Curiculum Vitae

Valentin Féray

Assistant professor, University of Zurich

Personal information

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• Education

2006 – 2009 PhD at Université Paris-Est Marne-La-Vallée:

Advisor Philippe Biane, senior CNRS researcher;

Title Functions on the set of Young diagrams: characters of symmetric groups and Kerov polynomials.

2003 – 2007 Student at *École Normale Supérieure de la rue d'Ulm* (ranked 2nd at the entrance national competition).

2001 – 2003 Undergraduate studies in *Classes Préparatoires* at *Lycée Louis-Le-Grand (Paris)*.

• Employment history

2013 – ... Assistant professor for pure Mathematics at the University of Zurich (Switzerland).

2009 – ... CNRS junior researcher at LaBRI, Université de Bordeaux (France). On leave from August 2013.

2007 – 2009 PhD fellow and teaching assistant at University Paris-Est Marne-La-Vallée.

• Institutional responsabilities

2013 – ... Faculty member (Faculty of Sciences, University of Zurich)

2011 – 2013 Vice-director of the « Combinatorics and Algorithms » research team in LaBRI.

• Approved research projects

2015 – 2016/2017 Member of French-Swiss collaboration project *Permutations aléatoires sous contraintes: algorithmique et analyse*, funded by Germaine de Staël program of *Swiss academy of Engeneering Science*. Approved amount (on the Swiss side): 4,500 CHF (4,328 €) per year. Grant nb: 2015-09.

2014 – 2017 Principal investigator of the SNSF (Swiss National Science Fundation) grant "Dual combinatorics of Jack polynomials". Approved amount: 241,615 CHF (232,431 €). Grand nb: SNF-149461.

2011 – 2014 Member of the ANR (French national research agency) grant PSYCO (active participation to the design of the proposal). Approved amount: 111,142 €. Grant nb: ANR-11-JS02-0001.

• Supervision of graduate students and postdoctoral students

2016 Oct – ...	Cosupervision with Mathilde Bouvel (lecturer, University of Zurich) of a PhD student, Lisa Hofer.
2016 Oct – ...	Supervision of a PhD student, Raúl Penaguião.
2015 Oct – ...	Supervision of two postdoctoral students, Jehanne Dousse and Marko Thiel.
2014 Jun – ...	Supervision of a PhD student, Dario De Stavola.
2014 Jan–Dec	Supervision of a postdoctoral student, Per Alexandersson.
2011 – 2014	Cosupervision with Jean Christophe Aval (CNRS junior researcher, LaBRI) of a PhD student, Omar Tout. Omar succesfully defended his PhD on Nov. 24th, 2014.

• Teaching activities

2013 – ...	Teaching as professor at University in Zurich (courses: representation theory, enumerative combinatorics, random combinatorial structures, complex analysis, student seminar on permutations, analytic combinatorics, introduction to Ising model).
2007 – 2009	Teaching assistant during my PhD (courses: Analysis I, Algebra I, Programming in C I and II).

• Communications towards general public

Aug. 2012, 2014, 2016	Participation to "Mat'les Vacances", a math "summer camp" to convince underprivileged high school students that they can also do long studies in mathematics or other scientific areas. Participation to the associated book *Maths la Terminale, Ed. Ellipse., 2016*
Nov. 2013	Talk for first year university students at « Mathematical Park » in Institut Henri Poincaré, Paris.
May 2009 & May 2010	I organized and animated a stand for CNRS at "salon de la culture et des jeux mathématiques" (mathematical culture and games show).

• Memberships in panels, boards and individual scientific reviewing activities

2010 – 2013	I have been a member of four hiring committee for permanent junior teacher-researcher positions (Marne-La-Vallée 2010-2012-2013, Caen 2012).
2008 – ...	Referee for several journals (J. Comb. Th. Ser. A, J. Alg. Comb., Internat. Math. Res. Not., Coll. Math., J. Alg., Pacific J. Math., J. Math. Soc. Japan, Math. Zeitschrift, SIAM J. Disc. Math., Ann. IHP, Ann. Comb., Sém. Loth. Comb., Method. Comp. Appl. Prob., Adv. Appl. Math, Prob. Th. Rel. Fields, Rand. Struct. Algo., Stat. Prob. Letters) and for FPSAC and AofA conferences.

• Organization of scientific meetings

Jan–Apr 2017	Co-organizer of the thematic quarter "Combinatorics and Interactions" at Institut Henri Poincaré, Paris.
2014 – ...	Organizer of a Discrete Math Seminar every second week at the University of Zurich.
Mar. 2013	Co-organizer of the annual week-long meeting of the ALÉA French research group in CIRM, Marseille.

• Invited presentations to peer-reviewed, internationally established conferences and/or international advanced schools

1. Invited plenary speaker at FPSAC 27 (International Conference on *Formal Power Series and Algebraic Combinatorics*) at Daejeon, South Korea, July 2015.

2. Invited to give a mini-course (3 hours lecture, plus exercise sessions) in the workshop *Probability and representation theory in Edinburgh*, February 2014.

3. Invited to give a series of lectures (8 hours) in Collège de France, Paris, January/February 2013.

4. Invited speaker in the special session on *Random structure in asymptotic representation theory*, SPA 34 (International Conference on *Stochastic Processes and Applications*), Osaka, Japan, September 2010.

A complete list of my presentations in workshops, seminars and conferences can be found on my web page.

• Miscellaneous

Small contribution to the open source mathematical software sage.

• Prizes and awards

1. I was invited to give a series of lectures in *Collège de France* by the "Peccot Foundation": this prestigious opportunity is given to one or two French mathematician(s) (or mathematician(s) working in France) under 30 each year. This invitation is often referred as "Prix Peccot".

2. Best student paper award at FPSAC 20 international conference.

Publication list

Publications marked with are the most relevant to this grant proposal. In my field, authors are listed in alphabetic order.

Journals papers:

1. *Gaussian fluctuations of Young diagrams and structure constants of Jack characters*, with Maciej Dołęga, Duke Mathematical Journal, 165 (7), pp. 1193-1282, 2016.
2. *Cyclic inclusion-exclusion*, SIAM J. Discrete Math, 29 (4), pp. 2284-2311, 2015.
3. *On products of long cycles: short cycle dependence and separation probabilities*, with Amarpreet Rattan, Journal of Algebraic Combinatorics, **42**, (1) pp. 183-224, 2015.
4. *Quasi-symmetric functions as polynomial functions on Young diagrams*, with Jean-Christophe Aval, Jean-Christophe Novelli and Jean-Yves Thibon, Journal of Algebraic Combinatorics, **41** (3), pp. 669-706, 2015.
5. *Jack polynomials and orientability generating series of maps*, with Maciej Dołęga and Piotr Śniady, Séminaire Lotharingien de Combinatoire, **B70j**, 50 pp (electronic), 2014.
6. *An edge-weighted hook formula for labelled trees*, with I. P. Goulden and Alain Lascoux, Journal of Combinatorics, **5** (2), pp. 245-269, 2014.
7. *A simple model of trees for unicellular maps*, with Guillaume Chapuy and Éric Fusy, Journal of Combinatorial Theory Series A, **120**, pp. 2064–2092, 2013.
8. *Asymptotics of some statistics in Ewens random permutations*, Electronic Journal of Probability, **18** (76), pp. 1-32, 2013.
9. *A multivariate hook formula for labelled trees*, with I. P. Goulden, Journal of Combinatorial Theory Series A, **120**, pp. 944-959, 2013.
10. *P-partitions revisited*, with Victor Reiner, Journal of Commutative Algebra, **4** (1), pp. 101-152, 2012.
11. *Linear extension sums as valuations of cones*, with Adrien Boussicault, Alain Lascoux and Victor Reiner, Journal of Algebraic Combinatorics, **35** (4), pp. 573-610, 2012.
12. *On complete functions in Jucys-Murphy elements*, Annals of Combinatorics, **16** (4), pp. 677-707, 2012.
13. *Bijective enumeration of some colored permutations given by the product of two long cycles*, with Ekatarina Vassilieva, Discrete Mathematics, **312** (2), pp. 279-292, 2012.
14. *Partial Jucys-Murphy elements and star factorizations*, European Journal of Combinatorics **33**, pp. 189-198, 2012.
15. *Asymptotics of q-Plancherel measures*, with Pierre-Loïc Méliot, Probability Theory and Related Fields, **152** (3-4), pp. 589-624, 2012.
16. *Asymptotics of characters of symmetric groups related to Stanley character formula*, with Piotr Śniady, Annals of Mathematics, **173** (2), 887-906, 2011.
17. *Zonal polynomials via Stanley's coordinates and free cumulants*, with Piotr Śniady, Journal of Algebra, **334**, pp. 338-373, 2011.
18. *Explicit combinatorial interpretation of Kerov character polynomials as numbers of permutation factorizations*, with Maciej Dołęga and Piotr Śniady, Advances in Mathematics, **225** (1), pp. 81-120, 2010.

19. *Stanley's Formula for Characters of the Symmetric Group*, Annals of Combinatorics, **13** (4), pp. 453 - 461, 2010.

20. *Combinatorial interpretation and positivity of Kerov's character polynomials*, Journal of Algebraic Combinatorics, **29** (4), pp. 473-507, 2009.

21. *Application of graph combinatorics to rational identities of type A*, with Adrien Boussicault, Electronic Journal of Combinatorics, **16** (1), R145, 2009.

Monographs:

1. *Mod φ convergence: Normality zones and precise deviations,* with Pierre-Loïc Méliot and Ashkan Nikeghbali, Springer Briefs in Probability and Mathematical Statistics, Springer, in press.

2. *Approche duale des représentations du groupe symétrique,* Collection "Les cours Peccot", Spartacus, 2016.

Conference papers:

1. *Cyclic inclusion-exclusion*, talk, FPSAC 2016. Vancouver (Canada), to appear in DMTCS proc.

2. *Super quasi-symmetric functions via Young diagrams*, with Jean-Christophe Aval, Jean-Christophe Novelli and Jean-Yves Thibon, poster, FPSAC 2014, Chicago (USA), DMTCS proc. AT, 169-180, 2014.

3. *On Kerov polynomials for Jack characters*, with Maciej Dołęga, poster, FPSAC 2013, Paris (France), DMTCS proc. AS, 569-580, 2013.

4. *A simple tree model for unicellular maps*, with Guillaume Chapuy and Éric Fusy, talk, FPSAC 2012, Nagoya (Japon), DMTCS proc. AR, 215–226, 2012.

5. *Asymptotics of some statistics in Ewens random permutations*, talk, AofA 2012, Montréal (Canada), DMTCS proc. AQ, 43–54, 2012.

6. *Dual combinatorics of zonal polynomials*, with Piotr Śniady, talk, FPSAC 2011, Reykyavik (Iceland), DMTCS proc. AO, 317-328, 2011.

7. *Linear coefficients of Kerov's polynomials: bijective proof and refinement of Zagier's result*, with Ekaterina Vassilieva, FPSAC 2010, San Francisco (États-Unis), poster, DMTCS proc. AN, 713-724, 2010.

8. *Application of graph combinatorics to rational identities of type A*, with Adrien Boussicault, FPSAC 2009, Hagenberg (Austria), poster, DMTCS proc, AK, 229 - 240, 2009.

9. *Explicit combinatorial interpretation of Kerov character polynomials as numbers of permutation factorizations*, with Maciej Dołęga et Piotr Śniady, FPSAC 2009, Hagenberg (Austria), talk, DMTCS proc, AK, 337-348, 2009.

10. *Combinatorial interpretation and positivity of Kerov's character polynomials*, FPSAC 2008, Viña del Mar (Chile), talk, DMTCS proc. AJ, 93-104, 2008. "best paper from a student" award.

Short description of selected scientific results

Field of research: algebraic combinatorics (combinatorial representation theory, symmetric functions), and applications to stochastic processes. Combinatorial approach in probability theory.

To make the structure clearer, I decided to split this section into two main parts. Both parts are of course connected: among other things, they both involve classical combinatorial objects (permutations, matchings, set-partitions, ...) and make use of cumulants combinatorics.

Dual combinatorics of Jack characters

Background. The representation theory of the symmetric group is a central topic in algebraic combinatorics, often considered as a toy model to understand representations of more complicated groups appearing in theoretical physics or Lie theory. Despite a long history, a new approach, that can be described as dual, was developed in the nineties. This approach was motivated by questions on large random Young diagrams (or random irreducible representation of the symmetric group): indeed, the classical approach in general fails to give asymptotic information on characters.

In this new approach, the main object is the (suitably renormalized) character value ϑ_μ on a permutation of cycle-type μ, seen as a function of the partition λ inducing the representation. In the 2000's, this function ϑ_μ has been investigated from a combinatorial viewpoint: among others by Stanley, Biane, Śniady, Goulden, Rattan, Petrullo, Senato and myself. The formulas obtained this way involves P-partitions and combinatorial maps, making connections with other classical domains of combinatorics. An overview of this flourishing domain is given in [M2][1]

Analogues of these results for *Jack polynomials* have recently been investigated. Jack polynomials are symmetric functions indexed by a real parameter $\alpha > 0$. Using them, Lassalle defined a deformation $\vartheta_\mu^{(\alpha)}$ of the function ϑ_μ (which corresponds to $\alpha = 1$), initiating a dual approach to Jack polynomials. He then formulated two positivity conjectures about the coefficients of various expansions of $\vartheta_\mu^{(\alpha)}$. From an algebraic combinatorics point of view, a positivity conjecture suggests an underlying combinatorial structure. We refer to the research plan for motivations to try and uncover this combinatorial structure.

My contributions to this domain.

A first set of contributions leads to a better understanding of the case $\alpha = 1$:

- In a paper with Śniady [J16], we have shown how the combinatorics of the dual approach leads to sharp bounds on symmetric group characters. Finding such bounds has been the subject of many research papers, as it has applications in many fields: random walks, group theory, quantum encoding systems, ... We were able to unify and extend in a simple way some previous results in the field.
- a series of paper [J6,J7,J10,J11] goes deeper in the theory of P-partitions: among other things, we have found some multi-variate generalizations of summation hook formulas for trees and extended Knuth's tree hook formula for counting linear extensions to a larger class of posets (building on a commutative algebra interpretation of Knuth's formula). The understanding of hook formulas has lead to an important literature in the past few years and these formulas, while motivated by character combinatorics, are of independent interest.
- In [J4], we study the algebra of functions on Young diagrams that depend polynomially in multi-rectangular coordinates (this includes the ϑ_μ functions). This turns out to be isomorphic to the well-studied quasisymmetric function algebra. In a related paper [J2], we describe combinatorially a complete set of relations in this algebra. Again, this is also interesting independently of symmetric group representations, since it gives some new information on the quasi-symmetric function ring itself.

[1] References in this document are numbered according to publication section: *e..g.* J1 is the first item in the journal publication section.

I also investigated the generalization related to Jack polynomials, as suggested by Lassalle:

- with Śniady [J17], we gave a combinatorial formula for the case $\alpha = 2$, solving Lassalle's conjecture in this particular case; our result deepens the connection with map enumeration, as it involves a summation on maps on *non-oriented surfaces*.
- For a general value of α, we were not able to find a combinatorial description of $\vartheta_\mu^{(\alpha)}$; in [J5], we made a conjecture on the general form that the result should have and give evidence towards it.
- Interestingly enough, even if our understanding of the general α case is far from being complete, we could apply it to a problem in probability theory. Recall that analysing random Young diagrams, distributed with Plancherel measure, was the original motivation for this dual approach. There is a natural deformation of Plancherel measure associated to Jack polynomials. With Dołęga [J1], we could prove a central limit theorem for random Young diagram under this measure. The proof mixes algebraic ingredients (such as the above-mentioned partial results) and probabilistic tools (such as Stein's method with exchangeable pairs).

Dependency graphs and random permutations

Background. The theory of dependency graph is a toolbox to prove asymptotic normality of combinatorial statistics. The idea is the following: consider a family of random variables Y_a. If most pairs (Y_a, Y_b) are independent, then the sum $X_n = \sum Y_a$ will behave as a sum of independent variables and satisfy a central limit theorem. Dependency graphs formalize this simple idea by encoding dependencies in a graph and giving precise criteria of asymptotic normality. They have found applications in combinatorics (for subgraph counts in random graphs, pattern occurrences in uniform random permutations), but also in geometric probability or for models of cell populations (see the introduction of arXiv:1605.03836 for references).

My contributions to this domain.

- With Méliot and Nikeghbali [M1], we have shown more precise results for the sum X_n than the central limit theorem. Namely, we can describe the normality zone (i.e. give the scale until which the estimate given by the central limit theorem still holds) and we give the correction factor at the edge of this normality zone. These results are achieved by proving sharp bounds on cumulants. An interesting feature is that they fit in the larger framework of mod-φ convergence, as introduced by Kowalski and Nikeghbali. Therefore our result of normality zone also applies to objects in various areas of probability theory (although there is no underlying dependency graph): log-determinant of random matrices, multiplicative functions of a random integer, blocks in random set-partitions to name a few. Some problems on random characters, mentioned in the first part of this document, also fit in this context.
- The previous result uses the dependency graph hypothesis and sharpens the conclusion. In a recent preprint (arXiv:1605.03836; see also [J8]), we went in the opposite direction, weakening the dependency hypothesis. Indeed, in many examples, variables are not independent but close to. A typical example is the images of two distinct integers in a random permutations of size n: since they cannot be equal, they are certainly not independent, but this phenomenon becomes weaker when the value of n grows.

  We formalized this idea in the concept of weighted dependency graphs. Variables are now linked by weighted edges: the smaller the weight is, the closer from independence the corresponding variables are. Again, a normality criterion allows to prove the asymptotic normality for the sum X_n. This has various applications in combinatorial probability (random matchings, random graphs, random permutations) but also in classical probability theory (multivariate statistics on Markov chains) and statistical physics (simple symmetric exclusion process, Ising model).
- With a group of co-authors (in the preprint arXiv:1602.04960), I have also been interested in a model of constraint random permutations, namely uniform separable permutations. Here the independence structure breaks up completely and we describe asymptotic properties of these permutations by using a connection with random trees and the Brownian excursion. This leads us to the definition of an interesting limiting object, the Brownian separable permuton. This makes a connection between two fields of growing interest: Brownian limits for random combinatorial objects (such as the Brownian continuous random tree or the Brownian map) and the study of large deviations for permutations, which parallels similar results for graphs (developed through the theory of graphons).