

# Curriculum Vitae

Dr. Paolo Baldi

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Web of Science ID: U-9115-2018

## Research interests

My research interests have always revolved around logic, in particular non-classical logics. During my scientific career, I have addressed non-classical logics from different perspectives. First, during my doctoral studies, I familiarized with the field of algebraic proof-theory, applying algebraic and proof-theoretic methods to solve problems in the area of Mathematical Fuzzy Logic, and substructural logics, more generally. The main result of my doctoral thesis was a systematic characterization of classes of logics that are complete with respect to algebraic structure over the real  $[0,1]$  interval. This is a result of crucial importance for the area of Mathematical fuzzy logics, since algebras over  $[0,1]$  constitute the “standard” semantics of logics in the field. The result was obtained via an interplay of proof-theoretic and algebraic methodologies, encompassing most of the scattered results in the literature, and including other (infinitely many) new classes of logics.

During my first postdoc contract, I investigated formal models of vague quantifier expressions, such as “many”, “few”, “about half”, proposing new modelling principles, and encoding them in suitable game-theoretical frameworks, and proof-systems for fuzzy logics.

During my years of postdoc research I have been increasingly interested in investigating logical systems for reasoning under uncertainty. I have kept investigating fuzzy logics, and in particular the interrelation between fuzzy logics and logics for uncertain reasoning. In particular, in recent works, I have proven the equivalence of some logics in these two families, and introduced new proof-systems for using fuzzy logics as tools for reasoning under uncertainty.

I am currently investigating quantitative and qualitative measures of uncertainty which are *feasible* ( from the point of view of computational complexity), and the applications of such measures of uncertainty to decision-theoretic models, as a contribution to the modeling of bounded forms of rationality.

During my career, I had chances to form a strong international network, having obtained my PhD in Vienna, and having worked in Prague as a postdoctoral researcher, before moving to the Logic Group in the University of Milan. I have always worked in logic, and I have been exposed to the subject from a wide range of perspectives and approaches, having been affiliated during my career with Departments of Mathematics, Computer Science, and Philosophy in three different countries. This enabled me also to connect and present my work to different research communities, interested in either proof-theory, algebraic logic, fuzzy logic, vagueness, or uncertain reasoning.

Despite the fact that my research interests and competences have been mostly developed around theoretical subjects, I have also recently applied my expertise in logic in a complex real-world scenario. In 2020 I have indeed acted as a consultant for the implementation of a peer-review mechanism at the United Nations. I have developed for this purpose a software, based on the paradigm of logic programming, which was accepted and successfully used in a plenary session.

## Scientific Career

- (01/01/2019-Present). Postdoctoral fellow (Assegnista di ricerca) at the University of Milan - Department of Philosophy. Member of the Research Group LUCI (Logic uncertainty, Computation and Information).
- (01/03/2020 - 30/11/2020). Consultant for the United Nations Office on Drugs and Crime (UNODC). Devising and implementation of an algorithm for the *Mechanism for the Review of the Implementation of the United Nations Convention against Transnational Organized Crime (UNTOC)*.
- (01/04/2018-31/12/2018). Postdoctoral fellow at the Academy of the Sciences of the Czech Republic - Institute of Computer Science, Department of Theoretical Computer Science, Prague. Project Leaders: Prof. Carles Noguera and Prof. Petr Cintula.
- (01/01/2018-28/02/2018). Holder of a Scholarship by the Wolfgang Pauli Institute, Vienna.
- (01/09/2015-31/12/2017). Postdoctoral fellow within the Project *Modelling vague quantifiers with Mathematical Fuzzy Logic – MoVaQ-MFL*, at the Institute of Logic and Computation, Vienna University of Technology, Austria (Joint Project with the Academy of the Sciences of the Czech Republic - Institute of Computer Science).  
Project Leader (Austrian side): Prof. Christian G. Fermüller.

## Education

- (01/04/2011-12/08/2015). PhD - Doctoral Programme "Mathematical Logic in Computer Science", Vienna University of Technology, Austria.  
Title of the Thesis : *Standard Completeness: Proof-theoretical and Algebraic Methods*.  
Supervisor: Prof. Agata Ciabattoni.  
Mark: Sehr Gut (Excellent).  
During the doctoral studies I attended courses in Proof Theory (3 ECTS), Research Methods (6 ECTS), Philosophy of Science (6 ECTS), Knowledge Representation (3 ECTS), Computational Complexity (3 ECTS), Nonclassical logics, Modal and Epistemic Logics (3 ECTS) and Higher-Order Logics (3 ECTS).
- (01/03/2008-12/07/2010). Master Degree in Mathematics. University of Salerno (Italy).  
Mark: 110/110 cum Laude.  
Curriculum oriented towards Logic and Foundations of Mathematics.
- (01/10/2004-08/02/2008). Bachelor Degree in Mathematics. University of Salerno (Italy).  
Mark: 110/110 cum Laude.

## Key cooperation Partners

- Prof. Hykel Hosni, University of Milan, Department of Philosophy.
- Prof. Marcello D’Agostino, University of Milan, Department of Philosophy.
- Dr. Carles Noguera, Czech Academy of the Sciences, Institute of Information Theory and Automation.
- Doz. Petr Cintula, Czech Academy of the Sciences, Institute of Computer Science.
- Prof. Christian G. Fermüller, TU Wien, Institute of Logic and Computation.
- Prof. Agata Ciabattoni, TU Wien, Institute of Logic and Computation.
- Prof. Kazushige Terui, Kyoto University, Research Institute for Mathematical Sciences.

## (Peer-Reviewed) Publications

- P. Baldi, H. Hosni. A Logic-based tractable approximation of probability. *Journal of Logic and Computation*. *Accepted for publication*.
- F. D’Asaro, P. Baldi, and G. Primiero. “Introducing k-lingo: a k-depth Bounded Version of ASP System Clingo”. In: *Proceedings of the 18th International Conference on Principles of Knowledge Representation and Reasoning*. Nov.2021, pp. 661–665. DOI: 10.24963/kr.2021/65. URL: <https://doi.org/10.24963/kr.2021/65>.
- P. Baldi, H. Hosni. Logical Approximations of Qualitative Probability. *ISIPTA 2021. Proceedings of the Twelveth International Symposium on Imprecise Probability: Theories and Applications*, PMLR 147:12–21, 2021.
- P. Baldi, A. Ciabattoni, KP. Adlassnig. Bilattice CADIAG-II: Theory and Experimental Results. In: *Phuong N.H., Kreinovich V. (eds) Soft Computing: Biomedical and Related Applications. Studies in Computational Intelligence*, vol 981. Springer, Cham, 2021. [https://doi.org/10.1007/978-3-030-76620-7\\_1](https://doi.org/10.1007/978-3-030-76620-7_1)
- P. Baldi, P. Cintula, C. Noguera. Classical and Fuzzy Two-Layered Modal Logics for Uncertainty: Translations and Proof-Theory. *International Journal of Computational Intelligence Systems* 13(1):988–1001, 2020. <https://doi.org/10.2991/ijcis.d.200703.001>
- P. Baldi, H. Hosni. Depth-bounded Belief Functions. *International Journal of Approximate Reasoning*. 123:26-40, 2020. <https://doi.org/10.1016/j.ijar.2020.05.001>
- P. Baldi, M. D’ Agostino, H. Hosni. Depth-Bounded Approximations of Probability, *International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems (IPMU 2020)*. [https://doi.org/10.1007/978-3-030-50153-2\\_45](https://doi.org/10.1007/978-3-030-50153-2_45)
- P. Baldi, C. Fermüller, M. Hofer. On Fuzzification mechanisms for unary quantifications. *Fuzzy Sets and Systems*, 2020, <https://doi.org/10.1016/j.fss.2019.12.009>.
- P. Baldi, P. Cintula, C. Noguera. Translating classical probability logics into modal fuzzy logics. In M. Stepnicka, editor: *Proceedings of EUSFLAT 2019, Atlantis Studies in Uncertainty Modeling*, pp. 342–349. AtlantisPress, 2019.

- P. Baldi, C. Fermüller. From Semi-Fuzzy to Fuzzy Quantifiers via Łukasiewicz Logic and Games. The 10th Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT 2017), Warsaw (Poland). DOI: 10.1007/978-3-319-66830-7\_11
- P. Baldi, A. Ciabattoni, F. Gulisano. Standard Completeness for extensions of IMTL. FUZZ-IEEE 2017, Naples (Italy). DOI:10.1109/FUZZ-IEEE.2017.8015625
- P. Baldi. A calculus for Rational Łukasiewicz Logic and Related systems. International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems (IPMU 2016), Eindhoven (Netherlands). DOI: 10.1007/978-3-319-40581-0\_12
- P. Baldi, K. Terui. Densification of FL chains via residuated frames. Algebra Universalis. 75(2) :169- 195 (2016). DOI: 10.1007/s00012-016-0372-5
- P. Baldi, A. Ciabattoni. Standard completeness for uninorm-based logics. IEEE International Symposium on Multiple-Valued Logic (ISMVL 2015), Waterloo (Canada). DOI: 10.1109/ISMVL.2015.20
- P. Baldi, A. Ciabattoni. Uniform proofs of standard completeness for extensions of first-order MTL. Theoretical Computer Science. 603: 43-57 (2015). DOI: 10.1016/j.tcs.2015.07.014
- P. Baldi. A note on standard completeness for some extensions of uninorm logic. Soft Computing 18(8): 1463-1470 (2014). DOI: 10.1007/s00500-014-1265-1
- P. Baldi, A. Ciabattoni and L. Spendier (2012). Standard Completeness for Extensions of MTL: an Automated Approach. Workshop on Logic, Language, Information and Computation (WoLLIC2012), L. Ong and R. de Queiroz (Eds.), LNCS 7456, pp. 154-167. Springer, Heidelberg. DOI: 10.1007/978-3-642-32621-9\_12

#### **Submitted works**

- P. Baldi. A Hypersequent Calculus for Rational Łukasiewicz Logic.
- P. Baldi. Logic-based approximations of preferences. Submitted for the proceedings of the conference LOFT 2022.
- P. Baldi, H. Hosni. Degrees of Truth and Probability. Submitted to the post-proceedings of LOGICA 2021.

#### **Selected Contributed Talks at Conferences**

- Degrees of Truth and Probability. Contributed Talk at Logica 2021. Hejnice monastery, Czechia, 27 September – 1 October 2021.
- Logical Approximations of Qualitative Probability. Contributed Talk at ISIPTA 2021. 6-9 July 2021, online (originally planned in Granada).
- Depth-Bounded Approximations of Probability. Contributed Talk at IPMU 2020. 15-19 June 2020, online (originally planned in Lisbon).
- Depth-Bounded Belief Functions. Contributed Talk at International Symposium on Imprecise Probabilities: Theories and Applications (ISIPTA 2019). Ghent, Belgium, 3-6 July 2019.

- Translating logics of uncertainty into two-layered modal fuzzy logics. Contributed Talk at Advances in Modal Logic (AiML 2018), Bern, Switzerland, 27-31 August 2018.
- Modeling vague quantifiers with fuzzy logic: an alternative approach. Contributed Talk at MANYVAL 2017, Toulouse, France, 15-17 November, 2017.
- Towards a proof theory for fuzzy quantifiers: a calculus for Rational Łukasiewicz Logic . Contributed Talk at Logic, Algebra and Truth Degress (LATD 2016), Phalaborwa , South Africa, June 28-30, 2016.
- A calculus for Rational Łukasiewicz logic and related systems. (IPMU 2016), Eindhoven, Netherlands, June 20-24, 2016.
- Standard completeness for uninorm-based logics. IEEE International Symposium on Multiple-Valued Logic (ISMVL 2015), Waterloo (Canada). May 18-20, 2015
- Standard completeness: proof-theoretical and algebraic approaches. Contributed Talk at the 35th Linz Seminar on Fuzzy Set Theory, Linz, Austria, February 18-22, 2014.
- A proof-theoretical approach to Standard Completeness. Contributed Talk at MANYVAL 2013, Prague, Czech Republic, 4-6 September, 2013.
- Standard Completeness for Extensions of MTL: an Automated Approach. Contributed Talk at Logic, Algebra and Truth Degress (LATD 2012), Kanazawa , Japan, September 10-14, 2012.

### **Invited talks**

- Depth-Bounded Belief functions. Workshop on Logic and Argumentation. Vienna, 5-6 November 2019
- Standard Completeness: a novel algebraic approach. Workshop on admissible rules and Unification, II (WARU II) Les Diablerets, Switzerland, 30 January - 2 February, 2015.
- Density Elimination and Standard Completeness for extensions of UL and MTL. Prague seminar on substructural logics. Prague, 28–29 March 2014

### **Teaching and supervising**

- Teaching of the course “Topics in Logic, Probability and Computation ”, for PhD students, at the University of Milan, Department of Philosophy, for the academic year 2021/2022.
- Teaching of the course “Topics in Logic, Probability and Computation ”, for PhD students, at the University of Milan, Department of Philosophy, for the academic year 2020/2021.
- Teaching of the course “Introduction to Logic Research ”(3 ECTS), at the University of Milan, Department of Philosophy, for the academic year 2019/2020 and 2020/2021.
- Teaching of the course ”Logic and Computation” (6 ECTS), at the Vienna University of Technology, Institute of Logic and Computation, for the winter semester 2016 and 2017, together with Prof. Ciabattoni and Prof. Fermüller (main lecturers).

- Co-supervisor of a Master Degree Thesis in “Logic and Computation” at the Vienna University of Technology, and of a bachelor degree thesis in “Philosophy” at the University of Milan, Department of Philosophy.

### Academic service

- Organization of the “Logic Seminars” for the year 2019,2020,2021,2022 with the Logic Group at the University of Milan, Department of Philosophy.
- Organization of the “2nd Workshop on Logic and Information ” on 28/11/2019, and the “Workshop on Logical Consequence: Calculi and Semantics”, on 03/12/2019, both at the University of Milan, Department of Philosophy, together with G. Primiero, H. Hosni, M.D’Agostino.
- Member of the Program Committee for the “1st Workshop on Machine Ethics and Explainability - The Role of Logic Programming”, which was part of ICLP 2021 and took place online on 20/09/2021.
- Member of the Committee for the Vienna Center for Logic and Algorithm (VCLA) International Student Award 2018.
- Organizer of the “Workshop on Fuzzy Quantifiers and Related Topics” (2017) at TU Wien.
- Member of the Editorial Board of the scientific journal “The Reasoner”.
- Member of the organizing Committee of 2nd SYMICS Workshop 2018 , *ALCOP 2016*, *LATD 2014*, *Get Fun 2.0*. The last two events were part of the “Vienna Summer of Logic” (2014), the biggest event in the history of the discipline.
- Reviewer for the scientific journals *Logic and Logical Philosophy*, *Studia Logica*, *Logic Journal of the IGPL*, *Fuzzy Sets and Systems*, *Soft Computing*, *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, *Journal of Logic and Computation*, the international conferences IJCAR 2014, LATD 2014, FUZZ-IEEE 2017, WOLLIC 2017, ISMVL 2018, CSL 2018, IJCAR 2020, TABLEAUX 2021, WOLLIC 2021, CADE 28, IJCAR 2022, IPMU 2022, and for a chapter of a volume in the Springer series *Outstanding contributions to logic* .
- Membership of Scientific societies:
  - “Associazione Italiana di Logica e Applicazione Research Network” (AILA)
  - “European Society for Fuzzy Logic and Technology” (EUSFLAT)
  - “Working group on Mathematical Fuzzy Logic” (MathFuzzLog)

### Visiting Positions (at least 1 month)

- October 2014 - December 2014. Visiting Fellow, Prae-Doc. Academy of the Sciences of the Czech Republic, Prague, Czechia
- August 2019. Visiting Fellow, Post-Doc. Academy of the Sciences of the Czech Republic, Prague, Czechia

**Computer skills**

- Programming languages: Prolog, Mathematica, Python, Matlab, C++, Java.
- Proficient user of the LaTeX language for the editing of scientific works, and of Bibtex and Mendeley, for the management of bibliographical references.

**Language skills**

- Italian (native), English (proficient), Spanish (proficient), German (good), French (basic)

Milano

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