Below is a snapshot of my recent/current work, but my interests are not limited to what is written here. Basically, I am (almost) always in for learning about a new subject in theoretical computer science or mathematics (so count me in !).

Computational Complexity. I would like to draw formal links between the complexity of programs and mathematical invariants (e.g. (co)homological invariants such as (ℓ^2-)Betti numbers, topological entropy).

• I am interested in all known lower bounds and/or separation proofs. This already lead to a work with Luc Pellissier in which we use both topological entropy and Betti numbers for algebraic varieties to show lower bounds in algebraic models of computation (i.e. models of computations over the integers/reals). I expect some lower bounds on automata (obtained through the incompressibility method using Kolmogorov complexity) to be expressed through topological entropy as well.

• I worked and am still working on some semantic characterisations of complexity classes. For this I define some models of linear logic (Interaction Graphs models – a general framework for Girard's geometry of interaction constructions) in which the type $!\mathbf{Nat} \multimap \mathbf{Bool}$ captures known (predicate) complexity classes (usually defined in terms of automata). As the models are defined by a monoid action on measured spaces, I would like to show that invariants of the monoid action can be used to establish separation results. This lead me to current investigations on the relationships between (1) entropies, (2) Fuglede-Kadison determinants, (3) (ℓ^2-)Betti numbers, and (4) (dynamical) zeta functions.

• With Maxime Lucas, I am investigating a result by Malbos and Mimram providing lower bounds for the presentation of rewriting systems based on Betti numbers. We hope these can be used to prove some separation results between complexity classes.

Curry-Howard and beyond. I also work on models of linear logic, and mostly on dynamical "linear realisability" models ; I am particularly interested in models with alternative underlying models of computation (e.g. self-assembly, stochastic kernels).

• The stellar resolution model, with Boris Eng. This is our (formalised and generalised) version of the model of computation underlying Girard's transcendantal syntax series of "papers". The model of computation captures other models such as Wang's tiles and self-assembly models used in biocomputing. Moreover, we showed how to define a complete model of multiplicative linear logic. We are now starting to work on extensions to larger fragments, as well as first-order logic – the real new feature of transcendantal syntax. This extension of Curry-Howard to first-order could be particularly interesting (and thus worth the trouble of formalising Girard's writing) as it could establish connections between descriptive complexity and implicit complexity.

• The Markov processes model. This is generalisation of the Interaction Graph model where graphings (i.e. generalised dynamical systems used to represent programs) are replaced by general stochastic kernels (more precisely sub-probabilistic kernels) to deal with continuous probability distributions. I showed this models full linear logic. I would be interested in finding an expressive probabilistic language (for instance with continuous sampling) interpreted in the model.

• With Maxime Lucas, we are working on generalisations of the Interaction Graphs models based on category theory, leading us to learn more on sheaf theory (and to the unrealistic – for the moment – but exciting idea that sheaf cohomology would relate to complexity ; I mention that for Damiano ;-) we should definitely start a working group on the subject).

• In 2018-2019, I worked with Samuel Mimram and Eric Finster on relationships between Goodwillie's calculus of functors and models of linear logic. The project is now restarting with the addition of Maxime Lucas. We are currently studying a model of differential linear logic arising from a generalisation of polynomial functors, and tackling questions such as "what is a 2-model (or ∞-model) of linear logic ?"

Formal Language Theory. I have been working in the past two years with Jakob G. Simonsen on Agafonov's theorem which states that an infinite sequence is normal (i.e. random in some formal sense) iff all subsequences selected by a finite automata are normal. This lead us to three different works :

• A historical account of Agafonov's theorem and a(n embellished) translation of his original proof in russian (never published in english, even experts of the domain did not know the proof existed) – available on HAL ;

• A characterisation of Bernoulli distributions (soon to be submitted) as those distributions for which Agafonov's theorem holds ;

• An upcoming generalisation of Agafonov's theorem to (1) probabilistic devices, and (2) to more expressive models of computation modulo some restrictions on the notion of normality considered, unexpectedly leading to complexity lower bounds.

Static Analysis. I recently picked up work on static analysis I initiated with Thomas Rubiano and Jean-Yves Moyen (ATVA 2017). The collaboration involves Boris Eng, Clément Aubert, Assya Sellak, and Thomas Rubiano.

• We are finalising a C code analysis implementing the so-called *mwp* polynomial-time characterisation of Jones and Kristiansen, which should then be implemented within the LLVM and CompCert compilers.

• We are working on using the same techniques to develop an automated parallelisation tool on C code which we expect to outperform OpenMP for parallelising loops.

Philosophy. I am also collaborating with some philosophers.

• With Alberto Naibo and Mattia Petrolo we study how recent technical developments (e.g. geometry of interaction, classical realisability) can provide new perspectives on old questions in philosophy of logic (e.g. "what is a logical constant ?").

• With Alberto Naibo, I started working on the foundations of computer science and fundamental questions such as "what is a program ?", "what is an algorithm ?" ; we co-supervised an intern on the subject in 2019.

• With Jean-Baptiste Joinet, I am working on the notion of (behavioural) types, how it provides a formal theory of classification generalising previous proposals, and providing a new viewpoint on the concept of definitions by abstraction.

Linguistics. I also got involved in a project about computational linguistics (somehow related to the work mentioned above with Jean-Baptiste Joinet) lead by Luc Pellissier and Juan-Luis Gastaldi, and involving philosophers, historians (of science), and (computational) linguists. Although last year took a toll on the collaboration, I hope it will restart this year.