477*

*Looking for Intermediate Mass Black Holes in GCs: the mass-segregation method*, Pasquato, M. 2010, MMSAIt, 14, 59

*What Mass Segregation in NGC 2298 Says About the Presence of an IMBH* Gill, M., Trenti, M., Pasquato, M. & Miller, M. 2009, AAS Meeting Abstracts 213, 437.03

## **Recent Conferences, talks and workshops**

**Invited:** *Ringberg Workshop on Machine Learning in Astronomy*, Ringberg, Germany 08/12/2019 – 13/12/2019 (upcoming)

*Artificial Intelligence in Astronomy*, ESO Garching, Germany 22/07/2019 – 26/07/2019. Talk title: *Image-in science out? A proof of concept with deep learning on molecular cloud simulations.*

*Galaxy Coffee*, MPIA Heidelberg, Germany 18/07/2019 - all expenses paid by MPIA as I visited Dr. Alessandra Mastrobuono Battisti and Dr. Anna Sippel from 15/07/2019 to 19/07/2019. I also gave talks at Prof. H.-W. Rix (MPIA Heidelberg director), Dr. Annalisa Pillepich, and Prof. Nadine Neumeier group meetings. Talk title: *Applying machine learning to astronomy, beyond simple classification towards automatic science*

*KASI Colloquium*, Korea Astronomy and Space Science Institute, Korea 11/06/2019. Talk title: *Cluster analysis for multiple populations in GCs – NGC 2808 as a case study*

*IAU Symposium 351 & [MODEST-19](#)*, INAF Bologna, Italy, 27/05/2019 – 31/05/2019. Poster title: *Finding IMBHs with machine learning: encouraging results*

*MODEST-18*, Santorini, Greece, 25/06/2018 – 29/06/2018. Talk title: *Finding IMBHs in Star Clusters with Machine Learning*