

# PAOLO SARACCO



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## PERSONAL INFORMATION

Name: Paolo Saracco

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Researcher ID: P-4939-2015

Birthday and birthplace: 24/03/1989 - Ceva (CN), Italy

Languages: Italian (mother tongue), English (CEFR B2), Spanish (CEFR B2), Romanian (CEFR A2), French (CEFR A1)

Research interests: Associative rings and algebras; Hopf algebras; Category theory; Quantum algebra; Homological algebra

## CURRENT POSITION

**Collaborateur scientifique** of the ULB - Université Libre de Bruxelles (since 01/10/2023).

## PROFESSIONAL EXPERIENCE

(01/10/2020 - 30/09/2023) **Chargé de Recherches of the Fonds de la Recherche Scientifique - FNRS** (postdoc) at the ULB - Université Libre de Bruxelles. Project: *HoPFACT* - Hopf algebroids, Partial actions and Frobenius functors across Algebra and Category Theory.

(01/10/2019 - 30/09/2020) - **Collaborateur scientifique of the Fonds de la Recherche Scientifique - FNRS** (postdoc) at the ULB - Université Libre de Bruxelles. Project: *(CO)REPRESENTATIONS* - Categorical aspects and properties in the theory of quantum groups and their algebraic and geometric implications.

(01/05/2018 - 30/09/2019) - **Postdoctoral researcher** on non-commutative algebra and category theory in the team of prof. J. Vercruyse at the ULB - Université Libre de Bruxelles.

## EDUCATION

(01/11/2014 - 26/03/2018) - **PhD in Pure and Applied Mathematics**, achieved with honours. Department of Mathematics “G. Peano”, University of Turin, Italy.

Thesis: *Hopf Structures and Duality*.

Supervisor(s): prof. Alessandro Ardizzoni.

Co-supervisor(s): prof. Laiachi El Kaoutit Zerri (Univ. Granada, Spain).

(21/09/2012 - 16/07/2014) - **Master degree in Mathematics**, 110/110 summa cum laude. Department of Mathematics “G. Peano”, University of Turin, Italy.

Thesis: *On the Fundamental Structure Theorem for quasi-Hopf bimodules*.

Supervisor(s): dott. Alessandro Ardizzoni.

Co-supervisor(s): prof. Laiachi El Kaoutit Zerri (Univ. Granada, Spain).

(20/08/2008 - 20/07/2011) - **Bachelor degree in Mathematics**, 110/110 summa cum laude. Department of Mathematics “G. Peano”, University of Turin, Italy.

Thesis: *L'algebra lineare nello studio delle varietà di punti*.

Supervisor(s): dott. Mario Valenzano.

(01/09/2003 - 30/07/2008) - **Diploma di Maturità Classica** (Classical studies), 100/100. Liceo Classico Europeo “Umberto I” of Turin, Italy.

## QUALIFICATIONS

**02/10/2022 - 02/10/2032** *Abilitazione Scientifica Nazionale (ASN)* alle funzioni di *professore universitario di Seconda Fascia* nel Settore Concorsuale 01/A2 - GEOMETRIA E ALGEBRA, attestata dal Ministero dell'Università e della Ricerca.

**17/03/2021** Evaluación positiva (acreditación) de la Agencia Nacional de Evaluación de la Calidad y Acreditación (ANECA) a los efectos de contratación como *Profesor Ayudante Doctor*.

**08/03/2021** Evaluación positiva (acreditación) de la Dirección de Evaluación y Acreditación (DEVA) de la Agencia Andaluza del Conocimiento a los efectos de contratación como *Profesor Ayudante Doctor*.

**21/01/2020 - 31/12/2024** *Maître de conférences*, section 25 - Mathématiques.

## RESEARCH

### Publications

I have (co)authored 24 papers, all of them freely available on the open-access repository arXiv.org and on my homepage.

### Preprints

(24) S. Breaz, T. Brzeziński, B. Rybołowicz, P. Saracco, *Heaps of modules: Categorical aspects* (2023). ([arXiv:2311.01979](https://arxiv.org/abs/2311.01979))

Connections between heaps of modules and (affine) modules over rings are explored. This leads to explicit, often constructive, descriptions of some categorical constructions and properties that are implicit in universal algebra and algebraic theories. In particular, it is shown that the category of groups with a compatible action of a truss  $T$  (also called pointed  $T$ -modules) is isomorphic to the category of modules over the ring  $R(T)$  universally associated to the truss. This is widely used in the explicit description of free objects. Next, it is proven that the category of heaps of modules over  $T$  is isomorphic to the category of affine modules over  $R(T)$  and, in order to make the picture complete, that (in the unital case) these are in turn equivalent to a specific subcategory of the slice category of pointed  $T$ -modules over  $R(T)$ . These correspondences and properties are then used to describe explicitly various (co)limits and to compare short exact sequences in the Barr-exact category of heaps of  $T$ -modules with short exact sequences as defined previously.

(23) E. Batista, W. Hautekiet, P. Saracco, J. Vercruyssen, *Towards a classification of simple partial comodules of Hopf algebras* (2023). ([arXiv:2310.12728](https://arxiv.org/abs/2310.12728))

Making the first steps towards a classification of simple partial comodules, we give a general construction for partial comodules of a Hopf algebra  $H$  using central idempotents in right coideal subalgebras and show that any 1-dimensional partial comodule is of that form. We conjecture that in fact all finite-dimensional simple partial  $H$ -comodules arise this way. For  $H = kG$  for some finite group  $G$ , we give conditions for the constructed partial comodule to be simple, and we determine when two of them are isomorphic. If  $H = kG^*$ , then our construction recovers the work of M. Dokuchaev and N. Zhukavets. We also study the partial modules and comodules of the non-commutative non-cocommutative Kac-Paljutkin algebra  $\mathcal{A}$ .

(22) J. Berger, P. Saracco, J. Vercruyssen, *Everybody knows what a normal gabi-algebra is* (2023). ([arXiv:2308.09449](https://arxiv.org/abs/2308.09449))

Let  $A$  be a  $\mathbb{k}$ -algebra over a commutative ring  $\mathbb{k}$ . By the renowned Tannaka-Kreĭn reconstruction, liftings of the monoidal structure from  $\mathbb{k}$ -modules to  $A$ -modules correspond to bialgebra structures on  $A$  and liftings of the closed monoidal structure correspond to Hopf algebra structures on  $A$ . In this paper, we determine conditions on  $A$  that correspond to liftings of the closed structure alone, i.e. without considering the monoidal one, which lead to the notion of what we call a gabi-algebra. First, we tackle the question from the general perspective of monads, then we focus on the set-theoretic and the linear setting. Our main and most surprising result is that a normal gabi-algebra, that is an algebra  $A$  whose category of modules is (associative and unital normal) closed with closed forgetful functor to  $\mathbb{k}$ -modules, is automatically a Hopf algebra (thus justifying our title).

- (21) X. Bekaert, N. Kowalzig, P. Saracco, *Universal enveloping algebras of Lie-Rinehart algebras: crossed products, connections, and curvature* (2022). ([arXiv:2208.00266](https://arxiv.org/abs/2208.00266))

We extend a theorem, originally formulated by Blattner-Cohen-Montgomery for crossed products arising from Hopf algebras weakly acting on noncommutative algebras, to the realm of left Hopf algebroids. Our main motivation is an application to universal enveloping algebras of projective Lie-Rinehart algebras: for any given curved (resp. flat) connection, that is, a linear (resp. Lie-Rinehart) splitting of a Lie-Rinehart algebra extension, we provide a crossed (resp. smash) product decomposition of the associated universal enveloping algebra, and vice versa. As a geometric example, we describe the associative algebra generated by the invariant vector fields on the total space of a principal bundle as a crossed product of the algebra generated by the vertical ones and the algebra of differential operators on the base.

## Accepted

- (20) P. Saracco, *A remark on the Galois-type correspondence between ideal coideals and comodule subrings of a Hopf algebroid* (2023). To appear in Bull. Belg. Math. Soc. Simon Stevin ([arXiv:2308.05706](https://arxiv.org/abs/2308.05706))

We exhibit a bijective correspondence between certain left ideal coideals in a Hopf algebroid for which the resulting quotient is a coequalizer and certain right coideal subrings which are themselves an equalizer, remarkably improving a recent result of the author obtained in collaboration with L. El Kaoutit, A. Ghobadi and J. Vercruysse. Interpreting this result in the Hopf algebra setting provides a bijective correspondence which extends the previously known cases.

## Published

- (19) S. Breaz, T. Brzeziński, B. Rybołowicz, P. Saracco, *Heaps of modules and affine spaces*. Ann. Mat. Pur. Appl. (2023). ([arXiv:2203.07268](https://arxiv.org/abs/2203.07268), [doi.org/10.1007/s10231-023-01369-0](https://doi.org/10.1007/s10231-023-01369-0))

A notion of heaps of modules as an affine version of modules over a ring or, more generally, over a truss, is introduced and studied. Basic properties of heaps of modules are derived. Examples arising from geometry (connections, affine spaces) and algebraic topology (chain contractions) are presented. Relationships between heaps of modules and modules over a ring and affine spaces are revealed and analysed.

- (18) P. Saracco, J. Vercruysse, *Geometric partial comodules over flat coalgebras in Abelian categories are globalizable*. J. Pure Appl. Algebra **228** (2024), no. 3, Paper No. 107502. ([arXiv:2107.07299](https://arxiv.org/abs/2107.07299), [doi.org/10.1016/j.jpaa.2023.107502](https://doi.org/10.1016/j.jpaa.2023.107502))

We prove that geometric partial comodules over flat coalgebras in arbitrary abelian monoidal categories are globalizable. As a by-product, we obtain new globalization results in cases never considered before, such as partial corepresentations of Hopf algebras. Moreover, we show that for partial representations of groups and Hopf algebras, our globalization coincides with those described earlier in literature. Finally, we introduce Hopf partial comodules over a bialgebra as geometric partial comodules in the monoidal category of (global) modules. By applying our globalization theorem we obtain an analogue of the fundamental theorem for Hopf modules in this partial setting.

- (17) L. El Kaoutit, A. Ghobadi, P. Saracco, J. Vercruysse, *Correspondence Theorems for Hopf Algebroids with Applications to Affine Groupoids*. To appear in Canad. J. Math. (2023) ([arXiv:2211.07756](https://arxiv.org/abs/2211.07756), [doi.org/10.4153/S0008414X23000238](https://doi.org/10.4153/S0008414X23000238))

We provide a correspondence between one-sided coideal subrings and one-sided ideal two-sided coideals in an arbitrary bialgebroid. We prove that, under some expected additional conditions, this correspondence becomes bijective for Hopf algebroids. As an application, we investigate normal Hopf ideals in commutative Hopf algebroids (affine groupoid schemes) in connection with the study of normal affine subgroupoids.

- (16) A. Ardizzoni, L. El Kaoutit, P. Saracco, *Toward Differentiation and Integration between Hopf algebroids and Lie algebroids*. Publ. Mat. **67** (2023), no. 1, pp. 3-88 ([arXiv:1905.10288](https://arxiv.org/abs/1905.10288), [doi.org/10.5565/PUBLMAT6712301](https://doi.org/10.5565/PUBLMAT6712301))

With the aim of better understanding the geometrical aspects of the study of (commutative) Hopf algebroids, we develop a differentiation/integration duality between commutative Hopf algebroids and Lie-Rinehart algebras by resorting to a suitable continuous dual construction.

- (15) P. Saracco, *On anchored Lie algebras and the Connes-Moscovici bialgebroid construction*. J. Noncommut. Geom. **16** (2022), no. 3, pp. 1007–1053. ([arXiv:2009.14656](https://arxiv.org/abs/2009.14656), [doi.org/10.4171/jncg/475](https://doi.org/10.4171/jncg/475))

We show how the Connes-Moscovici's bialgebroid construction naturally provides universal objects for Lie algebras acting on non-commutative algebras.

- (14) A. Ardizzoni, P. Saracco, D. Ştefan, *PBW-deformations of graded rings*. Israel J. Math. **249** (2022), no. 2, 769–856. ([arXiv:1710.04444](https://arxiv.org/abs/1710.04444), [doi.org/10.1007/s11856-022-2325-3](https://doi.org/10.1007/s11856-022-2325-3))

There exist in the literature a number of results extending to the renowned PBW Theorem to broader classes of filtered algebras. The aim of this paper is that of proving a general enough formulation of this outstanding theorem that allows one to recover, in a unified way, many of the existing results as well as new ones.

- (13) M. D’Adderio, W. Hautekiet, P. Saracco, J. Vercauteren, *Partial and global representations of finite groups*. Algebr. Represent. Theor. (2022). ([arXiv:2005.09465](https://arxiv.org/abs/2005.09465), [doi.org/10.1007/s10468-022-10136-3](https://doi.org/10.1007/s10468-022-10136-3))

Given a subgroup  $H$  of a finite group  $G$ , we begin a systematic study of the partial representations of  $G$  that restrict to global representations of  $H$ . After adapting several results from [M. Dokuchaev, R. Exel, P. Piccione, “Partial representations and partial group algebras”, J. Algebra **226**, (2000), no. 1, 505-532] (which correspond to the case  $H = \{1_G\}$ ), we develop further an effective theory that allows explicit computations. As a case study, we apply our theory to the symmetric group  $\mathfrak{S}_n$  and its subgroup  $\mathfrak{S}_{n-1}$  of permutations fixing 1: this provides a natural extension of the classical representation theory of  $\mathfrak{S}_n$ .

- (12) P. Saracco, J. Vercauteren, *On the globalization of geometric partial (co)modules in the categories of topological spaces and algebras*. Semigroup Forum **105** (2022), no. 2, 534–550. ([arXiv:2107.06574](https://arxiv.org/abs/2107.06574), [doi.org/10.1007/s00233-022-10269-3](https://doi.org/10.1007/s00233-022-10269-3))

We study the globalization of partial actions on sets and topological spaces and of partial coactions on algebras by applying the general theory of globalization for geometric partial comodules, as previously developed by the authors. We show that this approach does not only allow to recover all known results in these settings, but it allows to treat new cases of interest, too.

- (11) P. Saracco, J. Vercauteren, *Globalization for geometric partial comodules*. J. Algebra **602** (2022), 37-59. ([arXiv:2001.07669](https://arxiv.org/abs/2001.07669), [doi.org/10.1016/j.jalgebra.2022.03.013](https://doi.org/10.1016/j.jalgebra.2022.03.013))

We discuss globalization for geometric partial comodules in a monoidal category with pushouts and we provide a concrete procedure to construct it, whenever it exists. The mild assumptions required by our approach make it possible to apply it in a number of contexts of interests, recovering and extending numerous ad hoc globalization constructions from the literature in some cases and providing obstruction for globalization in some other cases.

- (10) T. Brzeziński, B. Rybołowicz, P. Saracco, *On functors between categories of modules over trusses*. J. Pure Appl. Algebra **226** (2022), no. 11, Paper No. 107091. ([arXiv:2006.16624](https://arxiv.org/abs/2006.16624), [doi.org/10.1016/j.jpaa.2022.107091](https://doi.org/10.1016/j.jpaa.2022.107091))

Categorical aspects of the theory of modules over trusses are studied. Tensor product of modules over trusses is defined and its existence established. In particular, it is shown that bimodules over trusses form a monoidal category. Truss versions of the Eilenberg-Watts theorem and Morita equivalence are formulated. Projective and small-projective modules over trusses are defined and their properties studied.

- (9) P. Saracco, *Universal enveloping algebras of Lie-Rinehart algebras as a left adjoint functor*. Mediterr. J. Math. **19** (2022), no. 2, Paper No. 92, 19 pp. ([arXiv:2102.01553](https://arxiv.org/abs/2102.01553), [doi.org/10.1007/s00009-022-01985-9](https://doi.org/10.1007/s00009-022-01985-9))

We prove how the universal enveloping algebra constructions for Lie-Rinehart algebras and anchored Lie algebras are naturally left adjoint functors. This provides a conceptual motivation for the universal properties these constructions satisfy. As a supplement, the categorical approach offers new insights into the definitions of Lie-Rinehart algebra morphisms, of modules over Lie-Rinehart algebras and of the infinitesimal gauge algebra of a module.

- (8) L. El Kaoutit, P. Saracco, *The Hopf Algebroid Structure of Differentially Recursive Sequences*. Quaest. Math. **45** (2022), no. 4, 547–593. ([arXiv:2003.08180](https://arxiv.org/abs/2003.08180), [doi.org/10.2989/16073606.2021.1885520](https://doi.org/10.2989/16073606.2021.1885520))

A differentially recursive sequence over a differential field is a sequence of elements satisfying a homogeneous differential equation with non-constant coefficients in the differential algebra of Hurwitz series. Following *Comparing topologies on linearly recursive sequences*, we show in this paper that the space of all differentially recursive sequences over a given field with a non-zero differential admits, in a canonical way, a structure of Hopf algebroid over the subfield of constant elements. We prove also that it is the direct limit, as a left comodule, of all spaces of formal solutions of linear differential equations and that it satisfies, as Hopf algebroid, the universal property of the SAFT finite-dual from *Differentiation and integration between Hopf algebroids and Lie algebroids*. When the differential on the base field is zero, we recover the Hopf algebra structure of linearly recursive sequences.

- (7) P. Saracco, *Antipodes, preantipodes and Frobenius functors*. J. Algebra Appl. **20** (2021), no. 7, 2150124, 32 pp. ([arXiv:1906.03435](https://arxiv.org/abs/1906.03435), [doi.org/10.1142/S0219498821501243](https://doi.org/10.1142/S0219498821501243))

Following the promising results of *Hopf modules, Frobenius functors and (one-sided) Hopf algebras*, I developed further the investigation of the relationship between the Hopf property for (quasi-)bialgebras and the Frobenius property for the free two-sided Hopf module functor. The main theorem of this paper fully characterizes quasi-bialgebras with preantipode in terms of the aforementioned Frobenius property and suggests the possibility of using Frobenius functors to relate Frobenius and Hopf monads.

- (6) P. Saracco, *Hopf modules, Frobenius functors and (one-sided) Hopf algebras*. J. Pure Appl. Algebra **225** (2021), no. 3, 106537. ([arXiv:1904.13065](https://arxiv.org/abs/1904.13065), [doi.org/10.1016/j.jpaa.2020.106537](https://doi.org/10.1016/j.jpaa.2020.106537))

By analysing carefully the proof of the well-known Structure Theorem of Hopf modules, one may observe that the notions of adjoint triples and Frobenius functors naturally appear in the study of the Hopf property for bialgebras. A deeper investigation in this direction revealed that Frobenius functors can be used to effectively study (one-sided) Hopf algebras and the relationship between the Hopf and the Frobenius properties.

- (5) P. Saracco, *Coquasi-bialgebras with Preantipode and Rigid Monoidal Categories*. Algebr. Represent. Theory **24** (2021), no. 1, 55-80. ([arXiv:1611.06819](https://arxiv.org/abs/1611.06819), [doi.org/10.1007/s10468-019-09931-2](https://doi.org/10.1007/s10468-019-09931-2))

Hopf algebras can be characterized as coalgebras whose category of finite-dimensional comodules is rigid monoidal with monoidal underlying functor to vector spaces. In this paper I prove a similar Tannaka-Krein reconstruction theorem for coquasi-bialgebras with preantipode over a commutative ring, thus showing that preantipodes are in fact a more suitable analogue of antipodes for coquasi-bialgebras than coquasi-antipodes.

- (4) L. El Kaoutit, P. Saracco, *Comparing topologies on linearly recursive sequences*. Ars Math. Contemp. **16** (2019), n. 2, 319-329. ([arXiv:1705.03433](https://arxiv.org/abs/1705.03433), [doi.org/10.26493/1855-3974.1436.7a2](https://doi.org/10.26493/1855-3974.1436.7a2))

As a consequence of the results achieved in *Topological tensor product of bimodules, complete Hopf algebroids and convolution algebras*, we show that the space of linearly recursive complex sequences enjoys a rich topological structure and we compare some of them.

- (3) L. El Kaoutit, P. Saracco, *Topological tensor product of bimodules, complete Hopf algebroids and convolution algebras*. Commun. Contemp. Math. **21** (2019), no. 6, 1-53. ([arXiv:1705.06698](https://arxiv.org/abs/1705.06698), [doi.org/10.1142/S0219199718500153](https://doi.org/10.1142/S0219199718500153))

In a first attempt to approach the problem of integration for Lie algebroids from an algebraic point of view, we study the structure of complete Hopf algebroid (formal groupoid) on the linear dual of the universal enveloping algebra of a Lie-Rinehart algebra and its connections with the topological completion of the finite dual of the same.

- (2) P. Saracco, *On the structure theorem for quasi-Hopf bimodules*. Appl. Categ. Structures **25** (2017), no. 1, 3-28. ([arXiv:1501.06061](https://arxiv.org/abs/1501.06061), [doi.org/10.1007/s10485-015-9408-9](https://doi.org/10.1007/s10485-015-9408-9))

Antipodes for bialgebras can be characterized in terms of a structure theorem for Hopf modules. In this paper I introduce the notion of preantipodes for quasi-bialgebras and I prove that they provide the right analogue of antipodes in the non-coassociative context, by proving that their existence is equivalent to a structure theorem for quasi-Hopf bimodules.

- (1) A. Ardizzoni, L. El Kaoutit, P. Saracco, *Functorial constructions for non-associative algebras with applications to quasi-bialgebras*. J. Algebra **449** (2016), 460-496. ([arXiv:1507.02402](https://arxiv.org/abs/1507.02402), [doi.org/10.1016/j.jalgebra.2015.11.029](https://doi.org/10.1016/j.jalgebra.2015.11.029))

Published before but actually following *On the structure theorem for quasi-Hopf bimodules*. In this paper we provided a duality between non-associative algebras and non-coassociative coalgebras in the spirit of the Sweedler/Michaelis' duals and we extended this duality at the level (co)quasi-bialgebras, with the aim of studying it for (co)quasi-bialgebras with preantipode at a later time.

In addition, I acted as referee for peer-reviewed scientific journals (São Paulo Journal of Mathematical Sciences, Journal of Algebra and Its Applications, Rendiconti del Seminario Matematico, Communications in Algebra, International Electronic Journal of Algebra, Revista de la Unión Matemática Argentina, Bulletin Mathématique de la Société des Sciences Mathématiques de Roumanie) and as a reviewer for the zbMATH ([25 reviews](#)) and the Mathematical Reviews ([6 reviews](#)).

## Communication activities

I have delivered around 40 presentations concerning my research, mainly as contributions but also as poster presentations or seminars. The pdf files of many of my talks, as well as of the posters, are freely available on my personal homepage. Moreover, I have actively (co)organized a number of congresses, workshops, seminars.

### *Presentations at (inter)national conferences [\* when invited]*

**Jul 2023\*** “*Smash and crossed product decompositions of universal enveloping algebras and Lie-Rinehart algebra connections*”, Communication at the conference “Hopf Algebroids and Noncommutative Geometry”, Queen Mary University of London, London (UK).

**Jul 2023\*** “*On a correspondence between ideal coideals and coideal subrings of Hopf algebroids*”, Communication at the Tenth Congress of Romanian Mathematicians, University of Pitești, Pitești (Romania).

- Sep 2022\*** “*From left ideal two-sided coideals to normal Hopf ideals in Hopf algebroids, and groupoids*”, Communication at the conference “New Trends in Hopf Algebras and Monoidal Categories”, Università di Torino, Torino (Italy).
- Jul 2022\*** “*Smash and crossed product decompositions of universal enveloping algebras and Lie-Rinehart algebra connections*”, Communication at the conference “Hopf algebras, monoidal categories and related topics”, Simion Stoilow Institute of Mathematics of the Romanian Academy, Bucharest (Romania).
- Jun 2022** “*From left ideal two-sided coideals to normal Hopf ideals in Hopf algebroids, and groupoids*”, Communication at the conference “Noncommutative Geometry and Higher Structures”, Scalea (Italy).
- Dec 2021** “*Sul Problema dell’Integrazione per gli Algebroidi di Lie*”, Communication at the conference “Welcome Home 2021”, Università di Torino, Torino (Italy).
- Sep 2021\*** “*A mathematical overview of universal enveloping algebras and their universal properties*”, Communication at the conference “Geometry for Higher Spin Gravity: Conformal Structures, PDEs, and Q-manifolds”, Erwin Schrödinger International Institute for Mathematics and Physics (ESI), Vienna (Austria).
- Sep 2021** “*Globalization for Geometric Partial Comodules*”, short presentation at the “Category Theory CT 20-21”, Università degli Studi di Genova, Genoa (Italy).
- Jun 2021** “*Globalization for geometric partial comodules*”, Communication at the “Categories and Companions Symposium 2021”, online.
- Dec 2020** “*A gentle introduction of the Connes-Moscivici’s bialgebroid and its universal properties*”, Communication at the conference “Welcome Home 2020”, Università di Torino, Torino (Italy).
- May 2019** “*A pair of Frobenius pairs for Hopf modules*”, Communication at the conference “Rings, Modules, and Hopf Algebras”, Universidad de Almeria, Almeria (Spain).
- Dec 2018** “*Dalle Algebre di Frobenius ai Funtori di Frobenius, alla Teoria delle Algebre di Hopf*”, Communication at the conference “Welcome Home 2018”, Università di Torino, Torino (Italy).
- Oct 2018** “*Tannaka-Kreĭn reconstruction and coquasi-bialgebras with preantipode*”, Communication at the conference “SIC - Séminaire Itinérant de Catégories”, Université de Lille, Lille (France).
- Jul 2018\*** “*An Hopf Algebroid Approach to Jets Spaces and Lie Algebroid Integration*”, Communication at the conference “GTM Seminar: some topics in Commutative Algebra and Algebraic Geometry”, Politecnico di Milano, Milan (Italy).
- Aug 2017\*** “*On Lie-Rinehart algebras and complete duals of co-commutative Hopf algebroids*”, Communication at the conference “Brussels Hopf Algebra Workshop 2017”, Université Libre de Bruxelles, Bruxelles (Belgium).
- Sep 2015\*** “*The Structure Theorem for quasi-Hopf bimodules: from quasi-antipodes to preantipodes*”, Communication at the “III Congreso de Jovenes Investigadores de la RSME”, Universidad de Murcia (Spain).
- Jun 2015** “*On the Structure Theorem for Quasi-Hopf Bimodules*”, Communication at the conference “New trends in Hopf algebras and tensor categories”, Royal Flemish Academy of Belgium for Science and the Arts, Bruxelles (Belgium).

### ***Seminars, posters and other contributions***

- May 2023** “*Closed categories, modules and (one-sided) Hopf algebras*”, 1 hour seminar within the cycle “EQuAL - European Quantum Algebra Lectures”, online.
- Mar 2023** “*Glimpses from truss theory*”, 1 hour seminar within the cycle “Algebra and Representation Theory Seminar”, Università degli Studi di Roma “Tor Vergata”, Rome (Italy).
- Feb 2022** “*Globalization for Geometric Partial Comodules*”, poster presented at the CIMPA school “From Dynamics to Algebra and Representation Theory and Back”, Universidade Federal de Santa Catarina (UFSC), Florianópolis (Brazil).
- Oct 2021** “*About the integration problem for Lie algebroids*”, 1 hour seminar within the cycle *NCG&T Seminar* at Charles University, Prague.
- Jun 2021** “*Universal properties of universal enveloping algebras: a bestiary of adjunctions*”, 1 hour seminar within the cycle *Geometric methods in Mathematics* at Dresden, online.
- Jun 2021** “*Globalization for geometric partial comodules*”, 1 hour seminar at the “ItaCa Fest 2021”, online.
- May 2021** “*Globalization for geometric partial comodules*”, 1 hour seminar within the cycle *Quantum Groups Seminars*, online.

- Jan 2021** “*Connes-Moscovici’s bialgebroids as universal enveloping algebras of anchored Lie algebras*”, 1 hour seminar within the cycle *Quantum Algebras*, Queen Mary University of London (UK).
- Dec 2020** “*A gentle introduction of the Connes-Moscovici’s bialgebroid and its universal properties*”, 1 hour seminar within the cycle *SPP@ULB*, Bruxelles (Belgium).
- Mar 2020** “*More on Frobenius and Hopf*”, poster presented at the spring school “TiCT - Topics in Category Theory”, International Centre for Mathematical Sciences, Edinburgh (UK).
- Dec 2019** “*Interactions between differential algebra and Hopf algebra theory*”, 1 hour seminar within the cycle *Antwerp Algebra Seminar*, Antwerp (Belgium).
- Oct 2019** “*Hopf Algebras, Frobenius Functors and the Structure Theorem of Hopf Modules*”, 1 hour seminar, Swansea University, Swansea (UK).
- Jul 2019** “*On Frobenius and Hopf*”, poster presented at the CIMPA school “Research School on Quantum Simmetries”, Universidad de los Andes, Bogotá (Colombia).
- May 2019** “*One-sided Hopf algebras and Frobenius pairs of functors for Hopf modules*”, 1 hour seminar within the cycle *ALGB Seminars* organized by the Algebra Research Group ALGB of the VUB, VUB, Bruxelles (Belgium).
- Mar 2019** “*One-sided Hopf algebras and Frobenius pairs of functors for Hopf modules*”, 1 hour seminar within the cycle *Seminar on Quantum groups, Hopf algebras and monoidal categories* organized by VUB, ULB and UCL, UCL, Louvain-la-Neuve (Belgium).
- Jan 2019** “*Antipodes vs Preantipodes*”, poster presented at the conference “Aspects of Higher Representation Theory: Quantum Groups and Categorification”, VUB, Bruxelles (Belgium).
- Dec 2018** “*Antipodes vs Preantipodes*”, poster presented at the conference “Quantum 60, Colloquium on Algebra and Representations”, Huerta Grande, Cordoba (Argentina).
- Nov 2018** “*Hopf Algebroids and the integration problem for Lie Algebroids*”, 1 hour seminar, Campus of Ceuta of the University of Granada, Ceuta (Spain).
- Mar 2018** “*A survey on Hopf algebra theory between algebra and geometry*”, 1 hour seminar within the cycle *Seminari di Algebra e Geometria Algebraica*, Department of Mathematics “G. Peano”, University of Turin (Italy).
- Mar 2018** “*Una (breve) introduzione alle algebre di Hopf*”, 1 hour seminar within the cycle *Mathematics Ph.D. Seminars*, Department of Mathematics “G. Peano”, University of Turin (Italy).
- Dec 2016** “*A Reconstruction Theorem for Coquasi-bialgebras with Preantipode*”, 1 hour seminar within the cycle *Seminar on Quantum groups, Hopf algebras and monoidal categories* organized by VUB, ULB and UCL, Université libre de Bruxelles, Bruxelles (Belgium).
- Apr 2016** “*Finite dual constructions*”, 2 hours seminar, University of Bucharest (Romania).
- Nov 2015** “*A duality result for (dual) quasi-bialgebras*”, 1 hour seminar, IEMath, Granada (Spain).
- Dec 2014** “*Il preantipode ed il Teorema Fondamentale di Struttura per i quasi-bimoduli di Hopf*”, 1 hour seminar within the cycle *Mathematics Ph.D. Seminars*, Department of Mathematics “G. Peano”, University of Turin (Italy).
- Aug 2014** “*Il preantipode ed il Teorema Fondamentale di Struttura per i quasi-bimoduli di Hopf*”, 1/2 hour seminar, Department of Mathematics and Computer Science, University of Ferrara (Italy).

### ***Collaboration in organizing congresses, workshops, seminars***

- Conference: *Hopf Days in Brussels 2023* together with R. Aziz, J. Vercruyssen. ULB - Université Libre de Bruxelles, September 4-5, 2023.
- Summer school: *BSSM - Brussels Summer School in Mathematics 2023* together with R. Aziz, W. Hautekiet, T. Saille. ULB - Université Libre de Bruxelles, August 28-September 1, 2023.
- Conference: *Second Antipode Workshop* together with M. D’Adderio, J. Vercruyssen. ULB - Université Libre de Bruxelles, September 12-13, 2022.
- Summer school: *BSSM - Brussels Summer School in Mathematics 2022* together with R. Aziz, Y. Chamaoui, W. Hautekiet, T. Letourmy, T. Saille, P. Van Overschelde. ULB - Université Libre de Bruxelles, August 29-September 2, 2022.
- Conference: *Advances in Hopf Algebroids* together with A. Ghobadi. Online, July 7, 2021.

- Seminars: *SPP@ULB - Students meet PhDs and Postdocs at ULB*. Cycle of Mathematics PhD seminars. ULB, 2019 - ongoing.
- Workshop: *Mini-Workshop: A Categorical Day in Turin* together with A. Ardizzoni, C. Bertolin and F. Cardone. University of Turin (Italy), May 11, 2017.
- Conference: *Brauer groups, Hopf algebras and monoidal categories. A conference in honour of Stef Caenepeel on the occasion of his 60th birthday* together with A. Agore, A. Ardizzoni, S. Dăscălescu, I. Goyvaerts, G. Militaru and J. Vercruysse. University of Turin (Italy), May 24-27, 2016.
- Workshop: *Workshop on Hopf Algebras and Related Topics* together with A. Ardizzoni and I. Goyvaerts. University of Turin (Italy), January 21-22, 2016.
- Conference: *Ferrara Algebra Workshop, a Congress in Honor of Prof. Claudia Menini* together with A. Ardizzoni, E. Ermili, F. Ermili, R. Ermili and F. Stumbo. University of Ferrara (Italy), September 17-18, 2015.

## Scientific collaborations

- Alessandro Ardizzoni, Università di Torino (Italy).
- Eliezer Batista, Universidade Federal de Santa Catarina (Brazil).
- Xavier Bekaert, Université de Tours (France).
- Simion Breaz, Babeş-Bolyai University (Romania).
- Tomasz Brzeziński, Swansea University (UK).
- Michele D'Adderio, William Hautekiet & Joost Vercruysse, Université Libre de Bruxelles (Belgium).
- Laiachi El Kaoutit, Universidad de Granada (Spain).
- Niels Kowalzig, Università di Roma Tor Vergata (Italy).
- Bernard Rybołowicz, Heriot-Watt University (UK)
- Dragos Ştefan, Universitatea din Bucureşti (Romania).

## Periods as visiting researcher

- Institut Henri Poincaré, Paris (France), with X. Bekaert and N. Kowalzig. 26 June 2023 - 30 June 2023.
- Università degli Studi di Roma “Tor Vergata” (Italy) with prof. F. Gavarini. 14 March 2023 - 23 March 2023.
- Università degli Studi di Roma “Tor Vergata” (Italy) with N. Kowalzig. 10 June 2022 - 17 June 2022.
- Universidade Federal de Santa Catarina (Brazil) with prof. E. Batista. January 24, 2022 - February 21, 2022.
- University of Granada (Spain) with prof. L. El Kaoutit. November 24, 2019 - December 4, 2019.
- Swansea University (UK) with prof. T. Brzeziński. October 6, 2019 - October 19, 2019.
- University of Granada (Spain) with prof. L. El Kaoutit. November 5, 2018 - November 14, 2018.
- University of Granada (Spain) with prof. L. El Kaoutit. November 17, 2017 - November 30, 2017.
- University of Bucharest (Romania) with prof. D. Ştefan, February 15, 2016 - May 17, 2016.
- University of Granada (Spain) with prof. L. El Kaoutit. November 2, 2015 - December 2, 2015.

## Participation to Research Projects

- Member of the Working Group “CaLISTA - Cartan geometry, Lie, Integrable Systems, quantum group Theories for Applications”, COST action CA21109, action chair R. Fiorese (2022 - today)
- Personal project “*HoPFACT* - Hopf algebroids, Partial actions and Frobenius functors across Algebra and Category Theory” as chargé de recherches of the FNRS at the ULB (2020 - 2023)
- Personal project “*(CO)REPRESENTATIONS* - Categorical aspects and properties in the theory of quantum groups and their algebraic and geometric implications” as collaborateur scientifique of the FNRS at the ULB (2019 - 2020)
- Participant to the MIS project “ANTIPODE” (FNRS) at the ULB, coordinated by J. Vercauteren (2018 - 2019).
- Participant to the local research project *Ricerca Finanziata dall'Università (ex 60%)*, Type A, “Algebra e dintorni” of the University of Turin, coordinated by A. Ardizzoni (2017 - 2019).
- Participant to the local research project *Ricerca Finanziata dall'Università (ex 60%)*, Type A, “Algebra e Argomenti Correlati” of the University of Turin, coordinated by M. Roggero (2016 - 2017).
- Participant to the *Proyectos de I+D+I* (Programa Estatal de Fomento de la Investigación Científica y Técnica de Excelencia, Spain) of the Ministerio de Economía y Competitividad, research project “Avances y Nuevas Perspectivas en Estructuras de Algebroides de Hopf, Grupoides y Algebroides de Lie”, grant MTM2016-77033-P, coordinated by L. El Kaoutit (2016 - 2019).
- Participant to the local research project *Ricerca Finanziata dall'Università (ex 60%)*, Type A, “Algebra e sue applicazioni” of the University of Turin, coordinated by M. Roggero (2015 - 2016).
- Participant to the local research project *Ricerca Finanziata dall'Università (ex 60%)*, Type B - Young Researchers, “Algebra, Geometria Algebrica e Storia” of the University of Turin, coordinated by C. Bertone (2015 - 2016).
- Participant to the local research project *Ricerca Finanziata dall'Università (ex 60%)*, Type A, “Algebra e Geometria Algebrica e loro applicazioni” of the University of Turin, coordinated by M. Roggero (2014 - 2015).
- Participant to the local research project *Ricerca Finanziata dall'Università (ex 60%)*, Type B - Young Researchers, “Algebra e Geometria Algebrica” of the University of Turin, coordinated by A. Ardizzoni (2014 - 2015).

## Membership of organizations or research institutes

**EMS** Associate of the *European Mathematical Society* (2020 - today).

**BMS** Associate of the *Belgian Mathematical Society* (2020 - today).

**GNSAGA (INdAM)** Member of the *Gruppo Nazionale per le Strutture Algebriche, Geometriche e loro Applicazioni*, section *Strutture algebriche e geometria combinatoria* (2014 - today).

**UMI** Associate of the *Unione Matematica Italiana* (2014 - today).

## Prices and awards

(02/10/2022) *Abilitazione Scientifica Nazionale* alle funzioni di professore universitario di Seconda Fascia nel Settore Concorsuale 01/A2 - GEOMETRIA E ALGEBRA, from Ministero dell'Università e della Ricerca.

(17/03/2021) *Acreditación a Profesor Ayudante Doctor* from ANECA.

(08/03/2021) *Acreditación a Profesor Ayudante Doctor* from DEVA.

(21/01/2020) *Qualification “Maître de conférences”*. Qualification number 20225333775.

(06/11/2018) *Quality award - year 2017*, assigned by the Politecnico di Torino (Italy) to recognize and encourage excellence in research (shared with other deserving PhD students) for my research activity during 2017.

(17/11/2017) *Quality award - year 2016*, assigned by the Politecnico di Torino (Italy) to recognize and encourage excellence in research (shared with other deserving PhD students) for my research activity during 2016.

(06/05/2016) *Medaglia d'argento* and *Premio Picco Botta* from the University of Turin (Italy) for the best master thesis in Mathematics (shared with Luca Alasio).

(01/10/2012) *Menzione Optime* (acknowledgement of merit in study) from Unione Industriale di Torino (Italy).

## Fundings

(24/04/2022 - 21/05/2022) *Chaire internationale to prof. Tomasz Brzeziński*, €4000.00. The “Chaires internationales” are aimed at inviting established scientific personalities to the ULB for a period of one month for collaboration in teaching and/or research.

(03/09/2020) *Funding from the GNSAGA*, €900.00, assigned by the GNSAGA-INdAM (Italy) for a research period in Granada (gave up due to COVID-19 pandemic).

(27/05/2020) *Fonds Agathon De Potter*, €850.00, assigned from the Académie Royale de Belgique to participate to the conference “*Hopf algebras, categories and related topics*” in Bucharest in July 2020 (gave up due to COVID-19 pandemic).

(01/10/2020 - 30/09/2023) *Chargé de Recherches* of the F.R.S.-FNRS at the ULB of Bruxelles (Belgium).

(01/10/2019 - 30/09/2020) *Collaborateur scientifique* of the F.R.S.-FNRS at the ULB of Bruxelles (Belgium).

(01/05/2018 - 30/09/2019) *Postdoctoral fellowship* at the ULB of Bruxelles (Belgium).

(14/02/2016 - 17/05/2016) *Erasmus Scholarship*, €690,00, to spend a training and research period at the University of Bucharest.

(22/06/2015) *IEMath-GR support for visits of young talented researchers*, €1000.00, assigned by the IEMath of Granada (Spain) to spend a research period at the University of Granada.

(19/12/2014) *Funding from the GNSAGA*, €624.00, assigned by the GNSAGA-INdAM (Italy) to participate to the “*Congreso de la Real Sociedad Matematica Española 2015*”.

(01/11/2014 - 31/10/2017) *Ph.D. scholarship* at the University of Turin (Italy).

## Other activities

- I contributed to the visitor’s guide of the exhibition “Order of Operations” (04/06-11/07, 2021), conceived and produced by Ohme in co-production with Bozar.

## TEACHING EXPERIENCE

### Theses supervised

**2023** Supervisor of the research work of Vlad Stroia “Groebner bases and computational algebraic geometry” for the course *Travail de recherche et communication scientifique* at ULB (bachelor thesis).

**2023** Supervisor of the research work of Hanka Lednicka “Les groupes de Lie” for the course *Travail de recherche et communication scientifique* at ULB (bachelor thesis).

**2020** Supervisor of the research work of Eliott Van Steirteghem “Axiom of Choice and Applications” for the course *Travail de recherche et communication scientifique* at ULB (bachelor thesis).

**2017** Co-supervisor of Irene Soccolini’s master thesis “Poincaré-Birkhoff-Witt Theorem and its extensions”.

Furthermore, I have been member of the jury of the master thesis of Léonel Damdja Mfondja (ULB, August 2021) and of Francisco Gabriel Klock Campos Vidal (Universidade Federal de Santa Catarina, February 2024).

### Teaching

*Duties: preparing and giving lectures and exercise sessions, office hours.*

**Spring 2022** ULB, *Algèbre et géométrie III - Algèbre non-commutatif* (coordinator Špela Špenko) - exercise sessions for 24h out of 48h [2,5 out of 5 ETCS]

**Fall 2021** ULB, *Algèbre et géométrie II - Algèbre commutatif* (coordinator Joost Vercruyssen) - exercise sessions for 24h out of 48h [2,5 out of 5 ETCS]

**Spring 2021** ULB, *Algèbre et géométrie III - Algèbre non-commutatif* (coordinator Špela Špenko) - exercise sessions for 12h out of 48h [1,25 out of 5 ETCS]

**Spring 2021** ULB, *Algèbre et géométrie I - Géométrie Affine et Projective* (coordinator Špela Špenko) - exercise sessions for 12h out of 96h [1,25 out of 10 ETCS]

**Fall 2020** ULB, *Algèbre et géométrie II - Algèbre commutatif* (coordinator Joost Vercruysse) - exercise sessions for 12h out of 48h [1,25 out of 5 ETCS]

**Spring 2020** ULB, *Algèbre et géométrie III - Algèbre non-commutatif* (coordinator Špela Špenko) - exercise sessions for 24h out of 48h [2,5 out of 5 ETCS]

**Spring 2020** ULB, *Algèbre et géométrie I - Géométrie Affine et Projective* (coordinator Špela Špenko) - exercise sessions for 24h out of 96h [2,5 out of 10 ETCS]

**Spring 2019** VUB, *Hopf Algebras and Quantum Groups* (with Joost Vercruysse) [2 out of the 6 ECTS]

## Tutoring

*Duties: tutorial classes and additional exercise sessions, supporting students in preparing for the exams.*

**Fall 2017** University of Turin, *Collaborazione didattica per cicli di esercitazioni* (art. 76): *Tutorato di Matematica I*, Degree in Chemistry and Chemical Technologies, University of Turin.

**Fall 2016** University of Turin, *Collaborazione didattica per cicli di esercitazioni* (art. 76): *Tutorato di Matematica I*, Degree in Chemistry and Chemical Technologies, University of Turin.

**Fall 2014** University of Turin and CRT Foundation, *Collaborazione didattica per cicli di esercitazioni* (art. 76): *DMT project*.

**2013** University of Turin and Ministry of Education, University and Research, *PP&S project*.

**Spring 2013** University and Municipality of Turin, *Borsa studenti part-time* (art.13): *Scuola dei Compiti project*.

**Spring 2011** University of Turin, *Borsa studenti part-time* (art.13): *Calcolo delle Probabilità e Statistica*.

## INSTITUTIONAL OFFICES

**2016 - present** Exam committee member (italian *cultore della materia*) for the Scientific Disciplinary Sector MAT/02 Algebra. Appointed on the 14/07/2016 at the Department of Mathematics “G. Peano”, University of Turin (Italy). Duties: grading final exams.

**2019** Member of the panel for the prize “Premio Iava” at the Liceo Classico Europeo “Umberto I” of Turin.

**2015 - 2017** Member of the Research Commission at the Dept. of Mathematics “G. Peano” of the University of Turin.

## PERSONAL SKILLS AND COMPETENCES

### Language certificates

#### *English*

**May 2015** University Language Centre (CLA-UniTO) test.  
Common European Framework for Languages (CEFR): level B2.

**Mar 2007** English for Speakers of Other Languages (FCE), University of Cambridge (United Kingdom).  
Common European Framework for Languages (CEFR): level B2.

#### *Spanish*

**Feb 2007** Diploma de Español como Lengua Extranjera (DELE, Nivel intermedio), Instituto Cervantes  
Common European Framework for Languages (CEFR): level B2.

#### *Romanian*

**May 2016** Language Certificate from the Department of Romanian Language and Literature, University of Bucharest  
Common European Framework for Languages (CEFR): level A2.

## Other skills and competences

L<sup>A</sup>T<sub>E</sub>X, Maple suite (Maple, Maple SIM, Maple TA), R, Python, Statistica, Matlab, HTML, C++, Microsoft Office packages.

I hereby authorize the processing of the personal data contained in this CV in compliance with the Italian Personal Data Protection Code (D. Lgs. no. 196, 30 June 2003).

Bruxelles, April 9, 2024,

A handwritten signature in blue ink, appearing to read 'Palo...'. The signature is written in a cursive style and is positioned below the date.