

## **ALLEGATO B**

UNIVERSITÀ DEGLI STUDI DI MILANO

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## **Paolo Giordano** **CURRICULUM VITAE**

(N.B. IL CURRICULUM NON DEVE ECCEDERE LE 30 PAGINE E DEVE CONTENERE GLI ELEMENTI CHE IL CANDIDATO RITIENE UTILI AI FINI DELLA VALUTAZIONE.

LE VOCI INSERITE NEL FACSIMILE SONO A TITOLO PURAMENTE ESEMPLIFICATIVO E POSSONO ESSERE SOSTITUITE, MODIFICATE O INTEGRATE)

### **INFORMAZIONI PERSONALI (NON INSERIRE INDIRIZZO PRIVATO E TELEFONO FISSO O CELLULARE)**

COGNOME	GIORDANO
NOME	PAOLO
DATA DI NASCITA	27, MARZO, 1966

Data

17 Gennaio 2024

Luogo

Vienna (AT)

# Curriculum vitae

## Address

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Present position: Project leader (senior researcher), Faculty of Mathematics, University of Vienna

## Present research interests

- Nonlinear theories of generalized functions
- Non-Archimedean mathematical analysis (but **no one** of my papers is in non-standard analysis)
- Foundation of infinite-dimensional analysis and differential geometry
- Mathematical theories of complex systems
- Transportation modeling and related decision support systems
- Mathematical modeling of urban growth and housing markets

At present, my research projects have been funded for about **2.56 million of Euro** from 2002 to 2023, and I have about **1.3 million Euro in three different FWF projects** under evaluation (see below, Sec. “Collaborazione con l’Università di Vienna”, pag. 14).

## Education

- *University of Bonn*, Ph.D. in Mathematics awarded in December 2009. In the thesis we use methods of non-Archimedean analysis to study non-normable infinite dimensional spaces. Title: “Fermat reals: nilpotent infinitesimals and infinite dimensional spaces”. Supervisor Prof. S. Albeverio. Degree "Very good + (0.7)"; overall grade of the promotion "magna cum laude".
- *Università degli Studi di Milano*, M.Sc. in Mathematics. Title: “A model of extended line with actual infinitesimals”. Supervisor Prof. L. Galgani. Degree 110/110 Cum laude.
- *Habilitation* (venia docendi in Mathematics), University of Vienna, Austria, November 2019. External habilitation committee: V. Benci (University of Pisa), C. Garetto (Loughborough University), I.V. Melnikova (Ural Federal University).

## Academic experiences

### Main research activities as principal investigator and awards

- August 2020 - July 2024: project leader of FWF stand alone research project *Functional analysis of infinite bounded operators*. Co-applicants and collaborators of the project are Prof. M. Kunzinger (Dep. of Mathematics, University of Vienna, Austria) and Prof. H. Vernaëve (Dep. of Mathematics, University of Ghent, Belgium).
  - The three years project aims at showing the flexibility of a non-Archimedean framework in strongly extending classical results of functional analysis using a simpler setting, and in applications to singular PDE and QM.
  - In this project I am the Ph.D. supervisor of D.E. Kebiche at the University of Vienna.
  - The project funding is of 407'000 Euro.
- February 2021 - January 2024: project leader of FWF (Austrian Fund for the Promotion of Scientific Research) stand alone research project *Applications of generalized smooth functions*. Co-applicant and collaborator of the project is Prof. M. Kunzinger (Dep. of Mathematics, University of Vienna, Austria).
  - In the three years project we study the Pontryagin's maximum principle of optimal control and numerical visualization tools for generalized smooth functions.
  - In this project I am the Ph.D. supervisor of K. Islami and supervisor of post-doc A. Bryzgalow at the University of Vienna.
  - The project funding is of 210'000 Euro.
- August 2021 - July 2024: project leader of FWF stand alone research project *Fourier transforms and Cauchy-Kowalevski theorem for generalized smooth functions*. Co-applicant and collaborator of the project is Prof. M. Kunzinger (Dep. of Mathematics, University of Vienna, Austria).
  - In the one year project we finish the study of hyperfinite and classical Fourier transforms and prove the Cauchy-Kowalevski theorem for generalized smooth functions and a large class of Schwartz distributions.
  - The project funding is of 82'000 Euro and aims to complete the PhD studies of A. Mukhammadiev and D. Tiwari.
- October 2021 - September 2024: PhD supervisor of S. Nugraheni at the Faculty of Mathematics of the University of Vienna in the framework of Ernst Mach Grant - ASEA-UNINET scholarship *Solving PDE with infinite bounded operators* (40'000 Euro). Co-supervisor Prof. M. Kunzinger.
- August 2017 - July 2021: project leader of FWF stand alone research project *Hyperfinite methods for generalized smooth functions*, Wolfgang Pauli Institute, Vienna. Co-applicant and collaborator of the project is Prof. M. Kunzinger (Dep. of Mathematics, University of Vienna, Austria).
  - The three years project concerned the study of hyperfinite methods for generalized functions, the proof of general theorems for the solutions of singular nonlinear PDE and the study of a Fourier transform that applies to every generalized function (not only to those of tempered type).
  - In this project I was the Ph.D. supervisor of A. Mukhammadiev and D. Tiwari at the University of Vienna.
  - The project funding is of 397'000 Euro.
- December 2012 - May 2016: project leader of FWF stand alone research project *Analysis and Geometry based on generalized numbers*, Dep. of Mathematics, University of Vienna. Co-applicant and collaborator of the project is Prof. M. Kunzinger (Dep. of Mathematics, University of Vienna, Austria).
  - The four years project concerned the development of a new theory of generalized functions as set-theoretical maps on a non-Archimedean ring of generalized numbers. These generalized functions extend Schwartz distributions but are closed with respect to composition.
  - The project funding was of 321'000 Euro.

- June 2013 - May 2016: project leader of FWF stand alone research project *Non-Archimedean Geometry and Analysis*, Dep. of Mathematics, University of Vienna (AT). Co-applicants of the project: Prof. M. Kunzinger (Dep. of Mathematics, University of Vienna, Austria) and Prof. V. Benci (Dep. of Mathematics, University of Pisa, Italy).
  - The three years project concerned the development of the theory of Fermat reals for the study of non-normable infinite dimensional spaces and its applications, as well as the relationships with other branches of Non-Archimedean analysis.
  - In this project I supervised two senior post-docs: L. Luperi Baglini (at present, he is associate professor at the University of Milan) and E. Wu (at present, he is professor at Shantou University, CN).
  - The project funding was of 349'000 Euro.
- October 2010 - September 2012: project leader of the research project *Nilpotent Infinitesimals and Generalized Functions*, Dep. of Mathematics, University of Vienna, supported by an FWF Lise Meitner grant. Co-applicant of the project: Prof. M. Kunzinger (Dep. of Mathematics, University of Vienna, Austria).
  - The project concerned the application of non-Archimedean analysis to generalized functions.
  - The project funding was of 115'200 Euro.
- June 2006 - July 2009: director, together with A. Vancheri, of the research project *Supporto alle decisioni basato su modello matematico per il problema dei "grandi generatori di traffico"*, Dep. of Mathematics, University of Italian Switzerland.
  - The project funding from Canton Ticino's administration was of 89'577 Euro.
- February 2005 - June 2009: director of the European Commission research project (Marie Curie reintegration grant MERG-CT-2005-014906) *Continuum State Cellular Automata and Random Equations*, Dep. of Mathematics, University of Italian Switzerland.
  - The project funding was of 40'000 Euro.
- March 2002 - February 2004: Marie Curie individual fellowship of the European Commission HPMF-CT-2002-01792, *A new approach to differential geometry of spaces of mappings and its applications*, Institute of Applied Mathematics, University of Bonn.
  - The project funding was of 140'200 Euro.
- June 2001 - November 2001: DAAD (Deutscher Akademischer Austausch Dienst, German academic exchange service) fellowship at the Dep. of Mathematics of the University of Bonn.

## Research activities as co-director

- May 2007 - December 2009: co-director of the SNSF research project *Effects of Neighborhood Choice on Housing Markets: a model based on the interaction between microsimulations and revealed/stated preference modeling*, Dep. of Mathematics, Accademia di architettura, University of Italian Switzerland (CH). Director of the project: Prof. Dr. R. Maggi, Istituto di Ricerche Economiche, University of Italian Switzerland.
  - In this context I was PhD co-advisor of M. Esmaeili.
  - The project funding was of 241'650 Chf.
- September 2006 - December 2009: co-director of the Swiss National Science Foundation research project *Mathematical modeling of on-line communities*, Dep. of Mathematics, University of Italian Switzerland. Director of the project: Prof. Dr. A. Vancheri.
  - In this context I was PhD co-advisor of G.L. Ciampaglia (at present, he is professor at University of South Florida).
  - The project funding was of 120'800 Chf.

## Main invited lectures

1. Plenary speaker at the conference 9th SEAMS-UGM 2023, International Conference on Mathematics and Its Applications. Title: “Artificial general intelligence based on mathematical theory of complex systems”.
2. Invited speaker at the conference 9th SEAMS-UGM 2023, International Conference on Mathematics and Its Applications. Title: “Generalized smooth functions for nonlinear singular PDE”.
3. Plenary speaker at the conference “Generalized Functions 2022”, September 2022. Title: “Consequences of neglecting infinitesimals (and infinities) from mathematics”.
4. Invited speaker at the “Seminario di Analisi Matematica”, Dipartimento di Matematica *Federigo Enriques*, Università degli Studi di Milano, January 2020. Title: “A Grothendieck topos of generalized functions”.
5. Invited speaker at the “Seminario di Logica Matematica”, Dipartimento di Matematica *Federigo Enriques*, Università degli Studi di Milano, January 2020. Title: “A universal mathematical theory of complex systems”.
6. Invited speaker at the conference “Souriau 2019”, May 27-31 2019, Paris-Diderot University; title: “The Grothendieck topos of generalized functions”.
7. Invited talk at Institute for Scientific Interchange (ISI), Turin, 30 November 2016, “MaTryCS - A mathematical theory of complex systems”.
8. Invited plenary lecture at the conference “Algebra, Geometry and Mathematical Physics”, Brno, Czech Republic, September 12-14, 2012; title: “Infinitesimal without Logic”.
9. Invited talks at the University of Pisa, January 21, 2015: title: “Generalized smooth functions”, “Fermat reals”.
10. Invited opening talk at the workshop “Workshop on diffeologies etc”, Aix en Provence, France, June 25 - 27, 2014. Title: “Theory of infinitely near points in smooth manifolds: the Fermat functor”.

## Reviewing activities

I am reviewer for: Acta Mathematica, Transaction of the American Mathematical Society, Proceedings of the American Mathematical Society, American Mathematical Monthly, Journal of the London Mathematical Society, Nonlinearity, Monatshefte für Mathematik, Asymptotic analysis, Topology proceedings, Arabian Journal of Mathematics, Commentationes Mathematicae Universitatis Carolinae, Novi Sad Journal of Mathematics, International Journal of Applied Mathematics and Computer Science, Advances in Complex Systems, Environmental modelling and software, Physics Letters A.

## Teaching activities

- 2021 - present: Ph.D. supervisor of 3 students and 1 post-doc at the Faculty of Mathematics, University of Vienna, AT.
- 2018 - 2022: Ph.D. supervisor of 2 students at the Faculty of Mathematics, University of Vienna, AT.
- 2012 - 2015: research supervisor of 2 senior post-docs, Faculty of Mathematics, University of Vienna, AT.
- 2010 - 2014: teaching of the 1<sup>st</sup> year master course *Metodi quantitativi per l'analisi del territorio*, Accademia di architettura di Mendrisio, University of Italian Switzerland.
- 2009: co-teaching of the 1<sup>st</sup> year master course *Metodi quantitativi per l'analisi del territorio*, Accademia di architettura di Mendrisio, University of Italian Switzerland, together with A. Vancheri.
- 2006 - 2009: Ph.D. co-advisor of M. Esmaeili and G.L. Ciampaglia.

- 2004 - 2005: lecturer of the courses MATLAB I and Probability I for the researchers of the SNSF research project *Mathematical modeling of urban growth processes: a cellular automata and statistical mechanical based approach*.
- 1999: lecturer of the course *Programming language MATLAB* at the Politecnico di Milano, Italy, Mechanics and Aeronautics Engineering courses.
- 1999 - 2003: teaching assistant, Dep. of Mathematics, Università della Svizzera Italiana.
- 1997 - 1999: lecturer of the 1st year course of Mathematics, Dep. of Economics of the II facoltà di Economia di Novara, Italy.

## Publications

In my publications, where my name appears as the last one, I proposed and supervised the majority of ideas as well as actively contributed in developing them.

All the following publications have been peer-reviewed and listed in ISI Web of Science, Scopus or DOAJ. Non indexed publications are: 18, 21, 22, 31. Please, note that **no one** of my articles is about non-standard analysis. For the links to these publications, see my home page: [www.mat.univie.ac.at/~giordap7/](http://www.mat.univie.ac.at/~giordap7/)

1. Nugraheni, S., Giordano, P., Generalized holomorphich functions: sketches of a new theory. To appear in the volume “Women is Analysis and PDE”, series “Research Perspectives Ghent Analysis and PDE Center”, Birkhäuser, 2023.
2. Mukhammadiev, A., Tiwari, D., Giordano, P., A Fourier transform for all generalized functions, 2023. Accepted in *Dissertationes Mathematicae*, 2023.
3. Tiwari, D., Mukhammadiev, A., Giordano, P., Hyper-power series and generalized real analytic functions, 2023. *Monatshefte für Mathematik*.  
<https://doi.org/10.1007/s00605-023-01849-8>.
4. Tiwari, D., Giordano, P., Hyperseries of Colombeau generalized numbers, 2021. *Monatshefte für Mathematik* 197, 193–223 (2022).  
<https://doi.org/10.1007/s00605-021-01647-0>
5. Gastão, S.F., Giordano, P., Bryzgalov, A., Lazo, M.J., Calculus of variations and optimal control for generalized functions. *Nonlinear Analysis*, Vol. 216, 2022.  
<https://doi.org/10.1016/j.na.2021.112718>
6. Mukhammadiev A., Tiwari D., Apaaboah G., Giordano P., Supremum, infimum and hyperlimits in the non-Archimedean ring of Colombeau generalized numbers. *Monatshefte für Mathematik*, 2021.  
<https://doi.org/10.1007/s00605-021-01590-0>
7. Giordano P., Kunzinger M., A convenient notion of compact set for generalized functions. *Proceedings of the Edinburgh Mathematical Society*, Volume 61, Issue 1 February 2018 , pp. 57-92, 2018. DOI: <https://doi.org/10.1017/S0013091516000559>
8. Lecke A., Luperi Baglini L., Giordano P., The classical theory of calculus of variations for generalized functions. *Advances in Nonlinear Analysis*, Vol. 8, Issue 1, 2017. DOI: <https://doi.org/10.1515/anona-2017-0150>.
9. Luperi Baglini L., Giordano P., The category of Colombeau algebras. *Monatshefte für Mathematik*, 2017, Volume 182, Issue 3, pp. 649–674, 2017. DOI <https://doi.org/10.1007/s00605-016-0990-1>.
10. Giordano P., Kunzinger M., Inverse Function Theorems for Generalized Smooth Functions. In: Oberguggenberger M., Toft J., Vindas J., Wahlberg P. (eds) *Generalized Functions and Fourier Analysis. Operator Theory: Advances and Applications*, vol 260. Birkhäuser, Cham, 2017. DOI: [https://doi.org/10.1007/978-3-319-51911-1\\_7](https://doi.org/10.1007/978-3-319-51911-1_7)

11. Giordano P., Wu E., Calculus in the ring of Fermat reals. Part I: Integral calculus. *Advances in Mathematics*, Vol. 289, pp. 888–927, 2016. DOI: <https://doi.org/10.1016/j.aim.2015.11.021>
12. Giordano P., Luperi Baglini L., Asymptotic gauges: Generalization of Colombeau type algebras. *Math. Nachr.* Volume 289, Issue 2-3, pages 247–274, 2016. DOI: <https://doi.org/10.1002/mana.201400278>
13. Giordano P., Nigsch E., Unifying order structures for Colombeau algebras. *Math. Nachr.* 288, No. 11–12, 1286–1302, 2015. DOI: <https://doi.org/10.1002/mana.201400277>
14. Giordano P., Wu E., Categorical framework for generalized functions. *Arabian Journal of Mathematics*, Volume 4, Issue 4, pp 301–328, 2015. DOI: <https://doi.org/10.1007/s40065-015-0126-9>
15. Giordano P., Kunzinger M., Vernaev H., Strongly internal sets and generalized smooth functions. *Journal of Mathematical Analysis and Applications*, volume 422, issue 1, 2015, pp. 56–71. DOI: <https://doi.org/10.1016/j.jmaa.2014.08.036>
16. Vancheri A., Giordano P., Andrey D., Fuzzy logic based modeling of traffic flows induced by regional shopping malls. *Advances in Complex Systems* Vol. 17, N. 3 & 4, 2014, (39 pages). DOI: <https://doi.org/10.1142/S0219525914500179>
17. Giordano P., Caputo P., Vancheri A., Fuzzy evaluation of heterogeneous quantities: measuring urban ecological efficiency. *Ecological Modelling* 288, 2014, pp. 112–126. DOI: <https://doi.org/10.1016/j.ecolmodel.2014.06.001>
18. Giordano P., Which numbers simplify your problem?. Invited contribution for the volume: *Mathematics without boundaries: surveys in pure mathematics*. T. Rassias and P. Pardalos (Eds.), Springer 2014, XIII, pp. 181–220. See [www.springer.com/mathematics/analysis/book/978-1-4939-1105-9](http://www.springer.com/mathematics/analysis/book/978-1-4939-1105-9)
19. Giordano P., Fermat reals: infinitesimals without Logic. *Miskolc Mathematical Notes*, Vol. 14 (2013), No. 2, pp. 407–422. DOI: <https://doi.org/10.18514/MMN.2013.902>
20. Giordano P., Kunzinger M., New topologies on Colombeau generalized numbers and the Fermat-Reyes theorem. *Journal of Mathematical Analysis and Applications*, Vol. 399, Issue 1, pp. 229–238, 2013. DOI: <https://doi.org/10.1016/j.jmaa.2012.10.005>
21. Vancheri A., Giordano P., Caputo P., A 2009 European index of urban metabolism efficiency, in *A new urban metabolism*, J.A. Acebillo, A. Martinelli (eds), Actar, 2013. See [searchworks.stanford.edu/view/10196912](http://searchworks.stanford.edu/view/10196912)
22. Esmaeili M., Vancheri A., Giordano P., Modeling housing market dynamics using a multi-agent simulation of participants' cognitive behavior. In L. Diappi (editor) *Emergent phenomena in housing markets: gentrification, housing search, polarization*. Physica-Verlag, 2012, pp. 43–83. See [www.springer.com/economics/regional+science/book/978-3-7908-2863-4](http://www.springer.com/economics/regional+science/book/978-3-7908-2863-4)
23. Giordano P., Kunzinger M., Topological and algebraic structures on the ring of Fermat reals. *Israel Journal of Mathematics*, January 2013, Volume 193, Issue 1, pp. 459–505. DOI: <https://doi.org/10.1007/s11856-012-0079-z>
24. Giordano P., Fermat-Reyes method in the ring of Fermat reals. *Advances in Mathematics* 228, pp. 862–893, 2011. DOI: <https://doi.org/10.1016/j.aim.2011.06.008>
25. Giordano P., Infinite dimensional spaces and Cartesian closedness. *Journal of Mathematical Physics, Analysis, Geometry*, vol. 7, No. 3, pp. 225–284, 2011. See [www.mathnet.ru/php/archive.phtml?wshow=paper&jrnid=jmag&paperid=514&option\\_lang=eng](http://www.mathnet.ru/php/archive.phtml?wshow=paper&jrnid=jmag&paperid=514&option_lang=eng)
26. Giordano P., The ring of fermat reals, *Advances in Mathematics* 225 (2010), pp. 2050–2075. DOI: <https://doi.org/10.1016/j.aim.2010.04.010>
27. Giordano P., Infinitesimals without logic, *Russian Journal of Mathematical Physics*, 17(2), pp.159–191, 2010. DOI: <https://doi.org/10.1134/S1061920810020032>

28. Esmacili M., Vancheri A., Giordano P., Mathematical and Computational Modeling of Housing Market Dynamics. Systems Conference, 2010 4th Annual IEEE, pp. 29 - 34, 2010.  
DOI: <https://doi.org/10.1109/SYSTEMS.2010.5482468>
29. Vancheri A., Giordano P., Andrey D., Albeverio S., A model for urban growth processes with continuous state cellular automata, multi-agents and related differential equation. Part 1: Theory. Environment and Planning B: Planning and Design 2008, volume 35, issue 4, pages 723-739. DOI: <https://doi.org/10.1068/b31080a>
30. Vancheri A., Andrey D., Giordano P., Albeverio S., A model for urban growth processes with continuous state cellular automata, multi-agents and related differential equation. Part 2: Computer Simulations. Environment and Planning B: Planning and Design 2008, volume 35, pages 863-880. DOI: <https://doi.org/10.1068/b31080b>
31. Albeverio S., Giordano P., Minazzi F., Introduzione a Matematica e Filosofia, il problema dei fondamenti oggi. Atti del convegno di Mendrisio, 16 novembre 2001. PRISTEM/Storia 14-15, 2006. See [matematica-old.unibocconi.it/publicazioni/notestoria14-15.htm](http://matematica-old.unibocconi.it/publicazioni/notestoria14-15.htm)
32. Giordano P., Infinitesimal Differential Geometry, Acta Mathematica Universitatis Comenianae, 2004, LXIII, 2, pp. 235-278. See [www.emis.de/journals/AMUC/\\_vol-73/\\_no\\_2/\\_giordano/giordano.html](http://www.emis.de/journals/AMUC/_vol-73/_no_2/_giordano/giordano.html)
33. Giordano P., Nilpotent infinitesimals and synthetic differential geometry in classical logic. In Berger, Oswald, and Schuster, editors, "Reuniting the Antipodes - Constructive and Nonstandard Views of the Continuum". Peer reviewed conference paper: see proceedings of the Symposium in Venice, May 17-22, 1999. Vol. 306 of Synthese Library, Kluwer Academic Publishers, Dordrecht, 2001, pp. 75-92. DOI 10.1007/978-94-015-9757-9\_7
34. Bussotti F., Ferretti M., Giordano P. and Mazzali C., A synthetic index to estimate tree condition in the Permanent Monitoring Plots of the CONECOFOR programme, Annali dell'Istituto Sperimentale per la Selvicoltura, volume 30, pp. 67-72, 1999.  
See [www.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.c8dc2e20c6ec76375728/P/BLOB%3AID%3D1017](http://www.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.c8dc2e20c6ec76375728/P/BLOB%3AID%3D1017)
35. Ferretti M., Giordano P. and Mazzali C., Methods of analysis of the Integrated and Combined (I&C) evaluation system. Annali dell'Istituto Sperimentale per la Selvicoltura, volume 30, pp. 33-42, 1999.  
See [www.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.c8dc2e20c6ec76375728/P/BLOB%3AID%3D1017](http://www.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.c8dc2e20c6ec76375728/P/BLOB%3AID%3D1017)
36. Ferretti M., Giordano P. and Mazzali C., Definitions of risk, status and changes in the Permanent Monitoring Plots in Italy – A preliminary attempt. Annali dell'Istituto Sperimentale per la Selvicoltura, volume 30, pp. 135-149, 1999.  
See [www.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.c8dc2e20c6ec76375728/P/BLOB%3AID%3D1017](http://www.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.c8dc2e20c6ec76375728/P/BLOB%3AID%3D1017)
37. Ferretti M., F. Alianiello, S. Allavena, T. Amoriello, E. Amorini, F.A. Biondi, A. Buffoni, F. Bussotti, G. Campetella, R. Canullo, A. Costantini, A. Cutini, G. Fabbio, C. Ferrari, P. Giordano, E. Magnani, A. Marchetto, G. Matteucci, C. Mazzali, G. Mecella, R. Mosello, R. Nibbi, B. Petriccione, E. Pompei, F. Riguzzi, G. Scarascia-Mugnozza, M. Tita, The Integrated and Combined (I&C) Evaluation System – Achievements, Problems and Perspectives. Annali dell'Istituto Sperimentale per la Selvicoltura, volume 30, pp. 151-156, 1999.  
See [www.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.c8dc2e20c6ec76375728/P/BLOB%3AID%3D1017](http://www.corpoforestale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/D.c8dc2e20c6ec76375728/P/BLOB%3AID%3D1017)

## Books

1. Albeverio S., Andrey D., Giordano P., Vancheri A. (Eds.) (2007) *The Dynamics of Complex Urban Systems. An Interdisciplinary Approach*. Springer, Berlin Heidelberg New York. Proceedings of the conference held in Monte Verità (Ascona) 4-6 November 2004, 350 pages, Physica-Verlag Heidelberg.



2. Albeverio S., Giordano P., Vancheri A. (2021) *Metodi e modelli matematici per le dinamiche urbane*. Unitext series of Springer Verlag Italy.

## Contributions to conferences and invited lectures

1. Invited speaker at the online series “Diffeology seminars”. Title: “How to deal with continuous functions as if they were smooth: generalized smooth functions”, 2023. See <https://diffeology.net/index.php/seminar/>
2. Speaker at the “Seminari di Matematica Applicata”, Dipartimento di Matematica, Università di Pavia, April 2022; title: “The Picard-Lindelöf theorem for smooth singular PDE”
3. Speaker at the conference “ISAAC 2021”, August 2021, Ghent University; title: “The Picard-Lindelöf theorem for smooth PDE”.
4. Speaker at the conference “GF 2020”, September 2020, Ghent University; title: “Recent results in generalized smooth functions theory”.
5. Invited speaker at the “Seminario di Analisi Matematica”, Dipartimento di Matematica *Federigo Enriques*, Università degli Studi di Milano, January 2020.
6. Invited speaker at the “Seminario di Logica Matematica”, Dipartimento di Matematica *Federigo Enriques*, Università degli Studi di Milano, January 2020.
7. Invited speaker at the conference “Souriau 2019”, May 27-31 2019, Paris-Diderot University; title: “The Grothendieck topos of generalized functions”.
8. Speaker at the conference “MLFTA 18”, University of Torino, July 2018; title: “The Grothendieck topos of generalized functions”.
9. Speaker at the conference “ISAAC 2017”, Linnaeus University (Sweden), August 2017; title: “A Picard-Lindelöf theorem for singular nonlinear PDE”.
10. Invited talk at Institute for Scientific Interchange (ISI), Turin, 30 November 2016, “MaTryCS - A mathematical theory of complex systems”.
11. Speaker at the workshop WING 2016, June 29 – July 3, 2016, University of Innsbruck, Austria. Title: “Some ideas on generalized smooth functions”.
12. Invited speaker at the “Mini-workshop sulle matematiche non-Archimedee”, University of Pisa, January 22, 2015; title: “Reali di Fermat”.
13. Invited talk at the University of Pisa, January 21, 2015; title: “Funzioni lisce generalizzate”.
14. Speaker at the conference “Generalized Functions 2014”, Southampton, UK, September 8 - 12, 2014. Title: “Unifying order structures for Colombeau algebras”.
15. Invited talk at the conference “13th International Conference on p-adic Functional Analysis”, Paderborn, Germany, August 12–16, 2014. Title: “Theory of infinitely near points in smooth manifolds: the Fermat functor”.
16. Invited opening talk at the workshop “Workshop on diffeologies etc”, Aix en Provence, France, June 25 - 27, 2014. Title: “Theory of infinitely near points in smooth manifolds: the Fermat functor”.
17. Speaker at the conference “18th ÖMG Congress and Annual DMV Meeting”, Innsbruck, September 23 – 27, 2013; title: “Theory of infinitely near points in smooth manifolds: the Fermat functor”.
18. Invited speaker at the University of Bonn, May 28, 2013; title: “Generalized functions as a category of smooth set-theoretical maps”.

19. Speaker at the conference “9th International ISAAC Congress”, August 5-9, 2013, Krakow, Poland; title: “Generalized functions as a category of smooth set-theoretical maps”.
20. Speaker at the conference “XXII St. Petersburg Summer Meeting in Mathematical Analysis”, St. Petersburg, Russia, June 25-30, 2013; title: “Generalized functions as a category of smooth set-theoretical maps”.
21. Invited plenary lecture at the conference “Algebra, Geometry and Mathematical Physics”, Brno, Czech Republic, September 12-14, 2012; title: “Infinitesimal without Logic”.
22. Speaker at the conference “PDE, Microlocal and Time-frequency Analysis”, Novi Sad, Serbia, September 3-8, 2012; title: “Generalized functions as a category of smooth set-theoretical maps”.
23. Speaker at the conference “Mathematical Logic and General Topology”, Novi Sad, Serbia, September 5-8, 2012; title: “Ultrafilter sets smaller than their complements”.
24. Speaker at the conference “XVII Geometrical Seminar”, Zlatibor, Serbia, September 3-8, 2012; title: “Theory of infinitely near points in smooth manifolds: the Fermat functor”.
25. Invited speaker at the symposium "Theories of Continua: Logical and Philosophical Reflections" as part of the 14th *Congress of Logic, Methodology and Philosophy of Science* in Nancy, France, July 2011; title: “Knowledge comes from the dialectic between two worlds: the case of Fermat reals”.
26. Speaker at the conference “Generalized functions 2011”, Fort de France, Martinique, April 2011; Title: “Interacting worlds: transfer of ideas from Fermat ring to Colombeau’s ring”.
27. Invited lecturer at the course “Metodi matematici per la progettazione” of Prof. E. Marchetti, Polytechnic of Milan. Title: “Evidence based design: ovvero le interazioni tra matematica e urbanistica”. Milan, December 2009.
28. Speaker at the conference “Logic and Mathematics”, York, August 2009; title: “Fermat reals: An example of dialogue between formalism and intuition”.
29. Invited speaker at the colloquium of the Interdiziplinäre Zentrum für Komplexe Systeme (IZKS, Bonn, Germany), June 2009; title: “Dynamics of cities: A mathematical planning tool for shopping malls”.
30. Invited speaker at the conference “INPUT08”, Lecco, March 2009; title: “Planning of a complex system: the problem of big traffic generators”.
31. Invited lecturer at the course “Metodi matematici per la progettazione” of Prof. E. Marchetti, Polytechnic of Milan. Title: “Matematica dei sistemi complessi e decisioni in urbanistica”. Milan, November 2008.
32. Invited speaker at the conference “S4 modeling tour”, Milan, April 2008; title: “Interaction Spaces: a language for the collaboration between MAS and hard sciences”.
33. Speaker at the conference “Innovation for Sustainable Production 2008”, i-SUP 2008, April, 22-25, 2008, Bruges, Belgium; title: “A mathematical model of complex mobility patterns for big traffic generators competition and sustainability”.
34. Invited speaker at the conference VIIth AESOP workshop, Thematic Group on Planning and Complexity, Milan, 22 - 23 February 2008; title: “Interaction Spaces Theory: modeling complex systems with the details of MAS and the mathematics of Synergetics”.
35. Invited lecturer at the course “Metodi matematici per la progettazione” of Prof. M.S. Vianello, Polytechnic of Milan. Title: “Supporto alle decisioni in urbanistica mediante modello matematico”. Milan, November 2006.
36. Invited speaker at the conference “Systemic approach and microscale urban complexity”, February 2006; title: “Interaction Spaces: cellular automata + multi-agents models with sound mathematical properties”.

37. Invited speaker at the conference “Herbsttagung Schweizerische Mathematische Gesellschaft”, Lugano, 22-24 September 2005; title: “A mathematical model of urban systems”.
38. Speaker at the conference “Computer in Urban Planning and Urban Management”, London, July 2005; title: “Continuous valued cellular automata and decision processes of agents for urban dynamics”.
39. Invited speaker at the Bonn International Graduate School seminars, July 2003; title: “Infinitesimal Differential Geometry”.
40. Invited speaker at the conference “I numeri infinitesimi – Aspetti storici, filosofici, scientifici e didattici di una grande controversia”, Pisa November 2002; title: “Infinitesimi nilpotenti: metodo e creatività”.
41. Invited speaker at the Institute of Applied Mathematics of Bonn in October 2002, title “Differential geometry in spaces of mappings”.
42. Invited speaker at the conference “NSA 2002”, satellite conference of the meeting UMI-AMS, Pisa, June 2002. Title “‘Standard infinitesimals’: actual nilpotent infinitesimals in standard analysis”.
43. Invited speaker at the University of Trento (I), March 2001. Title: “Geometria Differenziale con infinitesimi nilpotenti”.
44. Speaker at the conference “Quantitative methods for applied sciences” Siena, June 2000. Title: “Quantifying changes in ecosystem status as measured by multiple indicators”.
45. Invited speaker at the “Workshop multitematico in Fisica e Matematica”, 9th September 2000, CERFIM Locarno (CH). Title: “Nilpotent infinitesimals in differential geometry, analysis and physics”.
46. Invited speaker at the Institute of Applied Mathematics of Bonn in June 1999, title “Nilpotent infinitesimals in infinite dimensional differential geometry”.
47. Speaker at the conference “Reuniting the antipodes: constructive and non-standard views of the continuum”, Venice, 17-23 May 1999, title “Nilpotent infinitesimals and Synthetic Differential Geometry in classical logic”.
48. Speaker at the conference “Non-standard Analysis and Related Methods” (Oberwolfach, Germany), February 1999, title “An extension of the hyperreals with nilpotent infinitesimals”.

## Description of the presented articles

The main AMS classifications of my papers are in *functional analysis* and in *global analysis, analysis on manifolds*.

### 1. Mukhammadiev, Tiwari, Giordano - A Fourier transform for all generalized functions

**Journal:** Dissertationes Mathematicae

**IF 2022:** 1.45

**AMS classification:** Fourier and Fourier-Stieltjes transforms and other transforms of Fourier type, Integral transforms in distribution spaces, Functional analysis, Generalized functions for nonlinear analysis.

**Description:** Using the existence of infinite numbers in the non-Archimedean ring of Robinson-Colombeau, we define the *hyperfinite Fourier transform*. The space of generalized functions we consider is that of generalized smooth functions (GSF), an extension of classical distribution theory sharing many nonlinear properties with ordinary smooth functions, like the closure with respect to composition, a good integration theory, and several classical theorems of calculus. We obtain a new notion that applies to all GSF, in particular to all Schwartz distributions and to all Colombeau generalized functions without growth restrictions. We prove that this FT generalizes several classical properties of the ordinary FT, and in this way we also overcome the difficulties of FT in Colombeau’s settings.

### 2. Tiwari, Giordano - Hyperseries of Colombeau generalized numbers

**Journal:** Monatshefte für Mathematik

**IF 2022:** 0.89

**AMS classification:** Distributions, generalized functions, distribution spaces; Generalized functions for

nonlinear analysis; Non-Archimedean analysis

**Description:** We solve the non trivial problem to define infinite sums of Colombeau generalized numbers by defining the notion of *hyperseries* and *hyper-power series*. On the contrary with respect to ordinary series, this allow us to recover several classical results (e.g. all the convergence tests and classical examples such as geometric hyperseries and Taylor series of exponential). The non-triviality of this problem is due to the presence of infinitesimal and infinite numbers so that an *ordinary* series converges *if* and only if its general term tends to zero (this unwanted result does not hold for hyperseries). This is the first of a series of papers aiming at proving the Cauchy-Kowalevski theorem for a large class of Schwartz distributions.

3. **Tiwari, Mukhammadiev, Giordano - Hyper-power series and generalized real analytic functions**

**Journal:** Monatshefte für Mathematik

**IF 2022:** 0.89

**AMS classification:** Distributions, generalized functions, distribution spaces; Generalized functions for nonlinear analysis; Non-Archimedean analysis.

**Description:** We study one variable generalized real analytic functions defined by hyper-power series. We define a new notion of non-Archimedean radius of convergence for these hyper-power series and extend classical results such as algebraic operations, composition, reciprocal, derivation, integration, a suitable formulation of the identity theorem and the characterization by local uniform upper bounds of derivatives of hyper-power series. On the contrary with respect to the classical use of series in the theory of Colombeau real analytic functions, we can recover several classical examples in a non-infinitesimal set of convergence. The notion of generalized real analytic function reveals to be less rigid both with respect to the classical one and to Colombeau theory, e.g. including classical non-analytic smooth functions with flat points and several distributions such as the Dirac delta. On the other hand, each Colombeau real analytic function is also a generalized real analytic function.

4. **Gastão, S.F., Giordano, P., Bryzgalov, A., Lazo, M.J. - Calculus of variations and optimal control for generalized functions**

**Journal:** Nonlinear Analysis

**IF 2022:** 1.71

**AMS classification:** Calculus of variations and optimal control, optimization; Distributions, generalized functions, distribution space; Generalized functions for nonlinear analysis

**Description:** We extend some results of higher order calculus of variations and optimal control to generalized functions (including Schwartz distributions): We prove D'Alembert principle in differential form, the du Bois-Reymond optimality condition and the Noether's theorem, definition of optimal control, weak Pontryagin principle and the Noether's theorem for optimal control. We study a singularly variable length pendulum, oscillations damped by two media and the Pais-Uhlenbeck oscillator with singular frequencies. A similar problem was attempted by J. Marsden in "Non-smooth geodesic flows and classical mechanics", Canad. Math. Bull., 1969, even if with an irreparable mistake, as proved by Kunzinger, Oberguggenberger, Steinbauer, Vickers, "Generalized Flows and Singular ODEs on Differentiable Manifolds", Acta Applicandae Mathematicae, 2004.

5. **Mukhammadiev, Tiwari, Apaaboah, Giordano - Supremum, infimum and hyperlimits in the non-Archimedean ring of Colombeau generalized numbers**

**Journal:** Monatshefte für Mathematik

**IF 2022:** 0,89

**AMS classification:** Functional analysis, Generalized functions for nonlinear analysis, Non-Archimedean analysis.

**Description:** The notion of limit of sequences in the topology of Colombeau generalized numbers does not generalize classical results. E.g. the sequence  $\frac{1}{n} \not\rightarrow 0$  and a sequence  $(x_n)_{n \in \mathbb{N}}$  converges *if* and only if  $x_{n+1} - x_n \rightarrow 0$ . This has several deep consequences, e.g. in the study of series, analytic generalized functions, or sigma-additivity and classical limit theorems in integration of generalized functions. The lacking of these results is also connected to the fact that Colombeau generalized numbers are not a complete ordered set, e.g. the set of all the infinitesimals has neither supremum nor infimum. We present a solution of these

problems with the introduction of the notions of *hypernatural number*, *hypersequence*, *close supremum* and *infimum*. In this way, we can generalize all the classical theorems for the hyperlimit of a hypersequence.

6. **Giordano, Kunzinger - A convenient notion of compact set for generalized functions**

**Journal:** Proceedings of the Edinburgh Mathematical Society

**IF 2022:** 0.72

**AMS classification:** Generalized functions for nonlinear analysis; Functional analysis (Spaces defined by inductive or projective limits).

**Description:** We introduce the notion of *functionally compact set* into the theory of nonlinear generalized functions in the sense of Colombeau. We then introduce spaces of functionally compactly supported generalized smooth functions that are close analogues to test function spaces of distribution theory. We then develop the topological and functional-analytic foundations of these spaces.

7. **Lecke, Luperi Baglini, Giordano - The classical theory of calculus of variations for generalized functions**

**Journal:** Advances in Nonlinear Analysis

**IF 2022:** 3.77

**AMS classification:** Calculus of variations and optimal control, optimization; Generalized functions for nonlinear analysis; Local Riemannian geometry

**Description:** We develop an extension of the classical theory of calculus of variations to a class of generalized functions which includes Schwartz distributions: Euler–Lagrange equations, classical necessary and sufficient conditions to have a minimizer, the necessary Legendre condition, Jacobi’s theorem on conjugate points and Noether’s theorem. We close with an application to low regularity Riemannian geometry.

8. **Giordano, Luperi - The category of Colombeau algebras**

**Journal:** Monatshefte für Mathematik

**IF 2022:** 0.89

**AMS classification:** Generalized functions for nonlinear analysis; Category theory

**Description:** we define and study Colombeau AG-algebras, which generalize several Colombeau different constructions of algebras of generalized functions extending Schwartz distributions. The main aim is to relate differential equations framed in algebras having different growth scales (not only polynomial growth, like in the classical Colombeau algebra).

9. **Giordano, Wu - Calculus in the ring of Fermat reals. Part I - Integral calculus**

**Journal:** Advances in Mathematics

**IF 2022:** 1.57

**AMS classification:** Calculus of functions on infinite-dimensional spaces; global analysis, analysis on manifolds; non-Archimedean functional analysis.

**Description:** This is the last of four papers aiming at study functions and operators in non-normable infinite dimensional spaces (e.g. spaces of smooth functions between non-compact smooth manifolds). The methods used are typical of non-Archimedean functional analysis and convenient vector spaces theory of P.W. Michor, A. Kriegl. The basic idea, which originates from A. Weil, is to first extend  $\mathbb{R}$  into a non-Archimedean ring  $\bullet\mathbb{R} \supseteq \mathbb{R}$  called ring of Fermat reals. Then every smooth function  $f \in \mathcal{C}^\infty(\mathbb{R}^n, \mathbb{R}^d)$  can be extended to a map of the type  $\bullet f : \bullet\mathbb{R}^n \longrightarrow \bullet\mathbb{R}^d$ , and this extension has good categorical property (Cartesian closedness, i.e. closure with respect to function spaces) to which methods similar to those used in convenient vector spaces can be applied. In this paper we prove existence and uniqueness of primitives and we study smoothness of infinite-dimensional integral and differential operators in suitable non-normable infinite dimensional spaces (e.g. in  $\mathcal{C}^\infty(M, N)$ , where  $M, N$  are smooth manifolds).

10. **Giordano, Luperi - Asymptotic gauges-Generalization of Colombeau type algebras**

**Journal:** Mathematische Nachrichten

**IF 2022:** 1

**AMS classification:** Generalized functions for nonlinear analysis; Ordinary differential equations.

**Description:** We generalize the construction of algebras of nonlinear generalized functions of Colombeau type so as to include the special, full and nonstandard analysis based Colombeau type algebras in a unique

general definition. In this setting, every linear ODE with singular coefficients can be uniquely solved. This marks a main difference with the Colombeau special algebra, where only particular linear ODEs can be solved (those of logarithmic type).

11. **Giordano, Kunzinger, Vernaevae - Strongly internal sets and generalized smooth functions**  
**Journal:** Journal of Mathematical Analysis and Applications  
**IF 2022:** 1.39  
**AMS classification:** Generalized functions for nonlinear analysis; Functional analysis.  
**Description:** We introduce and study the space of generalized smooth functions, a minimal extension of Colombeau generalized functions, and hence of Schwartz's distributions. Generalized smooth functions as morphisms between sets of generalized points form a sub-category of the category of topological spaces. In particular, they can be composed unrestrictedly. As a consequence, this allows one to consider the composition of two arbitrary Schwartz distributions (such as, e.g.,  $\delta \circ \delta$ ). Therefore, in this setting the notions of strong and weak solution for a differential equation are equivalent and nonlinear operations on Schwartz's distributions are possible (even of non polynomial type).
12. **Giordano, Kunzinger - New topologies on Colombeau spaces and the Fermat-Reyes theorem**  
**Journal:** Journal of Mathematical Analysis and Applications  
**IF 2022:** 1.39  
**AMS classification:** Generalized functions for nonlinear analysis; Functional analysis.  
**Description:** We introduce and study new topologies on spaces of Colombeau generalized points. Building on a new point value characterization of Colombeau generalized functions, we prove a Fermat–Reyes theorem (also called Carathéodory's differentiation criterion) that forms the basis of an approach to differentiation on spaces of generalized functions close to the classical one and including Schwartz distributions as a particular case.

## Preprints and articles in preparation

The following articles are at a very good stage of writing and their publication is planned in 2024.

### Submitted papers:

1. Giordano, P., Luperi Baglini, L., A Picard-Lindelöf theorem for smooth PDE. Under referees evaluation for Advances in Mathematics, 2023. Concerning this work, we believe it is important to underscore that Prof. I. Ekeland already reviewed this paper saying: *I was particularly interested in your paper because I have been trying for many years to do something similar myself [...] Unfortunately, my approach did not allow me to go beyond known results, whereas yours does. Congratulations!*  
See <http://dx.doi.org/10.13140/RG.2.2.13861.99045>
2. Giordano, P., Kunzinger M., Vernaevae H., A Grothendieck topos of generalized functions I: basic theory. See <http://arxiv.org/abs/2101.04492>. Under referees evaluation for Dissertationes Mathematicae, 2023.
3. Islami, K., Bryzgalov, A., Giordano, P., Infinitesimal and infinite numbers in mathematical physics. See <https://arxiv.org/abs/2401.08554>. Under referees evaluation for Nonlinear Dynamics, 2023.

### In preparation:

1. Nugraheni, S., Giordano P., Dirac delta as a generalized holomorphic function.
2. Nugraheni, S., Giordano P., Path integration for generalized holomorphic functions.
3. Nugraheni, S., Giordano P., Generalized holomorphic functions and Taylor hyper-power series.
4. Islami, K., Apaaboah, G., Giordano, P., Classical finite dimensional fixed point methods for generalized functions.
5. Bryzgalov A., Islami K., Giordano P., The Pontryagin maximum principle for generalized functions.

6. Giordano, P., Interaction spaces: towards a universal mathematical theory of complex systems. See <http://www.mat.univie.ac.at/~giordap7/IS.pdf>
7. Lupieri Baglini, L., Kebiche, D.E., Giordano, P., Vernaev, H., A Grothendieck topos of generalized functions II: ODE.
8. Giordano P., Lupieri Baglini L., Kebiche, D.E., Vernaev, H., A Grothendieck topos of generalized functions III: normal PDE.
9. Kebiche, D.E., Giordano, P., Universal properties of spaces of generalized functions.
10. Kebiche, D.E., Giordano, P., Hahn-Banach theorem in spaces of generalized functions.
11. Kebiche, D.E., Giordano, P., Riesz theorem in spaces of generalized functions.

## Collaborazione con l'Università di Vienna

Come descritto in <https://www.fwf.ac.at/en/funding/steps-to-your-fwf-project/further-information/applying-from-abroad>, per i prossimi sette anni posso sottoporre progetti FWF come “principal investigator”, anche se avrò un incarico in un’università italiana (a tempo definito al 75%, il rimanente 25% deve essere dedicato ai progetti FWF). Questo sembra compatibile con gli Art. 9, 10 del regolamento RTT dell’Università di Milano, dove si parla di possibilità di incarichi presso altre università nel caso in cui questi siano finalizzati alla mobilità internazionale per motivi di ricerca. Questi fondi FWF possono essere usati per i co-PI (impiegati presso l’Università di Milano), per post-doc o studenti di dottorato.

## URL

1. My FWF projects: Search for “P. Giordano” and select “Projects” in: <https://www.fwf.ac.at/en/discover/research-radar>
2. My projects on SNF website <http://p3.snf.ch/person-138211-Giordano-Paolo>