Regional Program MATH-AmSud
2016 Project Proposal (Research – Innovation)

Basic Form

- This form, and the associated CVs, must be filled **in English.** Before filling the form, please read carefully the bases published in the MATH-AmSud site (http://www.mathamsud.org/).
- This form must be sent by email in **.pdf** to the MATH-AmSud Secretariat (**math@mathamsud.org**) by the project's International Coordinator.

A. General Information

A1	Project title
	Lie-type structures

A2	Acronym
	LIETS

A3	Research domain
	Algebra, Combinatorics, Physics

A4	Project goals
	The aim of the project is to consolidate cooperation between groups of Argentina and Chile whose research topic is Lie algebras and their applications, and researchers of the Universities of Paris-Orsay, Paris-Diderot and Toulouse for the French counterpart.

A5	Abstract

	The proposal deals with different aspects of Lie algebras. The problems considered in the proposal are: a) The study of higher cup products in cohomology. Our main example is the brace structure which determines the Lie structure of Hochschild cohomology, brace algebras are described by certain non-cocommutative Hopf algebras, called dendriform bialgebras. Our goal is to find a notion of higher dendriform bialgebras whose subspace of primitive elements are determined by McClureSmith operad, whose binary operations are precisely the higher cup products. b) The description of the dendriform and brace structure on the c) The classification of involutive set-theoretical solutions of the Yang-Baxter equation, via the description of the cohomology groups of left braces and linear cycles. d) To extend the Lifshitz-Cardy formula in higher dimension to provide a microscopic account of the entropy of Lifshitz black holes.

A6	Scientific coordinators at each institution			
	South America A		**South America B**	
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A7	**Other participating institutions**	
	In South America Facultad de Astronomía, Matemática y Física (FaMAF),Universidad Nacional de Córdoba, Argentina.	**In France** - Laboratoire de Physique Théorique d'Orsay, Université de Paris-Sud. - Institut de Mathématiques, Université Paul Sabatier, Toulouse III. - Institut Mathématique Jean-Leray, Nantes.

A8	**List of expected participants (name and affiliation)**

	Eugene Babichev, Chargé de Recherche, Laboratoire de Physique Théorique d'Orsay, France. Emily Burgunder, Maître de Conférences, Institut de Mathématiques, Université Paul Sabatier, Toulouse III, France. Victoria Lebed, post-doc, Institut Mathématique Jean-Leray, Nantes, France. Muriel Livernet, Professor, Univ. Paris Diderot, Paris, France. Daniel López Neumann, Ph.D. student, Univ. Paris Diderot, Paris, France. Leandro Vendramin, Professor, Departamento de Matemáticas, Facultad de Ciencias Exactas y Naturales-Conicet, Universidad de Buenos Aires, Argentina. Agustín García Iglesias, Assistant Professor, CIEM, Facultad de Astronomía, Matemáticas y Física (FaMAF)-Conicet, Universidad Nacional de Córdoba, Argentina. Leandro Guarnieri, Ph.D. student, Departamento de Matemáticas, Facultad de Ciencias Exactas y Naturales-Conicet, Universidad de Buenos Aires, Argentina. Emiliano Acri, Ph.D. student, Departamento de Matemáticas, Facultad de Ciencias Exactas y Naturales-Conicet, Universidad de Buenos Aires, Argentina. Juan Orza, Ph.D. student, Departamento de Matemáticas, Facultad de Ciencias Exactas y Naturales-Conicet, Universidad de Buenos Aires, Argentina. Jorge Espinoza, Ph.D. student, Instituto de Matemática y Física, Universidad de Talca, Chile. Mokthar Hassaine, Professor, Instituto de Matemática y Física, Universidad de Talca, Chile. Steen Ryom-Hansen, Professor, Instituto de Matemática y Física, Universidad de Talca, Chile. María Ronco, Professor, Instituto de Matemática y Física, Universidad de Talca, Chile.

A9	**International Project Coordinator (to be chosen among the Scientific Coordinators mentioned in A6)**
	María Ronco, Instituto de Matemáticas,y Física (IMAFI), Universidad de Talca, Chile.

B. Project Details

B1. Project guidelines

I. **McClure-Smith operad of surjections.** Our aim is to find non-symmetric Hopf operads whose operad of primitive elements is the homotopically equivalent to the McClure-Smith operad ***S***_n. We will try to understand the structure of ***S***_n algebra of the higher Hochschild cohomology groups, introduced by T. Pirashvili.

II. **Hopf operads associated to lattice paths and to Lam and Pylyavskyy Hopf algebras.** We want to construct non-symmetric Hopf operads which generalize the operads defined on the spaces of m-Dyck paths, on the space spanned by all lattice paths, following previous works of L.-F. Préville-Rattelle and X. Viennot. We expect to compute the associated operads of primitive elements, and get a standard way to obtain m-versions of operads generated by binary operations. We also expect to study K-analogs of the operads of dissociative and dendriform algebras, whose free objects are described by T. Lam and P. Pylyavskyy K-theoretic analogues of the algebras of noncommutative symmetric functions and of planar rooted trees Hopf algebra.

III. **Cycle sets (or LD-systems) and set- theoretical braces.** We want to compute the Betti numbers of cyclic sets and their homology, as well as the 2-cocycles of braces. And also to study braided tensor products of braces.

IV. **Yang-Baxter equation, racks and Loday type algebras.** We want to understand the dendriform structure on the (co)homology theory of racks, as well as to set an appropriate framework to study the relationship between the set-theoretical Yang-Baxter equation, racks and set-theoretical braces, on one side, and dialgebras, dipterous and brace algebras, on the other side.

V. ***Cardy formula for Lifshitz black holes*.** Extend the Lifshitz Cardy formula in higher dimension, expecting to provide a microscopic account of the entropy of the Lifshitz black holes. Such formula can also be of interest in the search of entropy bound.

B2. Project description

Goals, motivation, methodology and contribution of each participating institution

The methodology and contribution of each participating institution are clearly exposed in the Project scope. The goals of the project are to solve the proposed problems.

M**otivation:**

I) Leibniz algebras are a non-commutative version of Lie algebras, introduced by J.-L. Loday in an attempt to set a suitable framework to work on non-commutative algebra. The study of this type of algebras led to the definition of new algebraic structures (described in [Jll1]) which play the role of universal enveloping algebras of Leibniz algebras (called dissociative algebras), and the Koszul duals of Leibniz and dissociative algebras (called Zinbiel algebras and dendriform algebras, respectively) which provide the chain complexes defining the the homology theories of these algebras. Surprisingly, there existed in literature many examples of these new types of structures: Leibniz algebras had been defined by A. Bloh in his study of Cartan-Eilenberg homology for generalized Lie algebras (see [Blo]), and dendriform relations had been described by S. Eilenberg and S. MacLane in the context of singular homology of certain CW spaces (see [EML]).

Loday's type algebras have been widely studied in the last 15 years.

- M. Aguilar showed in [Agu1] and [Agu2] that any Baxter algebra (also called Rota-Baxter algebra) gives rise to a dendriform algebra, and that it is possible to construct Baxter, and therefore dendriform algebras, from quasitriangular infinitesimal bialgebras. He also proved that diassociative algebras may be obtained in a similar way from associative algebras equipped with an average operator. These results were followed by works on the generalizations and applications of these theories, essentially by C. Bai, L. Guo and their collaborators (see [BGN] and [BBGN]), P. Kolesnikov (see [GuKo1]), K. Uchino (see [Uch1] and [Uch2]), and more recently T. Brzezinski (see [Brz]).

- Free dendriform algebras are equipped with a natural structure of non-cocommutative Hopf algebras. In particular, the free object on one element is a Hopf subalgebra of the Malvenuto-Reutenauer Hopf algebra of permutations (see [MaRe] and [LoRo1]). In fact, the free dendriform algebra on one element is a non-commutative version of Connes-Kreimer Hopf algebra appearing in the context of renormalization theory (see [CoKr]). These results motivated several works on Hopf algebras defined on spaces spanned by families of combinatorial objects, as planar trees, permutations and functions between finite sets, etc. (see for instance [HNT1], [NTT], [NoTh], [HNT2] and [FNT], also an operadic interpretation of these combinatorial Hopf algebras in [Liv1]), as well as publications on non-commutativee renormalisation theory (see [BrFr], [BFK], [EFMa1], [EFMa2] and [EFMa3]).

- In [Ron], we proved that the subspace of primitive elements of any dendriform bialgebra is a brace algebra, in the sense of M. Gerstenhaber and A. Voronov (see {GerVor]), in such a way that there exists an equivalence between the category of conilpotent dendriform bialgebras and the category of brace algebras. The free dendriform structure on the space spanned by the set of planar binary rooted trees was extended to the space spanned by all the faces of associahedra by F. Chapoton (see [Cha]), by defining a dendriform operad equipped with an extra associative product and a differential, which we called a 0-tridendriform algebra. In [BuRo], we proved that the subspace of primitive elements of any 0-tridendriform bialgebra is a differential associative algebra equipped with brace operations, this structure is homotopy equivalent to the J. McClure and J.Smith operad $\boldsymbol{S}$_2. Again, we were able to show that the category of $\boldsymbol{S}$_2 algebras is equivalent to the category of conilpotent 0-tridendriform bialgebras.

The aim of the algebraic part of the present project is to exploit the applications of Loday's type algebras to problems in combinatorics, physics and topology.

II) In the last decade, there has been an intense activity in order to promote the ideas underlying the standard anti-de Sitter/Conformal Field Theory correspondence [M] to conformal non-relativistic physics. This is mainly motivated by the fact that several non-relativistic conformal models that govern physics exist in different experimentally accessible areas such as in condensed matter physics. As in the standard case, the hope is to gain a better understanding of strongly coupled systems, and particularly to physical systems exhibiting a dynamical scaling near fixed points. These latter are characterized by an anisotropic scaling symmetry where the time and the space scale with different weight. The scaling weight of the time is called the dynamical exponent, and is generally represented by the letter z (the isotropic AdS case corresponding to z=1). In this case, the gravity dual metric, the so-called Lifshitz spacetime, admits this anisotropic scaling symmetry as part of their isometry, see [KLM]. The natural extension of the construction of [KLM] is to look for black hole configurations that asymptote the Lifshitz spacetimes. Holographically, they should describe the finite temperature behavior of some non-relativistic theories. Black hole solutions of this type are known with the name of ``Lifshitz black holes", and the quest for such solutions has received much attention, see e. g. [BBP] [DM] and [AGGH].

Project scope: The problems we propose to deal with in the present project are:
I) (M. Livernet, D. López N. and M. Ronco; Univ. de Paris-Diderot, Univ. de Talca) In [GerVor], M. Gerstenhaber and A. Voronov defined brace operations on the space CC*(A) of Hochschild cochains of an associative algebra A, which induce, together with the cup product, the Gerstenhaber algebra structure on the Hochschild cohomology HH*(A).
F. Cohen showed that if a space X is an algebra over the operad of singular chains of the topological operad of small cubes Q_2, defined by J. Boardman and R. Vogt , then its homology is a Gerstenhaber algebra. This result motivated Deligne's conjecture: does the Gerstenhaber algebra structure of HH*(A) come from an action of the algebraic operad Sing(Q_2) of singular chains on the Hochschild cochain complex CC*(A)? Deligne's conjecture was solved by J. McClure and J. Smith (see [McCl1] and [McCl2]) by giving an explicit description of an operad $\boldsymbol{S}$, endowed with a filtration satisfying that $\boldsymbol{S}$_n is weakly equivalent to Sing(Q_n). The operad $\boldsymbol{S}$_1 is the operad of associative differential algebras and $\boldsymbol{S}$_2 is spanned by an associative product and a brace structure, satisfying the same relations than the Gerstenhaber-Voronov operations on the Hochschild cochains. The n-ary operations of $\boldsymbol{S}$ are described by non-degenerate surjective maps. There exists several proofs of Deligne's conjecture, as well as constructions of filtered operads F which fully describe the structure of the loop spaces (see [BeFr]). The n-stage of such a filtration is called an E_n-operad. Using the description of the 0-tridendriform operad,

we got in [BuRo] a simple description of the operad S_2 in terms of two copies of the set of planar rooted trees with colored leaves.

Problem 1. As we explained in the previous paragraphs, it is possible to describe the operad ***S***_2, which is symmetric and generated by an infinite family of operations, using the operad of 0-tridendriform algebras, which is non-symmetric and generated by three binary operations. The question is if it is possible to construct a non-symmetric filtered operad T(n) satisfying that:
1. T(1) is the operad of associative differential algebras, and T(2) is the operad of 0-tridendriform algebras.
2. T(n) is spanned by a finite number of operations , for $n \geq 1$,
3. T(n) is a Hopf operad (which seems to be a natural condition because, but there are some problems about units to fix),
4. for $n \geq 1$, there exists an operad morphism from ***S***_n to T(n), such that for any T(n)-bialgebra A the subspace of its primitive elements Prim(H) is a ***S***_n subalgebra of H,
5. there exists an equivalence of categories between conilpotent T(n) bialgebras and ***S***_n algebras.
In fact, the surjection operad ***S*** may be replaced by some weakly equivalent operad. Our aim is to define higher dendriform structures, whose primitive operads describe higher braces.

Problem 2. It is known that the operad ***S***_n acts on Pirashvili higher Hochschild cochains HC*(n) (see [Pir]), for $n \geq 1$. However, it does not exist a description of the action of ***S***_n, for $n > 1$. A question related to Problem 1 is to get a description of the ***S***_n algebra structure of on HC*(n).

II) **Lattices of paths and the path lattice operad.** (M. Livernet, D. López N. and M. Ronco; Univ. de Paris-Diderot, Univ. de Talca) In [BaBe] and [BaBeMa], M. Batanin, C. Berger and M. Markl described different operads equipped with a natural action on the space of Hochschild cochains of an associative algebra. They described the lattice path operad ***L*** on sets, and give another way to prove Deligne's conjecture.
On the other hand, there exists there exist natural algebraic structures defined on the vector space spanned by lattice paths (see [PRVi]). In general, for $m > 1$, m-Dyck paths are a particular family of lattice paths, which are being widely studied due to their relation with Garsía-Haiman spaces (see [BePR]). In a joint work with D. López N. and L.-F. Préville-Ratelle (see [LPRR]), we described an m-version of dendriform structures on the spaces of m-Dyck paths, and defined a non-symmetric Hopf operad ***Dyck***(m) on the vector space spanned by m-Dyck paths, related to Bergeron's m-Tamari lattice.

Problem 3. The operad of 0-tridendriform algebras is obtained from the operad of dendriform algebras, by considering the geometric realization of the poset of planar binary trees and extending the operad from the space spanned by the vertices of the associahedra, to the space spanned by all the faces. A natural question is to do an perform a similar process on the operad ***Dyck***(m), for $m \geq 2$, in order to study the differential operad associated to it . So, we need to get a description of the geometric realization of the m-Tamari poset in order to extend the operad ***Dyck***(m) to a graded differential operad. In a recent talk, M. Konvalinka, explains how he, I. Pak and H. Thomas proved that the r-Tamari lattice is the 1-skeleton of a polyhedral complex, their construction will be our basis to work on this problem.

Problem 4. In [PRVi], L.-F. Préville-Ratelle and X. Viennot constructed, for any finite path P, a lattice Tam(P). For particular choices of P, they recover the classical Tamari lattice and the m-Tamari lattice. We want to use their construction to extend the operads ***Dyck***(m) to a filtered operad on the space of all paths.

III) (E. Burgunder, M. Livernet, M. Ronco; Univ. de Toulouse III, Univ. Paris-Diderot, Univ. de Talca) In [LaPy], T. Lam and P. Pylyavskyy described three Hopf algebras which they consider as K-theoretic analogues of the algebras of symmetric functions, of noncommutative symmetric functions and of the Malvenuto-Reutenauer Hopf algebra. In [BuRo] we proved that the algebra of big multi permutations ***M***MR defined in [LaPy] is in fact a 1-tridendriform bialgebra, as defined in [LoRo2], which may be obtained as a quotient of the algebra of surjective maps, spanned by the faces of permutohedra.

Problem 5. Compute the Lie algebras of primitive elements of Lam and Pylyavskyy Hopf algebras. Our purpose is to understand the way to generate them as free objects for certain algebraic theories (operads), and to get structure theorems (analogous to the Cartier-Milnor-Moore Theorem) for them. Let us point out that big multi permutations are in bijective correspondence with the operations of the McClure-Smith's operad , so we expect that the study of this Hopf algebra will help us to understand the structures we described in Problem 1).

IV) (V. Lebed and L. Vendramin, Univ. de Nantes, Univ. de Buenos Aires) Braces and linear cycle sets are algebraic structures playing a major role in the classification of involutive set-theoretic solutions to the Yang-Baxter equation. In [VeLe2], we introduced two cohomological theories for this type of objects, mixing the Harrison cohomology and the cohomology theory for general cycle sets, previously developed in [LeVe1]. We classified different classes of brace extensions in terms of second cohomology groups.

Problem 6. Cycle sets (or LD-systems). Compute the Betti numbers of cyclic sets and their homology. Use Dehornoy [Deh] calculus to construct (if possible) the free cycle set. Construct an universal covering of cycle sets and develop a theory of Galois coverings. Integrate cycle sets, pre-Lie algebras could be useful here. Apply cycle set homology [LV2] to construct new (virtual) knot invariants.

Problem 7. Braces. Compute the 2nd homology group of a finite brace [LeVe1]. Construct (if possible) the free brace. Use the Guitar Map [LeVe2] to study braided tensor products of braces.

V) (A. García Iglesias, M. Ronco, S. Ryom-Hansen, L. Vendramin; Univ. Nacional de Córdoba, Univ. de Buenos Aires, Univ. de Talca) The Yang-Baxter equation, racks and braces in their set theoretical version as exposed in [LeVe1] are difficult to deal with in the algebraic operad framework (see [LodVal]), because the relations defining these objects are not linear in the variables. However, there exist linear analogous of these elements, like the associative Yang-Baxter equation, dipterous algebras and brace algebras (see for instance [Agu1], [Agu2] and [LoRo2]). In [Cov], S. Covez described the dendriform structure of the cohomology complex of racks.

Problem 8. Establish a precise relationship between the set-theoretical objects related to the set-theoretical Yang-Baxter equations and M. Aguilar quasi-triangular infinitesimal bialgebras, dialgebras, dendriform algebra and dipterous algebras. Our final aim is to get a clear description of the dendriform algebra structure on the cochains of a rack, which must give a way to compute brace operations on the cochains and to study the existence of a Hodge type decomposition for the rack cohomology.

VI) (E. Babichev, M. Hassaine; Univ. de Paris-Sud, Univ. de Talca) ***Cardy formula for Lifshitz black holes.*** Since the seminal works of Bekenstein and Hawking [B,H], black holes are now considered as thermodynamical systems with a precise notions of temperature and gravitational entropy. On the other, since the entropy as a statistical interpretation as the counting of the microstates of the system, the Bekenstein-Hawking entropy should also count the microscopic states of a black hole. An important step has been done in that direction by Brown and Henneaux [BH] with their observation that the asymptotic symmetries of the three-dimensional AdS space consist in two copies of the Virasoro algebra (central extension of the Witt algebra) with a central charge. This algebra corresponds to the symmetry group of a two-dimensional Conformal Field Theory (CFT). In this case, the Cardy formula, whose derivation is based on the modular invariance, gives a precise counting of the asymptotic density of states just by knowing the values of the central charges and the ground state conformal weight [CA]. Mixing these two results, Strominger presented a simple and very elegant derivation of the entropy of the three-dimensional black hole [ST]. The extension of the Cardy formula for higher dimensional CFT is known as the Cardy-Verlinde formula, and is valid for CFT having a large central charge [VE]. Indeed, in this case, the entropy is no longer an extensive function due to the Casimir effect, and as a consequence the Cardy-Verlinde formula explicitly involves the Casimir energy (the sub-extensive part of the energy).

Problem 9. Recently, in the anisotropic Lifshitz case, a generalization of the Cardy formula has been proposed [GTT]. One of the main ingredients of this derivation was to exploit an isomorphism between the two-dimensional Lifshitz algebras with dynamical exponent z and 1/z. This isomorphism is then translated into a low-high temperature duality which permits to given a formula for the asymptotic growth of the number of states at a fixed energy. In the derivation of the Lifshitz-Cardy formula, neither the asymptotic symmetries nor the central charges were used, but a prominent role is played by the bulk soliton which is seen as the ground state. Note that the robustness and validity of this formula has been checked in many examples; see [GTT]. In a complete analogy with the Cardy-Verlinde formula, it would be interesting to extend the Lifshitz Cardy formula in higher dimension which would provide a microscopic account of the entropy of the Lifshitz black holes. The viability of such formula can be checked with the many examples of Lifshitz black holes present in the current literature. Such formula can also be of interest in the search of entropy bound. The anisotropic version of the Cardy formula does

not make any reference of the central charge, and the prominent role is played by the negative mass of the soliton. Another interesting but highly nontrivial task will consist in exploring if there is a correlation between this soliton mass that is free of any constant of integration and a possible central charge of some affine extension of the Lifshitz algebra.

Bibliography.

[Agu1] M. Aguiar, *On the associative analog of Lie bialgebras*, Journal of Algebra 244 (2001) 492-532.

[Agu2] M. Aguiar, *Infinitesimal bialgebras, pre-Lie and dendriform algebras*, in "Hopf Algebras", Lecture Notes in Pure and Applied Mathematics vol 237, 2004, 1-33.

[AGGH] E. Ayon-Beato, A. Garbarz, G. Giribet and M. Hassaine, *Lifshitz Black Hole in Three Dimensions*, Phys. Rev. D **80**, 104029 (2009).

[BGN] C. Bai, L. Guo, X. Ni, *Nonabelian generalized Lax pairs, the classical Yang-Baxter equation and PostLie algebras*, Communications in Mathematical Physics 297, 2010, 553-596.

[BBGN] C. Bai, O. Bellier, L. Guo, X. Ni, *Splitting of operations, Manin products and Rota-Baxter operators*, International Mathematics Research Notices , DOI: 10.1093/imrn/rnr266, 2012.

[B] J. D. Bekenstein, Phys. Rev. D, Vol. **7**, 1973, 2333-2346.

[BeFr] C. Berger and B. Fresse, *Combinatorial operad actions on cochains*, Math. Proc. Cambridge Philos. Soc. 137 (2004), 135-174.

[BBP] G. Bertoldi, B. A. Burrington and A. Peet, Phys. Rev. D**80**, 126003 (2009).

[Blo] Bloh, A., *Cartan-Eilenberg homology theory for a generalized class of Lie algebras*, Dokl. Akad. Nauk SSSR 175 (8), 1967, 824–826.

[BrFr] C. Brouder, A. Frabetti, *Renormalization of QED with planar binary trees*, Eur. Phys. J. C 19, 2001, 715–741.

[BFK] C. Brouder, A. Frabetti, C. Krattenthaler, *Noncommutative Hopf algebra of formal diffeomorphisms*, Adv. Math. 200 (2) 2006, 479-524.

[BH] J. D. Brown and M. Henneaux, Commun. Math. Phys. **104**, 207 (1986).

[Brz] T. Brzezinski, *Rota-Baxter systems, dendriform algebras and covariant bialgebras*, to appear in J. of Algebra.

[BuRo] E. Burgunder and M. Ronco, *Tridendriform structures on combinatorial Hopf algebras*, Journal of Algebra, Vol. 324, Issue 10 (2010) 2860-2883.

[CA] J. L. Cardy, Nucl. Phys**. B 270**, 317 (1986).

[Cov] S. Covez, *On the conjectural Leibniz cohomology for groups*, Journal of K-Theory, volume 10, issue 03, Cambridge University Press, 2012, , pp. 519-563.

[De] P. Dehornoy, *Set-theoretic solutions of the Yang-Baxter equation, RC-calculus, and Garside germs*,Adv. Math. 282, 2015, 93-127.

[EFMa1] K. Ebrahimi-Fard, D. Manchon; *A Magnus- and Fer- type formula in dendriform algebras*, Found. Comput. Math. Volume 9, Number 3, 2009, 295-316.

[EFMa2] K. Ebrahimi-Fard, D. Manchon; *Dendriform equations*, Journal of Algebra 322, 2009, 4053-4079.

[EFMa3] K. Ebrahimi-Fard, D. Manchon; *The tridendriform structure of a Magnus expansion*, Disc. and Cont. Dynamical Systems Vol. 34 No 3, 2014, 1021 – 1040.

[EML] S. Eilenberg, S. MacLane, *On the groups H(∏, n) II*, Ann. of Math., vol. 60, 1954, 49-139.

[FNT] L. Foissy, J.-C. Novelli, J.-Y. Thibon, P*olynomial realizations of some combinatorial Hopf algebras*, Journal of Noncommutative Geometry, 8 (1), 2014, 141-162.

[GuKo1] V. Gubarev, P. Kolesnikov, *Embedding of dendriform algebras into Rota-Baxter algebras*, Central European Journal of Mathematics, 11(2) , 2013, 226–245.

[GTT] H. A. Gonzalez, D. Tempo and R. Troncoso, JHEP **1111**, 066 (2011).

[H] S. W. Hawking, Commun. Math. Phys. **43**, 199 (1975).

[HNT1] F. Hivert, J.-C. Novelli, J.-Y. Thibon, *The algebra of binary search trees*, Theoretical Computer Science, 339 n. 1, 2005, 129-165.

[HNT2] F. Hivert, J.-C. Novelli, J.-Y. Thibon, *Trees, functional equations, and combinatorial Hopfalgebras*, European Journal of Combinatorics, 29 n.1 (2008), 1682-1695.

[KLM] S. Kachru, X. Liu and M. Mulligan, Phys. Rev. D**78**, 106005, (2008).

[LaPy] T. Lam, P. Pylyavskyy, Combinatorial Hopf algebras and K-homology of Grassmanians, Internacional Math. Research Notices, Vol 2007, Art. ID rmn125, 48 pages.

[LeVe1] V. Lebed, L. Vendramin, *Cohomology and extensions of braces*, http://arxiv.org/abs/1601.01633. Accepted for publication in Pacific J. Math.

[LeVe2] V. Lebed, L. Vendramin, *Homology of left non-degenerate set-theoretic solutions to the Yang-Baxter equation*, http://arxiv.org/abs/1509.07067.

[Liv1] M. Livernet, *From left modules to algebras over an operad: application to combinatorial Hopf algebras*, Annales Mathématiques Blaise Pascal 17, No. 1 (2010), pp. 47-96

[Jll1] J.-L. Loday, *Dialgebras*, in Dialgebras and Related operads, Lect. Notes in Math. 1763, Springer, Berlin 2001, 7-66.

[LoRo2] J.-L. Loday, M. Ronco, *Combinatorial Hopf Algebras*, Quanta of maths, 347–383, Clay Math. Proc., 11, Amer. Math. Soc., Providence, RI, 2010.

[LoVa] J.-L. Loday, B. Vallette, *Algebraic operads*, Grundlehren Math. Wiss. 346, Springer, Heidelberg, 2012.

[M] J. M. Maldacena, Adv. Theor. Math. Phys. **2**, 231 (1998).

[NTT] J.-C. Novelli, J.-Y. Thibon, N. Thiéry, *Hopf algebras of graphs*, Comptes-Rendus de l'Académie des Sciences, Paris Série I, 339, 2004, 607-610.

[NoTh] J.-C. Novelli, J.-Y. Thibon, *A Hopf algebra of parking functions*, proc. FPSAC'04 (Vancouver).

[PRVi] L.-F. Préville-Ratelle, X. Viennot, *An extension of Tamari lattices*, to appear. arXiv:1406.3787.

[ST] A. Strominger, J. High Energy Phys. **02**, 009 (1998).

[Uch1] K. Uchino, *Quantum analogy of Poisson geometry, related dendriform algebras and Rota-Baxter operators*, Lett. in Math. Physics 85, 2008, 91-109.

[Uch2] K. Uchino, *Noncommutative Poisson brackets on Loday algebras and related deformation quantization*, J of Symplectic Geometry, Vol. 11, Number 1, 2013, 93-108.

[Ve] E. Verlinde, hep-th/0008140.

Expected results

Problem 1. We expect to provide examples of **S**-algebras by considering infinitesimal bialgebras equipped with a differential. Our final aim is to describe a Hopf differential non-symmetric operad

whose operad of primitive elements has the higher cup products as primitive elements, we have good reasons to expect to get the whole ***S***-structure on an operad of this type.

Problem 2. Understand the action of the operad *S*_n on Pirashvili higher Hochschild cochains HC*(n).

Problem 3. Get a differential operad which extends the operad ***Dyck***(m), for m ≥ 2, and whose free objects are described in by the geometric realization of F. Bergeron's m-Tamari lattice. Study the operads on the primitive subspaces of the operad ***Dyck***(m), for m ≥ 2.

Problem 4. Define a filtered operad described by the vector space spanned by all lattice paths, such that the grade associated operad in degree m is ***Dyck***(m), for m ≥ 1.

Problem 5. Compute the Lie algebras of primitive elements of T. Lam and P. Pylyavskyy's Hopf algebras. Describe algebraic operads whose free objects are described by T. Lam and P. Pylyavskyy's Hopf algebras

Problem 6. Compute the Betti numbers of cyclic sets and their homology. Use Dehornoy [Deh] calculus to construct (if possible) the free cycle set. Construct an universal covering of cycle sets and develop a theory of Galois coverings. Apply cycle set homology [LV2] to construct new (virtual) knot invariants.

Problem 7. Compute the 2nd homology group of a finite brace [LeVe1]. Construct (if possible) the free brace. Use the Guitar Map [LeVe2] to study braided tensor products of braces.

Problem 8. Get a clear description of the dendriform algebra structure on the cochains of a rack, which permits us to compute brace operations on the rack cochains. Construct dipterous algebras from racks. Use previous constructions of free brace algebras to help to solve problem 7.

Problem 9. To extend the Lifshitz Cardy formula in higher dimension and provide a microscopic account of the entropy of the Lifshitz black holes.

B3. Schedule, with main execution stages

In the first year we plan to begin with Problems 1, 6,7, 8 and 9, and to get answers to Problems 3, 4 and 5.

During the second year we expect to get results on Problems 1, 6, 6, 8 and 9; and to be able to solve problem 2.

B4. Contributions

Present contributions so as to highlight the role of each partner and the integration among partners.

Eugene Babichev is Chargé de Recherche CNRS at the Institut de Physique Théorique d'Orsay, he works on solutions of higher-order gravity theories applied to blackholes. He expect to collaborate with Prof. Mother Hassaine on the subject.

Emily Burgunder is Maître de Conférences at the Institut de Mathématiques de l'Université de Toulouse III. She has two joint publications with M. Ronco on subjects related to the present project, her main research area are algebraic operads, and combinatorial Hopf algebras.

Victoria Lebed is a post-doctoral student at the Université de Nantes, in collaboration with Friedrich Wagemann. Her research interests are braidings, which includes the Yang-Baxter equation, braid groups, knots and their generalized versions, quandle and rack invariants, quasi-shuffle algebras, Hopf algebras and Hopf bimodules, Rota-Baxter algebras, operads, etc. These subjects include the main topics of the present project. She has two publications with L. Vendramin, and a third in preparation.

Muriel Livernet is Professor at the Université Paris-Diderot. Her ma

Daniel López Neumann is a Ph.D. student at the Université Paris-Diderot. He did his Master Thesis at the Univ. of Concepción, with the co-direction of M. Ronco, the subject of it are related to Problems 1, 2, 3 and 4 of the present project. He has a joint work with M. Ronco and another one in preparation with the results of his Master Thesis.

Agustín García Iglesias is CONICET Assistant Researcher at CIEM and Assistant Professor at FaMAF.

He has a joint publication, An explicit description of the second cohomology group of a quandle, with L. Vendramin on the subject of the project. His main research interest are Nichols algebras, Yetter-Drinfeld modules and racks. He has visited the IMAFI of Talca for short periods in the last two years, and he has given a short course on Nichols algebras for Master and Ph.D. students during one of his visits. Our aim is to develop a joint research group on Hopf algebras between chilean and argentinian researchers, he will cooperate with V. Lebed, L. Vendramin, M. Ronco and S. Ryom-Hansen.

Leandro Vendramin is a young researcher with a wide expertise in finite dimensional Hopf algebras and their classification. In the last years he has developed his own research subject on racks, set-theoretical solutions of the Yang-Baxter equation and related structures. He has two joint publications with V. Lebed, and one with A. García Iglesias.

Leandro Guarnieri, Emiliano Acri and Juan Acro are students at the Universidad de Buenos Aires, they will begin their Ph.D. in March, 2017, under the direction of Prof. L. Vendramin.

Mokthar Hassaine is Full Professor at the IMAFI of the Universidad de Talca. He proposal work at the project deals with black holes and gravitational solitons that arise as solutions of higher-order gravity theories. His research domain related to the project is on infinite dimensional Lie algebras, as Virasoro algebra, and applications to Conformal Field Theory. He will collaborate with E. Babichev, as well as participate in the organization of a Seminar devoted to joint work on the subject of the Project we expect to organize during October, 2017.

María Ronco is Full Professor at the IMAFI of the Universidad de Talca. She works on non-commutative Hopf algebras and the algebraic operads related to them. She has work on the subject for the last 15 years and has more than 15 publications on the subject. She has joint works with E. Burgunder and D. López Neumann. She will collaborate with E. Burgunder, D. López Neumann, M. Laverne, L. Vendramin and A. García Iglesias.

Steen Ryom-Hansen is Full Professor at the IMAFI of the Universidad de Talca. He works on Lie algebras, knot theory and representations of Hecke algebras. He participates regularly on the Quantum Colloquium organized by the CIEM group of the FaMAF in Argentina, which will be organized by him and M. Ronco in Talca in 2017. He will collaborate with L. Vendramin, A. García Iglesias and M. Ronco during the project.

Jorge Espinoza is a Ph.D. student of S. Ryom-Hansen.

B5. Institutions and CVs of coordinators

Description of each participating institution, and curriculum vitae of each coordinator (maximum 2 pages per coordinator).

B6. Additional information

Experience of the coordinators in similar projects.

- M. Livernet is the coordinator of a project CAPESCOFECUB (Brazil/France) entitled Factorization algebras in Mathematical Physics and Algebra.
- M. Livernet and M. Ronco have organized the CIMPA Research School "Algebra, Combinatorics and Physics", Universidad de Valparaíso, Chile, in January 2014.

- M. Ronco has Directed two ECOS Projects and one MathAm Sud previously:

a) International Cooperation Project MathAmSud 01-Math-10 OPECSHA, 2010-2011.

b) ECOS-Sud A01E04, Algebras de Hopf-Algèbres de Hopf, 2002-2004.

c) ECOS-Conicyt E01C06, Complejos de posets y operades, 2007 - 2009.

Present main activities and their relationship with the project's main goal.

1. Short courses of Profs. Babichev, Vendramin, Livernet and Garsía Iglesias, for Master and Ph. D. students of the IMAFI during their visits.
2. Organisation of the Colloquium Quantum 2017 in March 2017 at the IMAFI.
3. Mission of Prof. M. Hassaine to the Univ. of Paris-Sud to work with Prof. Babichev.
4. Mission of Prof. Laverne to the IMAFI in December 2017 to work with Profs. M. Ronco and S. ryom-Hansen.
5. Visit of V. Lebed to the Universidad the Buenos Aires to work with Prof. L. Vendramin and his students. She will also visit the IMAFI, financed by the Universidad de Talca and give a mini-seminar.
6. Mini-colloquium during the visits of Prof. García Iglesias and L. Guarneri to the IMAFI, we shall invite other researchers with the financial support of the Institute.
7. Mission of Prof. Babichev to the IMAFI during 2018, to work with Prof. Hassaine.
8. Mission of Prof. L. Vendramin to the France, to work with V. Lebed. Short visit to M. Livernet during the same period, talk at the Seminar.
9. Mission of M. Ronco to France, during 2018, to work with Profs. Livernet and Burgunder, and D. López N..

Perspectives of continuing collaboration after project financing is over.

The aim of the IMAFI (Univ. de Talca) is to establish a permanent cooperation with Argentinian research institutions, mainly with the Universities of Buenos Aires and Córdoba. We have made some progress in the last years, with a strong participation of researchers of the group of Algebra and Representations of the IMAFI in the Colloquium Quantum, organized once a year by the FaMAF of the Univ. Nacional de Córdoba. With the present project, we expect to develop a research line on Hopf algebras with the participation of argentinian and chilean researchers. Our aim is to make arrangements for the exchange of students and co-tutoring Ph.D.s.

The aim of the project is also to consolidate cooperation with the Universities of Toulouse, Paris-Sud and Paris-Diderot. Muriel Laverne has visited Chile many times, and has a permanent collaboration with the Algebra and Topology group of the Univ. of Curitiba, where M. Ronco has also spend short periods. We are going to present a Fondecyt Postdoctoral Project for a Ph.D. student of Prof. Laverne at Talca.

B7. International referees

Suggest names of at least 3 international referees to evaluate the project. These researchers should not be connected to people in the project.

1- J-Y. Thibon
2- Chengming Bai
3- M. Markl

Names of referees who should not review this project in your opinion (optional)

1-
2-

C. Project Budget

Project title:

Participating institutions:

The MATH-AmSud program **funds travel expenses** (air tickets and *per diem*) to researchers in research missions and workshops.

C1. First year (2017)

Planned missions – Year 1

Researcher	**Status (student, junior, senior)**	**Institution**	**Origin**	**Destination**	**Planned date**	**Duration (max. 30 days)**	**Estimated cost of the trip (€)**	**Estimate of total *per diem* (€)**	**Trip and Mission funding institution**	**Mission objectives**
M. Hassaine	Senior Researcher	Univ. de Talca	Talca	Paris	January 2017	20	1.700	1.600	Conicyt and CNRS	Joint work with E. Babichenko
M. Liverne t	Senior Researcher	Univ. Paris-Diderot	Paris	Talca	December 2017	20	1.700	1.600	Conicyt and CNRS	Joint work with M. Ronco
Leandro Guarneri	Student	Univ. de Buenos Aires	Buenos Aires	Talca	Octubre 2017	30	300	1.400	Mincyt and Conicyt	Joint work with M. Ronco and S. Ryom-Hansen
Agustín García Iglesias	Junior Researcher	Univ. Nac. de Córdoba	Córdoba	Talca	Octubre 2017	20	300	1.500	Mincyt and Conicyt	Joint work with M. Ronco and S. Ryom-Hansen
Victoria Lebed	Junior Researcher	Univ. de Nantes	Nantes	Buenos Aires	Junio 2017	20	1.700	1.500	CNRS and Mincyt	Joint work with L. Vendramin

<u>CONSOLIDATED BUDGET:</u> Year 1
Funding requested to the MATH-AmSud Program
Estimated costs (€)

	A. Travel costs (air tickets)	B- Maintenance costs (*per diem)*	**TOTAL**
MAEDI France			
CNRS France	3.400	1.600	5.000
INRIA France			
MINCYT Argentina	600	1.500	2.100
CAPES Brazil			
IMPA Brazil			
CONICYT Chile	1.700	4.500	6.200
CMM Chile			
Faculty of Mathematics (PUC – Chile)			
CONACYT Paraguay			
CONCYTEC Peru			
IMCA Peru			
ANII Uruguay			
MPPEUCT Venezuela			
SENESCYT Ecuador			
COLCIENCIAS Colombia			
Total requested funding to MATH-AmSud			
<u>Other funding</u>			
TOTAL	5.700	7.600	13.300

Do you have additional funding sources for this project[1]? (if so please specify the amount and source (s))

[1] Reserved for CNRS researchers

C2. Second year (2018)

Second year funding depends on approval of intermediate progress report.

Planned missions – Year 2

Researcher	**Status (student, junior, senior)**	**Institution**	**Origin**	**Destination**	**Planned date**	**Duration (max. 30 days)**	**Estimated cost of the trip (€)**	**Estimate of total *per diem* (€)**	**Trip and Mission funding institution**	**Mission objectives**
E. Babichev	Senior researcher	CNRS, Univ. de Paris Sud	Paris	Talca	June 2018	20	1.700	1.500	Conicyt and CNRS	Joint work with M. Hassaine
Leandro Vendramin	Senior researcher	Univ. de Buenos Aires	Buenos Aires	Paris	May 2018	20	1.700	1.600	Mincyt and CNRS	Joint work with V. Lebed and visit to M. Livernet
M. Ronco	Senior researcher	Senior researcher	Talca	Paris-Toulouse	June 2018	20	1.700	1.600	Conicyt and CNRS	Joint work with E. Burgunder and M. Livernet

<u>CONSOLIDATED BUDGET:</u> Year 2
Funding requested to the MATH-AmSud Program
Estimated costs (€)

	A. Travel costs (air tickets)	B- Maintenance costs (*per diem)*	**TOTAL**
MAEDI France			
CNRS France	1.700	3.200	4.900
INRIA France			
MINCYT Argentina	1.700		1.700
CAPES Brazil			
IMPA Brazil			
CONICYT Chile	1.700	1.500	3.200
CMM Chile			
Faculty of Mathematics (PUC – Chile)			
CONACYT Paraguay			
CONCYTEC Peru			
IMCA Peru			
ANII Uruguay			
MPPEUCT Venezuela			
SENESCYT Ecuador			
COLCIENCIAS Colombia			
Total requested funding to MATH-AmSud			
<u>Other funding</u>			
TOTAL	5.100	4.700	9.800

Do you have additional funding sources for this project[2]? (if so please specify the amount and source(s))

[2] Reserved for CNRS researchers

C3. BUDGET TOTALS

	Year 1	**Year 2**	**Total**
Funding requested to MAEDI (France)			
Funding requested to INRIA (France)			
Funding requested to CNRS (France)	5.000	4.900	**9.900**
Funding requested to MINCYT (Argentina)	2.100	1.700	**3.800**
Funding requested to CAPES (Brazil)			
Funding requested to IMPA (Brazil)			
Funding requested to CMM (Chile)			
Funding requested to Faculty of Mathematics (PUC – Chile)			
Funding requested to CONICYT (Chile)	6.200	3.200	**9.400**
Funding requested to CONACYT (Paraguay)			
Funding requested to CONCYTEC (Peru)			
Funding requested to IMCA (Peru)			
Funding requested to ANII (Uruguay)			
Funding requested to SENESCYT (Ecuador)			
Funding requested to MPPEUCT (Venezuela)			
Funding requested to COLCIENCIAS (Colombia)			
Matching funds from the partners			
Other sources			
TOTAL	**13.300**	**9.800**	**23.100**

ANNEX

Model CV (maximum 2 pages)

1/ Personal data

Name: Muriel Livernet
Birth date: December 14th., 1971
Professional address (with telephone and e-mail):
IMJ-PRG
University Paris Diderot
Bâtiment Sophie Germain
Case 7012
75205 Paris Cedex 5
e-mail: livernet@math.univ-paris-diderot.fr
webpage: https://webusers.imj-prg.fr/~muriel.livernet/

Current job title and size of the research group: Professor, Université Paris Diderot.
Group: Topologie et Géométrie algébriques (twenty one researchers, six merit professors, two postdocs)

2/ Highest obtained degree (with indication of place and date)

- PhD in mathematics, University Louis Pasteur (Strasbourg), 1998, Title: Homotopie rationnelle des algèbres sur une opérade. Advisor: J.-L. Loday

3/ Professional activity (the last 5 years)

- Sept 2015: Professor, University Paris Diderot
- 2011-2015: Maître de conférences (associate professor), University Paris 13

4/ Other duties/ positions

Visiting positions

- Brazil: University of Curtiba and Impa (3 weeks in 2012, 2014, 2015, 2016)
- Germany: MPIM Bonn (2 weeks, 2016)
- UK: Institut Isaac Newton (1 month, 2013)
- Chili: University of Valparaiso (1 month, 2006), University of Talca (1 month, 2011)
- USA: University of Southern California, Los Angeles (4 months, 2000)
- Sweden: Institut Mittag Leffler (1 month, 2006)
- MIT (1 year, 2007-2008)

5/ Awards, fellowships and external recognition

- French PEDR research grant: 2001-2005, 2006-2010 and 2011-2018
- Clay Institute research grant, 2008

NATO grant, 2000

6/ Ongoing funded research projects with dates, titles, sources of funding

French PEDR research grant: 2011-2018

7/ Projects approved in the last 5 years

- Capes-Cofecub program Factorization algebra in Mathematical Physics and Algebraic Topology (2013-2016)
- FOCAL program (scientific project of University Sorbonne Paris Cité) (2013-2015);

- MathAmSud OPECHSA program (2010-2011)

8/ Publications (last 5 years)

8.1– Highlight the most important publications related to the project theme

- M. Livernet and B. Richter, An interpretation of En-homology as functor homology , Mathematische Zeitschrift, Volume 269, No. 1-2 (2011), 193–219
- M. Livernet, Koszul duality of the category of trees and bar construction for operads, Proc. Int. Conf., in Nankai Series in Pure, Applied Mathematics and Theoretical Physics, Vol. 9 (World Scientific, Singapore, 2012), 107-138 **
- E. Hoefel and M. Livernet Open-closed homotopy algebras and strong homotopy Leibniz pairs through Koszul operad theory, Letters in Math. Phys. 101 (2012), 195–222
- M. Livernet, C. Roitzheim and S. Whitehouse, Derived A∞-algebras in an operadic context, Algebraic and Geometric Topology 13 (2013), 409-440
- E. Hoefel, M. Livernet On the Spectral Sequence of the Swiss-cheese Operad, Algebraic and Geometric Topology 13 (2013), 2039-2060
- M. Livernet, Pre-Lie systems and obstruction to A∞-structures over a ring, Journal of Homotopy and Related Structures, 9 (2014), No. 1, 109-124
- M. Livernet, B. Mesablishvili and R. Wisbauer, Generalised bialgebras and entwined monads and comonads, Journal of Pure and Applied Algebra 219 (2015) pp. 3263-3278 **
- C. Aponte, M. Livernet, M. Robertson, S. Whitehouse and S. Ziegenhagen, Representations of derived A-infinity algebras, dans ”Women in Topology: Collaborations in Homotopy Theory”, Contemporary Mathematics, 641 (2015), pp 1-28
- M. Livernet, Non-formality of the Swiss-cheese operad, Journal of Topology (2015), doi:10.1112/jtopol/jtv018 (11 pages)
- E. Hoefel, M. Livernet and J. Stasheff, A∞-actions and Recognition of Relative Loop Spaces, Topology and its Applications, 206 (2016), 126-147 **

8.2– Publications in cooperation with the project partners

9/ Theses oriented and post-doctoral fellows supervised

9.1– Finished/defended in the last 5 years

- PhD student: Julien Ducoulombier, PhD defended in december 2015

- 2 postdoctorate students: Ricardo Andrade (2013-2014), Stephanie Ziegenhagen (2014-2015)

ANNEX

Model CV (maximum 2 pages)

1/ Personal data

Name: María Ofelia Ronco
Birth date: December 23rd. , 1957
Professional address (with telephone and e-mail):
Instituto de Matemáticas y Física,
Universidad de Talca,
Campus Norte, Camino Lircay s/n,
Talca, Chile.
e-mail: mariaronco@inst-mat.utalca.cl
TE: +56 977659508

Current job title and size of the research group: Profesor Titular (Full professor).
The IMAFI has fourteen senior researchers, five of them work on subjects related to Lie algebras, , six Ph.D. students and some external post-doc.

2/ Highest obtained degree (with indication of place and date)

Doctor en Matemáticas (Ph. D. in Mathematics), Universidad de Buenos Aires, Argentina, 1988.

3/ Professional activity (the last 5 years)

Full profesor at the Instituto de Matemáticas y Física (IMAFI) of the Universidad de Talca.

4/ Other duties/ positions

Director of the Master in Sciences Program, Orientation in Mathematics, Instituto de Matemáticas y Física (IMAFI), Universidad de Talca.

5/ Awards, fellowships and external recognition

- External referee for Research Projects (Permanent position), Univ. Católica de Perú.

Visit to other Research Institutions

- LAGA, Université de Paris 13, July 2012, Paris (France).
- Programa Póst-Graduaçao em Matemática e Matemática Aplicada, Departamento de Matemática, Universidade Federal do Paraná, Curitiba (Brasil), December 2012.
- Issac Newton Institute for Mathematical Sciences, Cambridge (United Kingdom), January 2013.
- Departmento de Matemáticas, Universidad de Barcelona (Spain), February 2014.
- Institut de Mathématiques, Université de Toulouse III (France), January 2015.
- LAGA, Département de Mathématiques, Université de Paris 13 (France), February 2015.
- Centro de Investigación en Matemáticas (CIMAT), Guanajuato (México) July 2015.
- Department of Mathematics, University of Leicester (United Kingdom), August 2015.
- Max Planck Institut for Mathematics, Bonn (Germany) 15 days in February, 2016.

6/ Ongoing funded research projects with dates, titles, sources of funding

- Associated Researcher, MathAmSud 2015, Representations, homology and Hopf (REPHOMOL), 2016-2017.

7/ Projects approved in the last 5 years

- Director of the International Cooperation Project MathAmSud 01-Math-10 OPECSHA, 2010-2011.

- Investigador Principal, Proyecto Fondecyt Regular 1100380, Differential Hopf algebras and operads, 2010-2012.

- Co-researcher of the International Cooperation Project MathAm Sud 13Math-05. LAIS-Algèbres de Lie et systémes intégrables, 2013-2014.

- Principal Researcher, Proyecto Fondecyt Regular 2013 N 1130939, 2013-2015.

8/ Publications, last years.

8.1– Highlight the most important publications related to the project theme

- M. Ronco, *Shuffle bialgebras*, Ann. Inst. Fourier, Vol. 61, 3 (2011) 799-850.
- J.-L. Loday and M. Ronco, *Combinatorial Hopf Algebras*, Quanta of Math, Clay Mathematics Proceedings, Vol. 11 (2010) Alain Connes Birthday Conference, 347-384. **
- E. Burgunder and M. Ronco, *Tridendriform structures on combinatorial Hopf algebras*, Journal of Algebra, Vol. 324, Issue 10 (2010) 2860-2883.**
- D. Jimenéz and M. Ronco, *Tridendriform algebras spanned by partitions*, in Operads and Universal Algebra, Proceedings of the International Conference, Tianjin, China, 5-9 July 2010, Nankai Series in Pure, Applied Mathematics and Theoretical Physics, Vol. 9 (2012) **
- M. Ronco, *Generalized Tamari order*, in "Associahedra, Tamari Lattices and Related Structures", Tamari Memorial Festschrift, eds. F. Mller-Hoissen, J. Pallo and J. Stasheff, Progress in Mathematics 299 (Birkhuser, 2012) 337-348. **
- J.-L. Loday and M. Ronco, *Permutads*, Journal of Combinatorial Theory, Series A 120 (2013) 340-365.
- E. Burgunder, P-L. Curien, M. Ronco, *Free algebraic structures on the permutohedra*, preprint arXiv: 1503.0899, accepted for publication in Journal of Algebra. **
- D. López N., L.-F. Préville-Ratelle, M. Ronco, *Algebraic structures defined on m-Dyck paths*, preprint arXiv:1508.01252 (2015), sometida a Journal of Combinatorial Theory, Series A. **
- S. Forcey, M. Ronco, *Sustitution on Graph Associahedra*, Preprint 2016.

8.2– Publications in cooperation with the project partners

- E. Burgunder and M. Ronco, *Tridendriform structures on combinatorial Hopf algebras*, Journal of Algebra, Vol. 324, Issue 10 (2010) 2860-2883.
- E. Burgunder, P-L. Curien, M. Ronco, *Free algebraic structures on the permutohedra*, preprint arXiv: 1503.0899, accepted for publication in Journal of Algebra.
- D. López N., L.-F. Préville-Ratelle, M. Ronco, *Algebraic structures defined on m-Dyck paths*, preprint arXiv:1508.01252 (2015), sometida a Journal of Combinatorial Theory, Series A.

9/ Theses oriented and post-doctoral fellows supervised

9.1– Finished/defended in the last 5 years

- Master Thesis, Joselyn Albornoz Acosta, Depto. de Matemáticas, Fac. de Ciencias, Universidad de Valparaíso, finished in April 2012.
- Master Thesis, Diego Arcis, IMAFI, Universidad de Talca, finished November 2013.
- Co-Director Master Thesis, Daniel Alonso López Neumann, Universidad de Concepción, finished August 2015.
- Co-Director Ph.D. Thesis, Wilson Arely Martínez Flor, Universidad de Santiago de Chile, finished September 2015.

1/ Personal data

Name: Leandro Claudio Vendramin
Birth date: 2 de octubre de 1976
Professional address (with telephone and e-mail):
Departamento de Matemática,
Fac. de Ciencias Exactas y Nat, Universidad de Buenos Aires,
Pabellón I, Ciudad Universitaria
(1428) Buenos Aires, Argentina.
e-mail: lvendramin@dm.uba.ar
TE: +54 11 45763390-6, #916
Current job title and size of the research group:

Professor, FCEN, UBA, from 5/2014
The research group on algebra has more than 10 senior researchers,

2/ Highest obtained degree (with indication of place and date)

Doctor en Matemáticas (Ph. D. in Mathematics), Universidad de Buenos Aires, Argentina, 2010.

3/ Professional activity (the last 5 years)

Professor, FCEN, UBA, from 5/2014

4/ Other duties/ positions

Investigador Adjunto, CONICET, from 2012
Regular Associate of the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, from 01/2012

5/ Awards, fellowships and external recognition

- Alexander von Humboldt Fellowship, 2012–2013
- DAAD Short-term Postdoctoral Fellowship, 2011
- CONICET Postdoctoral Fellowship, 2010–2012
- DAAD Short-term Fellowship, 2009
- CONICET PhD Fellowship, 2005–2010

6/ Ongoing funded research projects with dates, titles, sources of funding

- PICTPICT-2014-1376, Álgebras de Nichols y aplicaciones, Director: L. Vendramin

7/ Projects approved in the last 5 years

- PICTPICT-2014-1376, Álgebras de Nichols y aplicaciones, Director: L. Vendramin
- UBACyT 20020110300037, 2012-2015 IJ, Álgebras de Hopf punteadas y álgebras de Nichols

Desde 2012 hasta 2015. Director: L. Vendramin

8/ Publications

8.1– Highlight the most important publications related to the project theme
- V. Lebed, L. Vendramin, *Cohomology and extensions of braces,* accepted for publication in Pacific J. Math. **

- L. Guarnieri, L. Vendramin, *Skew braces and the Yang-Baxter equation,* accepted for publication in Math. Comp. **
- H. Heckenberger, L. Vendramin, *The classification of Nichols algebras with finite root system of rank two*, accepted for publication in J. Europ. Math. Soc.
- E. Clark, M. Saito, L. Vendramin. *Quandle coloring and cocycle invariants of composite knots and abelian extensions*, J. Knot Theory Ramifications 25 (2016), no. 5, 1650024, 34 pp. **
- L. Vendramin, *Doubly transitive groups and cyclic quandles,* accepted for publication in J. Math. Soc. Japan **
- L. Vendramin, *Extensions of set-theoretic solutions of the Yang-Baxter equation and a conjecture of Gateva-Ivanova*, J. Pure Appl. Alg. 220 (2016), no. 5, 1681-2076 **
- I. Heckenberger, A. Lochmann, L. Vendramin. *Nichols algebras with many cubic relations,* Trans. Amer. Math. Soc. 367 (2015), 6315–6356
- I. Heckenberger, L. Vendramin, *Nichols algebras over groups with finite root system of rank two III,* J. Algebra 422 (2015), 223–256
- J. Dong, S. Natale, L. Vendramin, *Frobenius property for fusion categories of small integral dimension,* J. Algebra Appl. 14 (2015), no. 2, 1550011 (17 pages)
- I. Heckenberger, L. Vendramin, *Nichols algebras over groups with finite root system of rank two II,* J. Group Theory 17 (2014), no. 6, 1009–1034
- L. Vendramin, *Nichols algebras associated to the transpositions of the symmetric group are twist-equivalent,* Proc. Amer. Math. Soc. 140 (2012), no. 11, 3715-3723
- L. Vendramin, *On the classification of quandles of low order,* J. Knot Theory Ramifications 21 (2012), no. 9, 1250088
- I. Heckenberger, A. Lochmann, L. Vendramin, *Braided racks, Hurwitz orbits and Nichols algebras with many cubic relations, Transform. Groups 17 (2012), no. 1, 157-194*
- M. Graña, I. Heckenberger, L. Vendramin, *Nichols algebras of group type with many quadratic relations* Adv. Math. 227 (2011) 1956-1989
- N. Andruskiewitsch, F. Fantino, M. Graña, L. Vendramin, *Pointed Hopf algebras over sporadic simple groups, J. Algebra 325 (1) (2011) 305-320*
- N. Andruskiewitsch, F. Fantino, M. Graña, L. Vendramin, *The logbook of Pointed Hopf algebras over sporadic simple groups, J. Algebra 325 (1) (2011) 282-304*
- N. Andruskiewitsch, F. Fantino, M. Graña, L. Vendramin, *Finite-dimensional pointed Hopf algebras with* alternating groups are trivial, Ann. Mat. Pura Appl (4) 190 (2011), no. 2, 225-245.
- N. Andruskiewitsch, F. Fantino, M. Graña, L. Vendramin, *Pointed Hopf algebras over some sporadic simple groups*, C. R. Math. Acad. Sci. Paris 348 (2010) 605-608
- M. Graña, S. Freyre, L. Vendramin, *On Nichols algebras over PSL(2, q) and PGL(2, q),* J. Algebra Appl., Vol. 9, No. 2 (2010) 195–208
- M. Graña, S. Freyre, L. Vendramin, *On Nichols algebras over SL(2, Fq) and GL(2, Fq),* J. Math. Phys. 48, 123513 (2007) (11 pages)

8.2– Publications in cooperation with the project partners

- V. Lebed, L. Vendramin, *Cohomology and extensions of braces,* accepted for publication in Pacific J. Math.
- V. Lebed, L. Vendramin. Homology of left non-degenerate set-theoretic solutions to the Yang-Baxter equation. Submitted. arXiv:1509.07067

9/ Theses oriented and post-doctoral fellows supervised

9.1– Finished/defended in the last 5 years