Curriculum vitæ

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Research Interests

Category theory and everything about it.

- Stable ∞-categories
- Homotopical algebra
- Groth(endieck) derivators
- 2-categories and formal category theory
- locally presentable and accessible categories
- type theory and functional programming.

Present position

1 | **Postdoctoral fellow** — Jan 2020 | —
Tallinna Tehnikaülikooli Küberneetika Instituut | Tallinn EE

Past positions

1 | **Postdoctoral fellow** — Jul 2019 | Dec 2019
Centro de Matemática da Universidade de Coimbra | Coimbra PT

2 | **Postdoctoral fellow** — Sep 2018 | Feb 2019
Max-Planck-Institut für Mathematik | Bonn D

3 | **Postdoctoral fellow** — Mar 2017 | Apr 2018
Masarykova univerzita | Brno CZ

4 | **Postdoctoral fellow and Assistant Professor** — Sep 2016 | Nov 2016
University of Western Ontario | London CA

Education

2008 | 2012

1 | **Ph.D. in Mathematics** — Oct 2012 | Jun 2016
SISSA | Trieste
thesis: *t-structures on stable ∞-categories*

2 | **M.Sc. in Mathematics** — Oct 2010 | Jul 2012
Università degli studi di Padova
thesis: *Orlov reconstruction theorem*

3 | **B.Sc. in Mathematics** — Jan 2008 | Jun 2010
Università degli studi di Padova
thesis: *Monads and Beck's theorem*

PUBLICATIONS

1 | **Triangulated factorization systems and *t*-structures** w/S. Virili |
1705.08565v3 | *Journal of Algebra* | doi:10.1016/j.jalgebra.2019.12.021

We define triangulated factorization systems on triangulated categories, and prove that a suitable subclass thereof (the normal triangulated torsion theories) corresponds bijectively to t-structures on the same category. This result will then be placed in the framework of derivators regarding a triangulated category as the base of a stable derivator.

2 | **Categorical notions of fibration** w/E. Riehl |
1806.06129 | *Expos. Math.* (2019) | doi:10.1016/j.exmath.2019.02.004

Fibrations over a category *B*, introduced to category theory by Grothendieck, encode pseudo-functors $B^\circ \rightsquigarrow$ **Cat**, while the special case of discrete fibrations encode presheaves $B^\circ \to$ **Set**. A two-sided discrete variation encodes functors $B^\circ \times A \to$ **Set**, which are also known as profunctors from *A* to *B*. By work of Street, all of these fibration notions can be defined internally to an arbitrary 2-category or bicategory. While the two-sided discrete fibrations model profunctors internally to **Cat**, unexpectedly, the dual two-sided codiscrete cofibrations are necessary to model *V*-profunctors internally to *V*-**Cat**.

3 | **Hearts and towers in stable infinity-categories** w/D. Fiorenza, G. Marchetti |
1501.04658 | *Journal of Homotopy and Related Structures* 2019 | doi:10.1007/s40062-019-00237-0

We exploit the equivalence between t-structures and normal torsion theories on a stable ∞-category to show how a few classical topics in the theory of triangulated categories, i.e., the characterization of bounded t-structures in terms of their hearts, their associated cohomology functors, semiorthogonal decompositions, and the theory of tiltings, as well as the more recent notion of Bridgeland's slicings, are all particular instances of a single construction, namely, the tower of a morphism associated with a *J*-slicing of a stable ∞-category **C**, where *J* is a totally ordered set equipped with a monotone $\mathbb{Z}$-action.

4 | **A standard theorem on adjunctions in two variables**
1902.06074 | Preprints of the MPIM, 2018 (67)

We record an explicit proof of the theorem that lifts a two-variable adjunction to the arrow categories of its domains.

5 | **A Fubini rule for ∞-coends**
1902.06086 | Preprints of the MPIM, 2018 (68)

We prove a Fubini rule for ∞-co/ends of ∞-functors $F : \mathrm{C}^{\mathrm{op}} \times \mathrm{C} \to \mathrm{D}$. This allows to lay down "integration rules", similar to those in classical co/end calculus, also in the setting of ∞-categories.

6 | **Homotopical Algebra is not concrete** w/I. Di Liberti |
1704.00303 | *Journal of Homotopy and Related Structures* (2017): 1-15 | doi:10.1007/s40062-018-0197-3

We generalize Freyd's well-known result that "homotopy is not concrete", offering a general method to show that under certain assumptions on a model category *M*, its homotopy category $\mathrm{ho}(M)$ cannot be concrete. This result is part of an attempt to understand more deeply the relation between set theory and abstract homotopy theory.

7 | **Sober Ontic Structural Realism and Yoneda lemma**
abstract at the *Triennial conference of the SILFS*, Bologna

A note on why the Yoneda lemma prevents to take too strong a position towards the non-existence of relata (*radical* ontic structural realism posits that only relations exist).

8 | **Coend calculus**
based on 1501.02503v4 | book to appear for Cambridge University Press (2020?)

A survey of the most striking and useful applications of *co/end calculus*. This is a revised version of 1501.02503v4. After having given a series of preliminary definitions, we characterize co/ends as particular co/limits; then we derive a number of results directly from this characterization. The last sections discuss the most interesting examples where co/end calculus serves as a powerful abstract way to do explicit computations in diverse fields like Algebra, Algebraic Topology and Category Theory. The appendices serve to sketch a number of results in theories heavily relying on co/end calculus.

9 | **t-structures are normal torsion theories** w/D. Fiorenza |
1408.7003 | Applied Categorical Structures 24.2 (2016): 181-208 | doi:10.1007/s10485-015-9393-z

We characterize t-structures in stable ∞-categories as suitable quasicategorical factorization systems. More precisely we show that a t-structure t on a stable ∞-category **C** is equivalent to a normal torsion theory $\mathbb{F}$ on **C**, i.e. to a factorization system $\mathbb{F} = (E, M)$ where both classes satisfy the 3-for-2 cancellation property, and a certain compatibility with pullbacks/pushouts.

Preprints

1 | **Profunctor optics, a categorical update** w/B. Clarke, et al. |
2001.07488
Profunctor optics are bidirectional data accessors that capture data transformation patterns such as accessing subfields or iterating over containers. They are modular, meaning that we can construct accessors for complex structures by combining simpler ones. Profunctor optics have been studied only using **Sets** as the enriching category and in the non-mixed case. However, functional programming languages are arguably better described by enriched categories and we have found that some structures in the literature are actually mixed optics. Our work generalizes a classic result by Pastro and Street on Tambara theory and uses it to describe mixed V-enriched profunctor optics and to endow them with V-category structure. We provide some original families of optics and derivations, including an elementary one for traversals that solves an open problem posed by Milewski. Finally, we discuss a Haskell implementation.

2 | **On the unicity of formal category theories** w/I. Di Liberti |
1901.01594v1 | Submitted to TAC, January 2019
We prove an equivalence between cocomplete Yoneda structures and certain proarrow equipments on a 2-category **K**. In order to do this, we recognize the presheaf construction of a cocomplete Yoneda structure as a relative, lax idempotent monad sending each admissible 1-cell $f : A \to B$ to an adjunction $\mathbb{P}_! f \dashv \mathbb{P}^* f$. Each cocomplete Yoneda structure on **K** arises in this way from a relative lax idempotent monad "with enough adjoint 1-cells", whose domain generates the ideal of admissibles, and the Kleisli category of such a monad equips its domain with proarrows. We call these structures "yosegi". Quite often, the presheaf construction associated to a yosegi generates an ambidextrous Yoneda structure; in such a setting there exists a fully formal version of Isbell duality.

3 | **Accessibility and presentability in 2-categories** w/I. Di Liberti |
1804.08710v4 | Submitted to JPAA, January 2019
We outline a definition of accessible and presentable objects in a 2-category **K** endowed with a Yoneda structure; this perspective suggests a unified treatment of many "Gabriel-Ulmer like" theorems (like the classical Gabriel-Ulmer representation for locally presentable categories, Giraud theorem, and Gabriel-Popescu theorem), asserting how presentable objects arise as reflections of generating ones. In a 2-category with a Yoneda structure, two non-equivalent definitions of presentability for $A \in$ **K** can in principle be given: in the most interesting, it is generally false that all presheaf objects $\mathbb{P}A$ are presentable; this leads to the definition of a Gabriel-Ulmer structure, i.e. a Yoneda structure rich enough to concoct Gabriel-Ulmer duality and to make this asymmetry disappear. We end the paper with a roundup of examples, involving classical (set-based and enriched), low dimensional and higher dimensional category theory.

4 | **Localization theory for derivators**
1802.08193v1 | Submitted to TAC, March 2018
We outline the theory of reflections for prederivators, derivators and stable derivators. In order to parallel the classical theory valid for categories, we outline how reflections can be equivalently described as categories of fractions, reflective factorization systems, and categories of algebras for idempotent monads. This is a further development of the theory of monads and factorization systems for derivators.

5 | **Recollements in stable ∞-categories** w/D. Fiorenza |
1507.03913v2
We develop the theory of recollements in a stable ∞-categorical setting. In the axiomatization of Beilinson, Bernstein and Deligne, recollement situations provide a generalization of Grothendieck's "six functors" between derived categories. The adjointness relations between functors in a recollement $\mathbf{D}^0, \mathbf{D}, \mathbf{D}^1$ induce a "recollée" t-structure $\mathtt{t}_0 \uplus \mathtt{t}_1$ on **D** , given t-structures $\mathtt{t}_0, \mathtt{t}_1$ on $\mathbf{D}^0, \mathbf{D}^1$. Such a classical result, well-known in the setting of triangulated categories, is recasted in the setting of stable ∞-categories and the properties of the associated (∞-categorical) factorization systems are investigated. In the geometric case of a stratified space, various recollements arise, which "interact well" with the combinatorics of the intersections of strata to give a well-defined, associative $\uplus$ operation. From this we deduce a generalized associative property for n-fold gluing $\mathtt{t}_0 \uplus \cdots \uplus \mathtt{t}_n$, valid in any stable ∞-category.

Talks

1 | **The art of $\int$** Dec 2019
Invited speaker | ItaCa - Italian Category theorists conference

2 | **Axiomatic cohesion of toposes** Dec 2019
Invited speaker | Università "La Sapienza" - Rome

3 | **The formal category theory of derivators** Apr 2019
Invited speaker | Workshop on Derivators - Regensburg

4 | **On the unicity of the formal theory of categories** — Dec 2018
Talk on 1901.01594 | ULB - Bruxelles

5 | **Accessibility and Presentability in 2-categories** — Nov 2018
Talk on 1804.08710 | Università degli studi di Torino

6 | **Homotopical algebra is not concrete** — Sep 2017
Contributed talk | *British Topology Meeting* | Leicester

7 | **The formal category theory of derivators** — Sep 2017
Invited speaker | *Some trends in Algebra* | Prague

8 | **Sober Ontic Structural Realism** — Jun 2017
Invited speaker | *SILFS* | Bologna

9 | **Model categories** — May 2017
Invited speaker | *A categorical day in Turin* | Torino

10 | **t-derivators** — Feb 2017
Invited speaker | *Young researchers in homotopy theory*, Bonn

11 | **Coend calculus** — May 2016
Lectures on 1501.02503 | Leeds

Teaching & Organizational activities

1 | **ITI9200 - Introduction to Category Theory** — Jan 2020 | Jun 2020
Introduction to Category Theory and its Applications (*Sissejuhatus kategooriateooriasse ja selle rakendustesse*). Part of the MSc in Software Engineering at TalTech. Here you find the course syllabus, and the course webpage on tallcats.io. The course is an introduction to the basic concepts of Category Theory (categories, functors, natural transformations, universal properties, limits, colimits, monoidal categories, string diagrams...) and some applications in Computer Science.

2 | **appointee for Adjoint school 2019** — Mar 2019 | Jun 2019
A webinar and online applied Category Theory reading course. The project name is *Traversal optics and profunctors*. Led to the development of arXiv:2001.07488.

3 | **2-categories** — Padova - IT
A short course on 2-dimensional category theory. Tentative program: monoidal and enriched categories, the calculus of coends and Kan extensions, 2-categories, the bicategory of profunctors, the 2-category of derivators, 2-dimensional limits, the formal theory of monads, formal category theory.

4 | **PSSL 103 - Brno** — MU Brno - CZ
I have been one of the organizers of 103rd Peripathetic Seminar on Sheaves and Logic.

5 | **Formal category theory** — MU Brno - CZ
A series of lectures having the scope to breach in Riehl-Verity's theory of ∞-cosmoi.

6 | **Elements of Finite Mathematics** — UWO London - CA
Techniques of counting, probability, discrete and continuous random variables.

7 | **Homotopical Algebra** — MU Brno - CZ
A bottom-up introduction to the language of Homotopical Algebra

8 | **appointee for Kan Extension Seminar I** — Jan 2014 | Jul 2014
A webinar and online Category Theory reading course.

9 | **supervisor and coadvisor B.Sc. in Mathematics** — *student: Giovanni Ronchi*
Adjoint Functors | amslaurea.unibo.it

Other activities

1 | **Sparse skills**

I like the art of crafting books and drawing maps; this is not unrelated to my love for Mathematics. I am a pretty decent TeXnic (I maintain this CV as a github repo here). I know bits of Haskell, Python, and Wolfram. I like artificial languages (mi ŝatus verki vortaron al matematiko, kun terminoj el teoria kategorioj); again, this is not unrelated to my love for Mathematics.

2 | **Reviewer for**

zbMath, AMS Math. Rev.

Fosco Loregian