PPA 2026

Abstract Book

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Part I

Invited Talks

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Perfect sampling for hard spheres from strong spatial mixing

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We provide a perfect sampling algorithm for the hard-sphere model on subsets of $\mathbb{R}^d$ with expected running time linear in the volume under the assumption of strong spatial mixing. Our perfect sampling algorithm is efficient for a range of parameters for which only efficient approximate samplers were previously known and is faster than these known approximate approaches.

This talk is based on a joint work with Andreas Göbel, Marcus Pappik, and Will Perkins.

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Extremes of marked point processes: a lesson from time series

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The extremal behavior of stationary, heavy-tailed time series and the fundamental role of dependence in that framework are well understood. In this talk, we review the core concepts of this theory and demonstrate how they can be extended to the study of stationary marked point processes in Euclidean space.

We consider configurations where points are assigned real-valued random variables, we call scores, which may depend on the relative positions of neighboring points and external sources of randomness. We show that in the neighborhood of a point with an extremal score, one can often rescale both the positions and scores of nearby points to obtain a limiting point process termed the tail configuration.

By imposing specific dependence conditions on the scores, we use this local limit to derive global asymptotics for extreme scores within expanding regions of $\mathbb{R}^d$. Finally, we demonstrate the utility of this framework by applying it to several point process models from the literature.

This talk is based on the joint work [2] with Ilya Molchanov and Hrvoje Planinić.

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https://doi.org/10.1017/apr.2025.23

Universal limits for scale-invariant functionals

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We present a general framework for proving that scale-invariant functionals of spatial point processes have universal limiting distributions, meaning that the limit is independent of the underlying point-process distribution. Our primary motivation comes from topological data analysis (TDA), where we study the distribution of random persistence diagrams and show that the distribution of death/birth values admits a universal limit. We also demonstrate how the framework applies in other settings, including nearest-neighbor ratios (which are often used for intrinsic dimensionality estimation) and the spectrum of k-NN graphs (which is one of the main components in manifold learning theory).

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The expected length of a Euclidean MST and 1-norms of chromatic persistence diagrams

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A classic result on Euclidean minimum spanning trees (EMSTs) is the existence of an asymptotic constant, c, such that the expected length of the EMST of n points sampled uniformly at random in the unit square is $c\sqrt{n}$, in the limit when n goes to infinity. However, the value of c is not known. Prior to this work, the known bounds were $0.6008 < c < 0.7072$, and we improve the lower bound to $0.6289 < c$.

The motivation for this work is the stochastic analysis of chromatic persistence diagrams. In particular, we show that similar asymptotic constants exist for the expected 1-norms of all diagrams in the 6-pack of a randomly 2-colored set of points in the unit square, in which we study the inclusion of the disjoint union of the sublevel sets of the two monochromatic distance functions into the sublevel set of the bichromatic distance function.

This talk is based on a joint work with Ondřej Draganov, Sophie Rosenmeier, and Morteza Saghafian.

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Optimal matchings on random graphs and the belief propagation algorithm

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The "belief propagation algorithm" is a general *non random* optimization algorithm which is exact and has linear speed, when used on graphs without cycles (i.e. trees). We will start by presenting this algorithm on the simple setting of an optimal weight matching problem on a line whose edges have i.i.d. weights. We will progressively consider more complex settings, like Galton-Watson trees, the Erdös-Rényi graphs in the sparse regime, and finally the configuration model. In the two last examples, we will see when and how it is possible to overcome the presence of cycles in the graph and get results as the asymptotic weight of the matching or its local limit.

This talk is based on a joint work with Mike Liu, Laurent Ménard and Vianney Perchet.

Why determinantal point processes are good point sets: energy and discrepancy

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The construction of well-distributed point configurations on compact spaces is a fundamental problem with deep connections to potential theory, discrepancy theory and stochastic geometry. Two classical quantitative criteria to assess uniformity are the minimization of interaction energies and the minimization of discrepancy.

In this talk, we focus on determinantal point processes (DPP) as natural probabilistic models of repulsive point configurations. After introducing the basic properties of DPPs, we show how they provide a canonical framework in which low energy and low discrepancy arise simultaneously. We present recent results on energy and discrepancy bounds for DPPs on compact spaces, showing that these processes achieve asymptotically optimal behavior for a wide class of interaction kernels and discrepancy notions. These results highlight the role of repulsion and correlation structure in the quantitative uniformity of random point sets.

Overall, the talk aims to clarify the interplay between energy minimization, discrepancy, and determinantal structure, and to illustrate how DPPs serve as a unifying probabilistic model for well-distributed points.

First-order behavior of the time constant in continuous first-passage percolation

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Consider balls of small fixed radius placed independently and homogeneously in Euclidean space. Let S denote the union of these balls. A walker moves at unit speed outside S and at infinite speed inside S. The time needed to travel from the origin to a distant point x, along an optimal path, is proportional to the Euclidean norm of x. This defines an effective speed. How does this speed depend on the small radius? What happens if we replace the Euclidean norm by another norm?

This talk is based on a joint work with Anne-Laure Basdevant and Marie Théret.

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Strong sharp phase transition in the random connection model

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In this talk we consider a random connection model (RCM) ξ driven by a Poisson process η on a general state space. We derive uniform exponential moment bounds for an arbitrary cluster, provided that the intensity t of η is below a certain critical intensity t_T. The associated subcritical regime is characterized by a finite mean cluster size, uniformly in space. Under an exponential decay assumption on the connection function, we also show that the cluster diameters are exponentially small as well.

In the important stationary marked case and under a uniform moment bound on the connection function, we show that t_T coincides with t_c, the largest t for which ξ does not percolate. In this case, we also derive some percolation mean field bounds. Even in the classical unmarked case, our results are more general than what has been previously known. Our proofs are partially based on some stochastic monotonicity properties, which might be of interest in their own right.

The talk is based on the recent joint work [1] with Mikhail Chebunin (University of Ulm).

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Complexity of optimization and sampling algorithms for the continuous random energy model

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The continuous random energy model (CREM) is a certain Gaussian process indexed by a binary tree of depth T. It was introduced by Derrida and Spohn in [3] and by Bovier and Kurkova in [2] as a toy model of a spin glass.

In this talk, I will present recent results on hardness thresholds for algorithms that search for low-energy states. I will first discuss the existence of an *algorithmic hardness threshold* x_*: finding a state of energy lower than $-xT$ is possible in polynomial time if $x < x_*$, and takes exponential time if $x > x_*$, with high probability. I will also discuss related results on the complexity of sampling the Gibbs measure of inverse temperature parameter $\beta > 0$.

I shall then focus on the transition from polynomial to exponential complexity near the algorithmic hardness threshold of the optimization problem, by studying the performance of a certain beam-search algorithm of beam width N depending on T — we believe this algorithm to be natural and asymptotically optimal. The algorithm turns out to be essentially equivalent to the time-inhomogeneous version of the so-called N-particle branching Brownian motion (N-BBM), which has seen a lot of interest in the last two decades. Studying the performance of the algorithm then amounts to investigating the maximal displacement at time T of the time-inhomogeneous N-BBM. In doing so, we are able to quantify precisely the nature of the transition from polynomial to exponential complexity, proving that the transition happens when the log-complexity is of the order of $T^{1/3}$. This result appears to be the first of its kind and we believe this phenomenon to be universal in a certain sense.

This talk is based on joint works with Louigi Addario-Berry, Fu-Hsuan Ho and Alexandre Legrand, respectively.

References

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Crossing probabilities in scale-free geometric random graphs

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In the continuum percolation model we consider, vertices are given by the points of a Poisson process and are equipped with independent weights following a heavy tailed distribution. Any pair of distinct vertices is independently forming an edge with a probability decaying as a function of the product of the weights divided by the distance of the vertices.

We study the crossing probabilities of annuli, i.e. the probabilities that there exist paths starting inside a ball and ending outside a larger concentric ball with increasing inner and outer radii. Depending on the radii, the power-law exponent of the degree distribution and the decay of the probability of long edges, we identify regimes where the crossing probabilities by a path are equivalent to the crossing probabilities by one or by two edges. We also identify the escape probabilities from balls with strong centre, i.e. the asymptotics of the probability that there exists a path starting from a vertex with a given weight leaving a centred ball as radius and weight are going to infinity.

As a corollary we get the subcritical one-arm exponents characterising the decay of the probability that a typical point is in a component not contained in a centred ball whose radius goes to infinity.

This talk is based on a joint work with Emmanuel Jacob, Céline Kerriou, and Amitai Linker.

Persistence spheres:
a bi-continuous linear representation of measures for partial optimal transport

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Topological data analysis (TDA) and point processes (PP) meet in two complementary ways: persistence diagrams (PDs) can be viewed as realizations of point processes on the upper half-plane, and TDA summaries are effective for stationary point processes thanks to invariance under Euclidean isometries. In TDA, PDs are naturally compared via partial optimal transport metrics such as the 1-Wasserstein partial transport distance POT_1 [2], which allows unmatched mass to be deleted by sending it to the diagonal. To enable statistics for populations of PDs, one would like Hilbert-space embeddings that still respect this geometry; for this reason we study and extend *persistence spheres*, introduced in [1].

Persistence spheres map an integrable measure μ on the upper half-plane (including PDs as counting measures) to a function $S(\mu) \in C(\mathbb{S}^2)$, and the map is stable with respect to POT_1. Moreover, to the best of our knowledge, persistence spheres are the only such summary for which continuity of the inverse transformation has been established, i.e., the representation is not only stable but also admits a continuous reconstruction map on its image. The construction is rooted in convex geometry: for positive measures, the defining ReLU integral is the support function of the lift zonoid. Building on [1], we refine the definition to better match the POT_1 deletion mechanism, encoding partial transport via a signed diagonal augmentation. In particular, for integrable μ, the distance between $S(0)$ and $S(\mu)$ depends only on the persistence of μ, reflecting optimal transport to the diagonal at persistence cost. This removes ad hoc reweighting and yields a parameter-free representation at the level of measures (up to numerical discretization), while accommodating future extensions where μ is a smoothed measure derived from PDs (e.g., persistence intensity functions [3]).

We evaluate the refined method on multiple case studies, where μ is the persistence diagram (as a counting measure) associated with standard filtrations, and compare against persistence images, persistence landscapes, persistence splines, and sliced Wasserstein kernel baselines. In parallel, with Nicolas Chenavier and Christophe Biscio we are developing a statistical framework for applying persistence spheres to stationary point processes, including limit theorems for the induced functional summaries, in the spirit of asymptotic theories for (persistent) Betti numbers, persistence diagrams, and the accumulated persistence function [4–7].

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Point process convergence of large inradii of Poisson-Laguerre tessellation

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Random tessellations form a popular family of models used in a variety of fields. The object of our research is the Poisson-Laguerre tessellation, i.e. a random Laguerre tessellation whose generator is a stationary Poisson marked point process η. We study the behavior of the large inradii of the cells, where the inradius of a Laguerre cell $L((x,m),\eta)$ generated by the point (x,m) is defined as the largest radius r such that the ball $b(x,r)$ lies inside the cell $L((x,m),\eta)$.

We discuss the convergence of the process of large inradii and their generating points to a suitable Poisson process first in a setting with uniformly bounded marks and also in a setting with heavy-tailed marks. As a corollary, we get a convergence in distribution for the correctly rescaled maximal inradius.

This talk is based on a joint work with Matthias Schulte.

Wasserstein stability of the zero cell of a stationary Poisson hyperplane tessellation under directional perturbations

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A stationary Poisson hyperplane process (PHP) Φ in $\mathbb{R}^d$ is characterized by an intensity parameter $\lambda > 0$ and an even directional probability measure ϕ on the unit sphere S^{d-1}. A natural question is: how the geometric characteristics of Φ respond to perturbations of its defining parameters. In this talk, we investigate the stability of the zero cell $Z(\Phi)$, the random polytope containing the origin, under perturbations of the directional distribution ϕ.

Equipping the space $\mathcal{K}$ of convex bodies with a metric d induces Wasserstein metric $W_{1,d}$ on probability measures on $\mathcal{K}$. We study how this distance between the laws of two zero cells relates to the Wasserstein distance W_1 between respective directional distributions on S^{d-1}? We show that there exists an exponent $\alpha \in (0, 1]$ such that, for every reference directional distribution ϕ, there is a radius $R > 0$ with the property that

$$W_{1,d}\big(Z(\Phi_1), Z(\Phi_2)\big) \leq C(\lambda, \phi, R)\, W_1(\phi_1, \phi_2)^\alpha$$

for all directional distributions ϕ_1, ϕ_2 satisfying $W_1(\phi_i, \phi) < R$, where Φ_i denotes the PHP with parameters (λ, ϕ_i).

As an application of this stability result, we obtain an upper bound on the error term arising in the estimation of an unknown density from sampled data.

This talk is based on a joint work with Eliza O'Reilly and Gilles Bonnet.

Topological autoencoders++: fast and accurate cycle-aware dimensionality reduction

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This talk presents a novel topology-aware dimensionality reduction approach aiming at accurately visualizing the cyclic patterns present in high dimensional data. To that end, we build on the Topological Autoencoders (TopoAE) formulation.

First, we provide a novel theoretical analysis of its associated loss and show that a zero loss indeed induces identical persistence diagrams (in high and low dimensions) for the 0-dimensional persistent homology (PH_0) of the Rips filtration. We also provide a counter example showing that this property no longer holds for a naive extension of TopoAE to PH_d for $d \geq 1$.

Based on this observation, we introduce a novel generalization of TopoAE to 1-dimensional persistent homology (PH_1), called TopoAE++, for the accurate generation of cycle-aware planar embeddings, addressing the above failure case. This generalization is based on the notion of cascade distortion, a new penalty term favoring an isometric embedding of the 2-chains filling persistent 1-cycles, hence resulting in more faithful geometrical reconstructions of the 1-cycles in the plane.

We further introduce a novel, fast algorithm for the exact computation of PH for Rips filtrations in the plane, yielding improved runtimes over previously documented topology-aware methods.

Overall, our work also achieves a better balance between the topological accuracy, as measured by the Wasserstein distance, and the visual preservation of the cycles. Our C++ implementation is available in TTK.

This talk is based on a joint work with Mattéo Clémot and Julie Digne.

Second-order Poincaré inequalities and localization on the Poisson space

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Consider a Poisson point process $\mathcal{P}$ on a metric space and a function $H = H(\mathcal{P})$ which can be written as a sum of so-called score functions, i.e. $H = \sum_{x\in\mathcal{P}} \xi(x, \mathcal{P})$. Examples of such functions can be total edge-lengths or number of isolated points in spatial random graphs, but also more complex models like the number of accepted particles in Random Sequential Adsorption (RSA), which is an interacting particle system. It is known that when the functions ξ exhibit a certain kind of 'local' behaviour, then H satisfies a Central Limit Theorem when $\mathcal{P}$ grows.

This talk is based on a joint work with Joseph Yukich, where we propose the notion of 'localization', a weak condition on score functions which is sufficient to induce a CLT. We give Berry-Esseen type quantitative convergence rates and illustrate our results on several applications, among them the RSA model. The proof is based on new and improved second-order Poincaré inequalities for general functions of Poisson point processes, which are of independent interest.

Ideal Poisson-Voronoi tessellations in hyperbolic spaces

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In this talk, we will study the low intensity limit of Poisson-Voronoi tessellations on hyperbolic spaces of dimension 2 and higher. Limiting object, the ideal Poisson-Voronoi tessellation, is a natural, locally finite Möbius-invariant decomposition of the hyperbolic space into unbounded convex hyperbolic polytopes each with a unique end. After constructing this limiting object, we will look into some of its properties, in particular the geometric features of the cell containing the origin.

This talk is based on a joint work with Matteo d'Achille, Nicolas Curien, Nathanaël Enriquez and Russell Lyons.

Part II

Contributed Talks

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Asymptotically distribution-free goodness-of-fit testing for point processes

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Consider an observation of a multivariate temporal point process N with law $\mathcal{P}$ on the time interval $[0, T]$. To test the null hypothesis that $\mathcal{P}$ belongs to a given parametric family, we construct a convergent compensated counting process to which we apply an innovation martingale transformation. We prove that the resulting process converges weakly to a standard Wiener process.

Consequently, taking a suitable functional of this process yields an asymptotically distribution-free goodness-of-fit test for point processes. For several standard tests based on the increments of this transformed process, we establish consistency under alternative hypotheses. Finally, we assess the performance of the proposed testing procedure through a Monte Carlo simulation study and illustrate its practical utility with two real-data examples.

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Palm versions of marked Hawkes processes and applications

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In this talk, we present the Palm version of a marked Hawkes process with general dependence assumptions on its components (marks, law governing the number of offspring), extending results of Kirchner [2]. We use it to derive associated tail configurations (in the sense of Basrak et. al. [1]) for some scored versions of the underlying Hawkes process.

This talk is based on a joint work in progress with Hrvoje Planinić.

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Random burning of the Euclidean lattice

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The burning number of a graph is the minimal number of steps that are needed to burn all of its vertices, with the following procedure: at each step, one can choose a point to set on fire, and the fire propagates constantly at unit speed along the edges of the graph. In the joint work [1] with Alice Contat, we consider two natural random burning procedures in the discrete dimensional Euclidean torus $\mathbb{T}_n^d$, in which the points that we set on fire at each step are random variables.

Our main result deals with the case where at each step, the law of the new point that we set on fire conditionally on the past is the uniform distribution on the complement of the set of vertices burned by the previous points. In this case, we prove that as $n \to \infty$, the corresponding random burning number (i.e., the first step at which the whole torus is burned) is asymptotic to $T \cdot n^{d/(d+1)}$ in probability, where $T = T(d) \in (0, \infty)$ is the explosion time of a so-called generalised Blasius equation.

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Peeling procedure for stable Poisson point processes

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We consider the asymptotic properties of the sequence of convex hulls which arises as a result of a peeling procedure applied to the configurations of a strictly stable Poisson point process. Processes of the considered type are tightly connected with empirical point processes and stable random vectors (see, for example, [1]).

In [2], it was shown that in the case of a discrete spectral measure, the normalized convex hulls converge almost surely to a certain limiting convex set.

In the present talk, an (almost) arbitrary spectral measure is considered, and an upper bound of the correct order is obtained, which supports the conjecture about the existence of a limiting shape in the general case.

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Discrete-to-continuous limits of determinantal point processes

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Determinantal point processes (DPPs) are a class of point processes over a space Γ that can exhibit repulsive interactions, and are parametrized by a kernel $K : \Gamma \times \Gamma \to \mathbb{R}$. In computational statistics, DPPs can be used to subsample a data set $\Gamma = X_n$ of n data points; intuitively, repulsiveness allows to obtain subsamples that better cover the data set than a subsample of independent points of the same size would. Quantifying a *strict* advantage, though, is often a challenging issue. On the other hand, DPPs defined over a "continuous" space $\Gamma = \mathcal{X}$ (e.g., a domain of $\mathbb{R}^d$ or a manifold) can be studied using refined analytical tools, and desirable statistical properties can often be established.

We are concerned with the limiting behavior of DPPs on X_n towards a DPP on a compact space $\mathcal{X}$, when X_n is drawn i.i.d. in $\mathcal{X}$ and $n \to \infty$. We propose a non-asymptotic characterization of this limit in terms of the concentration of the linear statistics of those processes; this naturally allows to translate guarantees from the limiting DPP over $\mathcal{X}$ to the DPP over X_n. We show that this concentration takes place whenever the kernels of the processes concentrate towards each other, with rates controlled by the concentration rates of the kernels themselves. If the kernel of the DPP over X_n is well-crafted, this can be the case even when both the kernel of the continuous process and its underlying space are inaccessible, or when the kernel over X_n is a (very) noisy version of its continuous counterpart. We illustrate this methodology by establishing better-than-independent guarantees for a DPP-based coreset-construction strategy.

The talk is based on the joint work [1] with Nicolas Keriven.

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Asymptotic normality of persistent Betti numbers in dynamic Boolean models

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Topological data analysis offers a principled way to quantify disorder in complex, high-dimensional structures, but rigorous distributional theory for persistence-based summaries is still limited. We study persistent Betti numbers (number of persistent connected components, persistent loops, persistent voids, etc.) for a monotone dynamic Boolean model, where random grains arrive in space over time and generate a natural filtration of nerve complexes.

In a subcritical percolation regime (exponential decay of long connections), we prove that the centered and volume-rescaled persistent Betti numbers converge, in the Skorokhod topology, to a mean-zero Gaussian field (i.e., a *functional* CLT) as the window grows. To prove tightness, we use a two-parameter version of *Davydov's criterion* (see [1]). By restricting to the diagonal (birth = death), we also recover a CLT for the regular Betti numbers.

The talk is based on an ongoing joint work with Christian Hirsch. Additionally, in parallel with the theoretical development, we aim to apply the resulting Gaussian limits to black silicon morphology data from materials science.

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Asymptotic variance in hyperuniform point processes and functions of bounded variation

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I will explain how results of Bourgain, Brezis, Mironescu, and Dávila on functions of bounded variation relate to the asymptotic analysis of the number variance — and more general linear statistics — in hyperuniform point processes. I will present several results for both point processes and functional norms that arise from this connection.

This talk is based on joint works with J. Antezana, M. Levi, J. Ortega-Cerdà (University of Barcelona) and L. Molag (Carlos III University of Madrid).

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