Alfonso Veropalumbo

MAIL CONTACTS:

CERTIFIED MAIL:

RESEARCH ACTIVITY

My main research interests and expertise revolve around Observational Cosmology. In particular, my work is focused on the statistical analysis and characterization of the Large Scale Structure (LSS) of the Universe, with the aim of investigating important long-standing problems such as *i)* the origin of the accelerated expansion of the Universe, *ii)* the nature of the Dark Energy and Dark Matter, *iii)* the validity of Einstein's General Relativity.

We have now entered the era of "Precision Cosmology", when all fundamental cosmological parameters will be measured with % accuracy. For such a reason, the statistical samples that we expect to analyze in the near future will be of unprecedented sizes. This is the case, in fact, of the European Euclid Satellite (launch expected in 2023), an international consortium of which I have been a part of since the early stages. Over the next few years, this mission will produce catalogues of tens of billions of astronomical sources, about 3 order of magnitudes larger than the largest datasets currently available.

Within the Euclid framework, I have a leading role in defining strategies to manage these datasets in the best possible way, as well as in developing statistical estimators to efficiently compress information of scientific interest. At the same time I am actively involved in the development and testing of theoretical models to extract valuable cosmological information from the LSS probes. This is supported by my long-standing experience in programming (C++ and PYTHON) and using High-Performance computing facilities.

My major achievements can be summarized as follows:

- Strong expertise in the use of the three-point correlation statistics in the analysis of spectroscopic galaxy surveys, from both an observational and a theoretical perspective.

- Leading role in the development, implementation and validation of the official code for the measurement of the three-point correlation function of the spectroscopic galaxy samples that will be produced by the ESA mission Euclid.

- The exploitation of galaxy clustering probes (two- and three- point correlation functions) in joint analysis to improve our ability in constraining relevant cosmological parameters (e.g. the growth rate of structure f and the power spectrum amplitude σ_8).

- The development (in collaboration with other developers) of a library of numerical codes (written in C++ and PYTHON) for the analysis of cosmological-relevant statistics of galaxies samples in both real and simulated catalogs. This library is publicly available and is constantly updated.

Professional experience

APRIL 2023- PRESENT:	Ricercatore a tempo determination at INAF, Osservatorio Astronomico di Brera
AUGUST 2022- DECEMBER 2022:	Research assistant at the Department of Physics, University of Milano Statale
JANUARY 2018- JULY 2022:	Postdoctoral researcher (funded by ASI, Agenzia Spaziale Italiana, for the Euclid project) at the Department of Mathematics and Physics, University of Roma Tre.
MAY 2018:	Visiting astronomer at INAF - Osservatorio Astronomico di Trieste, working with Dr. Emiliano Sefusatti
APRIL 2016- JULY 2016:	Marco Polo fellow at Max-Planck-Institut für extraterrestrische Physic, München, working in the team led by Dr. Ariel Sanchez
JANUARY 2016- DECEMBER 2017:	Postdoctoral researcher at the Department of Physics and Astronomy, University of Bologna

Education

OCTOBER 2013-NOVEMBER 2016	PhD in Astronomy **Alma Mater Studiorum - Bologna University** Thesis: "Clustering of clusters as a cosmological probe" Advisors: Prof. Lauro Moscardini, Prof. Federico Marulli
SEPTEMBER 2009-SEPTEMBER 2013	Master degree in Astrophysics and Cosmology **Alma Mater Studiorum - Bologna University** Thesis: "Clustering di ammassi di galassie con cataloghi otticamente selezionati" 109/110 Advisors: Prof. Lauro Moscardini, Prof. Federico Marulli
SEPTEMBER 2005-DECEMBER 2009	Bachelor's degree in Astronomy **Alma Mater Studiorum - Bologna University** Thesis: "La radiazione di fondo cosmico a microonde" 98/110 Advisor: Prof. Lauro Moscardini

Membership and roles in scientific projects

- Euclid Consortium for the ESA satellite mission "Euclid".

  - **Main Developer** for the Euclid Science Ground Segment: Responsible for the development of the code that will estimate the 3-point correlation function of the spectroscopic survey. Developer and tester of two-point statistic processing function (2PCF). Organizer of the weekly meeting of the development and validation teams of all PFs for galaxy clustering analyses.

  - **Leader** (with two colleagues) of the Euclid "Nonlinear clustering" work package of the Galaxy Clustering Science Working Group, in charge of coordinating the work to exploit clustering data from the Euclid satellite. In this role I am responsible for the nonlinear *reconstruction* algorithms to increase the clustering signal.

- **Member** of the Higher-orders work package. I'm responsible for the coordination of the work concerning higher-order correlation function in configuration space (3PCF). First author of the pre-launch key project paper concerning exploitation 3PCF for cosmological constraints.

- **Member** of the "Clusters of Galaxies" Science Working Group . I'm contributing to the galaxy clusters clustering analysis.

- InDark experiment (*Inflation, Dark Matter and the Large-Scale Structure of the Universe*), Istituto Nazionale di Fisica Nucleare (INFN)

  - **Member** for the INFN Section of Roma Tre.

- XXL project (The ultimate XMM-Newton Extragalactic survey)

  - **Member** in charge of measuring and modeling clustering statistics for the galaxy clusters in the survey.

Teaching and mentoring activity

- Teaching assistant for the *Cosmology* course of the Physics Master's Degree, Department of Mathematics and Physics, University of Roma Tre (AA. 2018/2019, 2019/2020).

- **Organizer and Lecturer** of the PhD course on scientific programming: "Everything you always wanted to know about Python"
  Department of Physics and Astronomy, University of Bologna, November 6-17 2017
  lesson: *How to fit in Python: a short guide*

- **Organizer and Lecturer** of the final year PhD lectures
  Department of Physics and Astronomy, University of Bologna, December 2016
  lesson: *Cosmological constraints and how to find them*

- **Co-Supervisor** of 3 PhD students:

  1. Antonio Farina, University of Genova, Department of Physics (2022-current).

  2. Massimo Guidi (Title: "Improving analysis of higher-order clustering statistics in configuration space"), University of Roma Tre, Department of Mathematics and Physics (2018-2023).

  3. Jorge Enrique García-Farieta (Title: "Constraints on alternative cosmological models from clustering and redshift-space distortions"), joint PhD program between Universidad Nacional de Colombia, Bogotá, Colombia and University of Bologna (2017-2020).

- **Co-Supervisor** of 7 Master degree students:

  1. Antonio Farina, (Title: "Un nuovo modello per la funzione di correlazione a 3 punti delle galassie e le sue anisotropie: implementazione e validazione su dati simulati"), University of Roma Tre, Master degree in Physics (2022)

  2. Annachiara Binetti, (Title: "A robust characterisation of the statistical properties of higher-order correlation functions for next generation galaxy surveys"), University of Milano Statale, Master degree in Physics (2021)

  3. Niccolò Veronesi, (Title: "Cosmological exploitation of Neural Networks: constraining Ω_M from the two point correlation function of BOSS"), Alma Mater Studiorum - University of Bologna, Master degree in Astronomy and Astrophysics (2019)

  4. Giorgio Francesco Lesci, (Title: "Constraining the cosmological parameters through the galaxy cluster mass function in the AMICO KiDS-DR3 catalogue"), Alma Mater Studiorum - University of Bologna, Master degree in Astronomy and Astrophysics (2019)

5. Lorenzo Gigante (Title: "Measuring the power spectrum normalization with cluster clustering and stacked gravitational lensing"), Alma Mater Studiorum - University of Bologna, Master degree in Astronomy and Astrophysics (2019)

6. Giovanni Aricò, (Title: "Testing the methods to reconstruct and model the Baryon Acoustic Oscillations of different tracers using N-body simulations"), Alma Mater Studiorum - University of Bologna, Master degree in Astronomy and Astrophysics (2017)

7. Matteo Gaspari, (Title: "Vincoli cosmologici delle distorsioni geometriche della funzione di correlazione"), Alma Mater Studiorum - University of Bologna, Master degree in Astronomy and Astrophysics (2015)

- **Co-Supervisor** of 3 Bachelor degree students

  1. Leonardo Coppola (Title: "Confronto tra diversi stimatori dei multipoli della funzione di correlazione a due punti"), University of Bologna, Bachelor degree in Astronomy (2018)

  2. Francesco Falo, (Title: "Nuova misura del parametro di densità della materia dalle distorsioni geometriche nel clustering delle galassie BOSS"), University of Bologna, Bachelor degree in Astronomy (2018)

  3. Jacopo Neri, (Title: "Studio della funzione di massa degli aloni di materia oscura utilizzando la libreria C++ CosmoBolognaLib"), University of Bologna, Bachelor degree in Astronomy (2017)

Other scientific activity

- **Referee** for the Monthly Notices of the Royal Astronomical Society (MNRAS)

- **Referee** for Astronomy & Astrophysics (A&A)

National and International Conferences

Invited talks

- *Euclid GC Modelling Challenge meeting*, Trieste November 13-18 2022
  Title: *Configuration space KP - Opportunities and advantages*

- *Euclid Consortium Meeting 2022*, Oslo April, 26-29 2022
  Title: *Configuration space Key Projects of work package Nonlinear and higher-order*

- *Euclid Consortium Meeting 2021*, Online meeting May, 25-28 2021
  Title: *3PCF-GC: Implementation and Validation*

- *Terzo meeting Nazionale Collaborazione Euclid*, Bologna, February, 10-12 2020
  Title: *OULE3 Clustering in configuration space*

- *3PCF processing function restyling week + Euclid Higher-Order Work Package*, Trieste, September 23 2019 - October 4 2019
  Title: *Three Point Correlation Function - state of the art and updates*

- *Euclid Consortium Meeting 2019*, Helsinki, June, 4-8 2019
  Title: *3PCF-GC: Implementation and Validation*

- *Euclid LE3-SHE Joint meeting*, Nice, January 28 - February 1 2019
  Title: *3PCF-GC: Implementation and Validation*

- *Paving the way for next generation of cosmological surveys*, Sexten, July 2-7 2018
  Title: *Comparison of 3PCF estimators*

- *Euclid consortium meeting 2018*, Bonn, June 11-14 2018
  Title: *Updates on three-point correlation function Processing function*

- *Astrophysical Probes of Fundamental Physics*, Ferrara, September 7-11 2015
  Title: *Probing distance redshift relation from baryon acoustic oscillation in the galaxy clusters correlation function*

- *School of Astrophysics "Francesco Lucchin" The chemical complexity of the Universe with ALMA - the Galactic centre* , Populonia, May 25-29 2015
  Title: *Probing large scale structure with galaxy clusters clustering*

- *InDark Bologna*, Bologna, June 19 2014
  Title: *Vincoli cosmologici dalle oscillazioni acustiche barioniche nella funzione di correlazione degli ammassi di galassie*

Contributed talks

- *Barolo Astroparticle Meeting*, Barolo September, 8-10 2021
  Title: *The benefit of a joint 2- and 3- point clustering analysis*

- *Euclid GC+WL+CG+OU-LE3 meeging*, Paris, February 1-6 2020
  Title: *Configuration space Galaxy Clustering updates*

- *Universum meeting*, Milan, April 3-5 2019
  Title: *Galaxy higher-order correlation function: Three Point correlation function*

- *CLUSTER1, a view from Italy on galaxy clusters in the 21st century*, Turin, February-March 27-1 2017
  Title: *Detection of the anisotropic baryon acoustic oscillation feature in galaxy clusters clustering*

- *BAO & RSD: dark light on obscure acronyms*, Sexten, July 4-8 2016
  Title: *Cosmological constraints from the clustering of galaxy clusters*

- *Euclid GC-LE3 2016*, Milano, January 25-27 2016
  Title: *Distance-redshift relation with baryon acoustic oscillations of galaxy clusters*

- *Euclid galaxy clusters*, Bologna, May 5-6-7 2015
  Title: *BAO distance from galaxy clusters two point correlation function - A case of study*

- *Building the Euclid cluster meeting*, Sexten, July 7-11 2014
  Title: *Cosmological constraints from BAO signature in Galaxy Clusters correlation function*

Invited colloquia and seminars

- MPA - Max Planck Institute for extraterrestrial Physics, Garching, (online meeting) June 2022
  Title: *A methodological analysis for the galaxy 3-point correlation function*

- LAM - Laboratoire d'Astrophysique de Marseille, Café Club, Marseille, (online meeting) November 2020
  Title: *Cosmological constraints from higher-order clustering analysis*

- INAF - Astronomical observatory of Trieste, Trieste, May 2018
  Title: *The three-point correlation function: how to measure and use*

- University of Bologna, Department of Physics and Astronomy, November 2016
  Title: *PhD dissertation seminar: Clustering of clusters as a cosmological probe*

- Universitäts-Sternwarte München, München, June 8 2016
  Title: *Distance-redshift relation from the BAO signal from galaxy clusters clustering*

- Max-Planck-Institut für extraterrestrische Physic, München, May 3 2016
  Title: *Cosmological constraints from baryon acoustic oscillation in the clustering of galaxy clusters*

- International School for Advanced Studies (SISSA) Trieste, March 2016
  Title: *Cosmological constraints from the clustering of galaxy clusters*

OUTREACH

- Department of Mathematics and Physics of Roma Tre, FEBRUARY 23 2018
  Seminar title: *La materia vista attraverso la gravità*

SCHOOLS

- [TensorFlow Developer Certificate in 2023](), Zero to Mastery (ZTM), Online course, 2022

- [Complete Machine Learning & Data Science Bootcamp](), Zero to Mastery (ZTM), Online course, 2022

- *Codelab PyTorch*, Italian Association for Machine Learning (IAML), Rome, MARCH 17 2018

- *TR33 Winter school*, Tonale, DECEMBER 6-11 2015.

- *Bayesian Methods for the Physical Sciences*, Bologna, APRIL 16-24 2015

PUBLICATIONS

- Twenty-five (31) *peer-reviewed* publications (four (4) as 1st author).
  Eight (8) papers under review. Three (3) papers to be submitted in the next 3 months.

- h-index: 12

- Number of citations: 386

Refereed papers:

- Euclid Collaboration , ..., **Veropalumbo, A.**, et al., 2023, Astronomy and Astrophysics, volume: 671 pages: A102
  Euclid preparation. XXVI. The Euclid Morphology Challenge: Towards structural parameters for billions of galaxies

- Euclid Collaboration , ..., **Veropalumbo, A.**, et al., 2023, Astronomy and Astrophysics, volume: 671 pages: A101
  Euclid preparation. XXV. The Euclid Morphology Challenge: Towards model-fitting photometry for billions of galaxies

- Euclid Collaboration , ..., **Veropalumbo, A.**, et al., 2023, Astronomy and Astrophysics, volume: 671 pages: A100
  Euclid preparation. XXIV. Calibration of the halo mass function in $\Lambda(\nu)CDM$ cosmologies

- Ballardini, M., ..., **Veropalumbo, A.**, et al., 2023, Physical Review D, volume: 107 pages: 043532
  New constraints on primordial features from the galaxy two-point correlation function

- Veronesi, N., ..., **Veropalumbo, A.**, et al., 2023, Astronomy and Computing, volume: 42 pages: 100692
  Artificial neural networks for galaxy clustering: Learning from the two-point correlation function of BOSS galaxies

- Rosselli, D., ..., **Veropalumbo, A.**, et al., 2023, Astronomy and Astrophysics, volume: 669 pages: A29
  Testing general relativity: New measurements of gravitational redshift in galaxy clusters

- Fumagalli, A., ..., **Veropalumbo, A.**, et al., 2022, Journal of Cosmology and Astro-Particle Physics, volume: 2022 pages: 022
  Fitting covariance matrix models to simulations

- Contarini, S., ..., **Veropalumbo, A.**, et al., 2022, Astronomy and Astrophysics, volume: 667 pages: A162
  Euclid: Cosmological forecasts from the void size function

- Sarpa, E., ..., **Veropalumbo, A.**, et al., 2022, Monthly Notices of the Royal Astronomical Society, volume: 516 pages: 231-244
  Tracing the environmental history of observed galaxies via extended fast action minimization method

- **Veropalumbo, A.**, Binetti, A., Branchini, E., el al., 2022, Journal of Cosmology and Astro-Particle Physics, volume: 2022 pages: 033
  The halo 3-point correlation function: a methodological analysis

- Lesci, G., ..., **Veropalumbo, A.**, et al., 2022, Astronomy and Astrophysics, volume: 665 pages: A100
  AMICO galaxy clusters in KiDS-DR3: Constraints on cosmological parameters and on the normalisation of the mass-richness relation from clustering

- Euclid Collaboration , ..., **Veropalumbo, A.**, et al., 2022, Astronomy and Astrophysics, volume: 664 pages: A196
  Euclid preparation. XX. The Complete Calibration of the Color-Redshift Relation survey: LBT observations and data release

- Garrel, C., ..., **Veropalumbo, A.**, et al., 2022, Astronomy and Astrophysics, volume: 663 pages: A3
  The XXL survey. XLVI. Forward cosmological analysis of the C1 cluster sample

- Lesci, G., ..., **Veropalumbo, A.**, et al., 2022, Astronomy and Astrophysics, volume: 659 pages: A88
  AMICO galaxy clusters in KiDS-DR3: Cosmological constraints from counts and stacked weak lensing

- Moresco, M., **Veropalumbo, A.**, Marulli, F., el al., 2021, Astrophysical Journal, volume: 919 pages: 144
  C^3: Cluster Clustering Cosmology. II. First Detection of the Baryon Acoustic Oscillations Peak in the Three-point Correlation Function of Galaxy Clusters

- Marulli, F., **Veropalumbo, A.**, García-Farieta, J. E., el al., 2021, Astrophysical Journal, volume: 920 pages: 13
  C^3 Cluster Clustering Cosmology I. New Constraints on the Cosmic Growth Rate at z 0.3 from Redshift-space Clustering Anisotropies

- **Veropalumbo, A.**, Sáez Casares, I., Branchini, E., el al., 2021, Monthly Notices of the Royal Astronomical Society, volume: 507 pages: 1184-1201
  A joint 2- and 3-point clustering analysis of the VIPERS PDR2 catalogue at z 1: breaking the degeneracy of cosmological parameters

- Giocoli, C., ..., **Veropalumbo, A.**, et al., 2021, Astronomy and Astrophysics, volume: 653 pages: A19
  AMICO galaxy clusters in KiDS-DR3. Cosmological constraints from large-scale stacked weak lensing profiles

- Contarini, S., ..., **Veropalumbo, A.**, et al., 2021, Monthly Notices of the Royal Astronomical Society, volume: 504 pages: 5021-5038
  Cosmic voids in modified gravity models with massive neutrinos

- Sarpa, E., **Veropalumbo, A.**, Schimd, C., el al., 2021, Monthly Notices of the Royal Astronomical Society, volume: 503 pages: 540-556
  Extended fast action minimization method: application to SDSS-DR12 combined sample

- García-Farieta, J. E., ..., **Veropalumbo, A.**, et al., 2020, Monthly Notices of the Royal Astronomical Society, volume: 494 pages: 1658-1674
  Validating the methodology for constraining the linear growth rate from clustering anisotropies

- Contarini, S., ..., **Veropalumbo, A.**, et al., 2019, Monthly Notices of the Royal Astronomical Society, volume: 488 pages: 3526-3540
  Cosmological exploitation of the size function of cosmic voids identified in the distribution of biased tracers

- García-Farieta, J. E., ..., **Veropalumbo, A.**, et al., 2019, Monthly Notices of the Royal Astronomical Society, volume: 488 pages: 1987-2000
  Clustering and redshift-space distortions in modified gravity models with massive neutrinos

- Marulli, F., **Veropalumbo, A.**, Sereno, M., el al., 2018, Astronomy and Astrophysics, volume: 620 pages: A1
  The XXL Survey. XVI. The clustering of X-ray selected galaxy clusters at z 0.3

- Sereno, M., ..., **Veropalumbo, A.**, et al., 2018, Nature Astronomy, volume: 2 pages: 744-750
  Gravitational lensing detection of an extremely dense environment around a galaxy cluster

- Pierre, M., ..., **Veropalumbo, A.**, et al., 2017, Astronomische Nachrichten, volume: 338 pages: 334-341
  The XXL survey: First results and future

- Marulli, F., **Veropalumbo, A.**, Moscardini, L., el al., 2017, Astronomy and Astrophysics, volume: 599 pages: A106
  Redshift-space distortions of galaxies, clusters, and AGN. Testing how the accuracy of growth rate measurements depends on scales and sample selections

- **Veropalumbo, A.**, Marulli, F., Moscardini, L., el al., 2016, Monthly Notices of the Royal Astronomical Society, volume: 458 pages: 1909-1920
  Measuring the distance-redshift relation with the baryon acoustic oscillations of galaxy clusters

- Marulli, F., **Veropalumbo, A.**, Moresco, M., 2016, Astronomy and Computing, volume: 14 pages: 35-42
  CosmoBolognaLib: C++ libraries for cosmological calculations

- Sereno, M., **Veropalumbo, A.**, Marulli, F., el al., 2015, Monthly Notices of the Royal Astronomical Society, volume: 449 pages: 4147-4161
  New constraints on σ_8 from a joint analysis of stacked gravitational lensing and clustering of galaxy clusters

- **Veropalumbo, A.**, Marulli, F., Moscardini, L., el al., 2014, Monthly Notices of the Royal Astronomical Society, volume: 442 pages: 3275-3283
  An improved measurement of baryon acoustic oscillations from the correlation function of galaxy clusters at $z \sim 0.3$

Under Review Papers:

- Euclid Collaboration , ..., **Veropalumbo, A.**, et al., 2023, arXiv e-prints,
  Euclid preparation. XXXII. A UV-NIR spectral atlas of compact planetary nebulae for wavelength calibration

- Casas, S., ..., **Veropalumbo, A.**, et al., 2023, arXiv e-prints,
  Euclid: Validation of the MontePython forecasting tools

- Lesci, G., **Veropalumbo, A.**, Sereno, M., el al., 2023, arXiv e-prints,
  Mass bias and cosmological constraints from Planck cluster clustering

- Euclid Collaboration , ..., **Veropalumbo, A.**, et al., 2023, arXiv e-prints,
  Euclid preparation. XXXI. Performance assessment of the NISP Red-Grism through spectroscopic simulations for the Wide and Deep surveys

- Euclid Collaboration , ..., **Veropalumbo, A.**, et al., 2023, arXiv e-prints,
  Euclid preparation. XXX. Evaluating the weak lensing cluster mass biases using the Three Hundred Project hydrodynamical simulations

- Euclid Collaboration , ..., **Veropalumbo, A.**, et al., 2023, arXiv e-prints,
  Euclid Preparation XXIX: Forecasts for 10 different higher-order weak lensing statistics

- Guidi, M., **Veropalumbo, A.**, Branchini, E., el al., 2022, arXiv e-prints,
  Modelling the next-to-leading order matter three-point correlation function using FFTLog

- Euclid Collaboration , ..., **Veropalumbo, A.**, et al., 2022, arXiv e-prints,
  Euclid preparation. XXVII. Covariance model validation for the 2-point correlation function of galaxy clusters

Papers to be submitted:

- Euclid Collaboration, **Veropalumbo, A.**, et al., in prep.,
  Euclid preparation. Three-point correlation function of the Euclid spectroscopic sample: estimators, implementation, and validation.

- Lesci G., **Veropalumbo, A.**, et al., in prep.,
  Hydrostatic bias and cosmology from Planck cluster clustering

- **Veropalumbo, A.**, et al., in prep.,
  C3- Cluster clustering cosmology. III. Cosmological constraints from joint analysis of clustering statistics of a sample of galaxy clusters

PhD Thesis:

- *Clustering of Clusters as a Cosmological Probe*,
  November 2016, Alma Mater Studiorum, Università di Bologna

Technical Reports and Project Documents for ESA satellite Euclid:

- "Euclid SGS LE3 Software Design Document" EUCL-CNE-DDD-8-012. 2021. Mantainer

- "Euclid SGS LE3 Processing Function Requirements Specification Document" EUCL-EC-RS-8-002. 2016. Contributor

- "Euclid SGS LE3 Validation Plan & Software Tests Specifications" EUCL-CEA-PL-8-013. 2021. Contributor

- "Euclid Scientific Ground Segment Data Processing Technical Budget" EUCL-CNE-RP-8-001. 2018. Contributor

COMPUTER SKILLS

HIGH LEVEL LANGUAGES:	Excellent knowledge of object-oriented programming, (PYTHON, C, C++)
OPERATING SYSTEM:	LINUX/UNIX, OS, Windows
LIBRARIES:	MPI, OpenMP, CFITSIO, EIGEN, GSL, FFTW, ET AL.
DEVELOPMENT TOOLS:	GNU BINUTILS, GIT, VALGRIND, DOXYGEN, SPHINX.
VISUALIZATION:	GRAPHVIZ, MATPLOTLIB, GNUPLOT, JUPYTER NOTEBOOK.
ASTRONOMICAL SOFTWARES:	TOPCAT, IRAF
MACHINE LEARNING TOOLS:	scikit-learn, TENSORFLOW, KERAS, PYTORCH

Languages

ITALIAN:	mother tongue
ENGLISH:	good general knowledge

Date: May 8, 2023   Signature: