GEOMETRY, ANALYSIS & CONVEXITY

20 - 24 | JUNE

2022

SEVILLA

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geOmetry, anaLysis & convExity

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Poster sessions will be held during Coffee breaks on Tuesday.

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ABSTRACTS

Monday 20 June 2022

Spherical convex hull of random points on a wedge
Elisabeth Werner
Case Western Reserve University, USA

Consider two half-spaces H_1^+ and H_2^+ in $\mathbb{R}^{d+1}$ whose bounding hyperplanes H_1 and H_2 are orthogonal and pass through the origin. The intersection $\mathbb{S}^d_{2,+} := \mathbb{S}^d \cap H_1^+ \cap H_2^+$ is a spherical convex subset of the d-dimensional unit sphere $\mathbb{S}^d$ and is called a spherical wedge.

Choose n independent random points uniformly at random on $\mathbb{S}^d_{2,+}$ and consider the expected facet number of the spherical convex hull of these points. It is shown that, up to terms of lower order, this expectation grows like a constant multiple of $\log n$. The result is compared to the corresponding behavior of classical Euclidean random polytopes and of spherical random polytopes on a half-sphere.

Based on joint work with Florian Besau, Anna Gusakova, Matthias Reitzner, Carsten Schuett and Christoph Thaele.

On extensions of Grünbaum's inequality
Francisco Marín Sola
Universidad de Murcia, Spain

A classical result by Grünbaum provides a sharp lower bound for the ratio

$$\mathrm{vol}(K^-)/\mathrm{vol}(K)$$

of a convex body $K \subset \mathbb{R}^n$ that depends only on the dimension n (here K^- denotes the intersection of K with a halfspace bounded by a hyperplane passing through its centroid). In this work, on the one hand, we will discuss various recent results in the spirit of finding a generalization of Grünbaum's inequality, in both a geometric and a functional setting. On the other hand, we will show further generalizations of this result to the case of cuts (by hyperplanes) through other particular points.

This is part of joint work with David Alonso-Gutiérrez, Javier Martínez Goñi and Jesús Yepes Nicolás.

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$\sim$: *Coffee Break* :$\sim$

11:30–12:00

Algebraic structures on valuations on convex functions
Jonas Knoerr

TU Vienna, Austria

At the heart of modern integral geometry is the algebraic theory of valuations initiated by Alesker, in particular the Alesker product and Bernig-Fu convolution, which define partial product structures on the space of translation invariant valuations on convex bodies. Recently, many results from the theory of valuations on convex bodies have been extended to the class of dually epi-translation invariant valuations on convex functions and I will talk about an extension of these two product structures to this functional setting. For the Alesker product, this extension relies on a description of a dense subspace of the space of all such valuations in terms of mixed Hessian valuations, a functional analog of mixed volumes. This characterization can be seen as a version of McMullen's conjecture for dually epi-translation invariant valuations on convex functions.

12:00–12:30

Directional curvatures of convex bodies in $\mathbb{R}^n$
Fátima F. Pereira

CIMA & Department of Mathematics, University of Évora, Portugal

Take a point ξ on the boundary of a convex body F in $\mathbb{R}^n$, near which the boundary is given by an implicit equation. We present an easy formula to compute the curvature of F at ξ in the direction of any its tangent vector. For this we consider the intersection curve between the boundary of F and a suitable plane, without using the plane equations or the curve expression. But if we used them we would see that the formula we obtained is equivalent to the existing ones. We also show that when the directional curvature of F is positive, then there is the directional derivative of the Minkowski functional of the polar set of F, and we propose a formula to calculate it.

$\sim$: *Lunch Break* :$\sim$

15:30–16:30

Isoperimetric inequalities in L_p spaces when p is less than 1
Grigoris Paouris
Texas A& M University, USA

We establish a family of isoperimetric inequalities for polar L_p-centroid bodies that interpolate between the classical inequalities of Lutwak-Zhang for polar-centroid bodies and Busemann inequality for intersection bodies. The approach depends on new empirical versions of these inequalities.

Based on joint work in progress with R. Adamczak, P. Pivovarov and P. Simanjuntak.

$\sim$: *Coffee Break* :$\sim$

17:00–17:30

Complex ellipsoids and complex symmetry
Luis Montejano
UNAM at Queretaro, Mexico

The solution of the complex isometric Banach conjecture: "if any two n-dimensional subspaces of a complex Banach space V are isometric, then V is a Hilbert space´´ realizes heavily in a characterization of the complex ellipsoid.

An ellipsoid is the image of a ball under an affine transformation, if this affine transformation is over the complex numbers, we refer to it as a complex ellipsoid. Characterizations of real ellipsoids have received much attention over the years, however, characterizations of complex ellipsoids have been scarcely studied. The purpose of this talk is the study of complex ellipsoids which is naturally related to the study of complex symmetry. So, characterizing and understanding complex symmetry is vital to characterizing complex ellipsoids. Our main contribution is an unexpected characterization of complex ellipsoids which has no analogue over the real numbers.

It is interesting to note the use of various types of topological techniques in the proofs of most of our results.

Joint work with Jorge Arocha and Javier Bracho.

17:30–18:00

Ryll-Wojtaszczyk homogeneous polynomials on strictly convex circular domains in $\mathbb{C}^n$

Paulina Pierzchała

AGH University of Science and Technology, Faculty of Applied Mathematics, Kraków, Poland

The aim of this talk is to present some applications of the Ryll-Wojtaszczyk homogeneous polynomials on strictly convex circular domains in $\mathbb{C}^n$. They were originally constructed in the unit ball by Ryll and Wojtaszczyk [4] and found many applications, e.g. in the construction of the inner function in the unit ball [1]. Then it turned out that similar homogeneous polynomials existed also in strictly convex circular domains in $\mathbb{C}^n$ [2].

In this talk we will show how Ryll-Wojtaszczyk homogeneous polynomials can be applied in the investigation of the so-called Radon inversion problem for holomorphic functions on circular strictly convex domain $\Omega \subset \mathbb{C}^n$ [3], i.e. given $p > 0$ and H - a strictly positive continuous function on $\partial\Omega$ find a function f holomorphic in Ω such that

$$\int_0^1 \left| f(zt) \right|^p dt = H(z), \quad \text{where } z \in \partial\Omega.$$

[1] Aleksandrov A. B., *Inner functions on compact spaces*, Functional Anal. Appl. **18** (1984) 87–98.

[2] Kot P., *Homogeneous polynomials on strictly convex domains*, Proc. Amer. Math. Soc. **135** (2007), p. 3895-3903.

[3] Pierzchała P., Kot P., *Radon inversion problem for holomorphic functions on circular, strictly convex domains*, Complex Anal. Oper. Theory 15, **80** (2021), p. 1-31.

[4] Ryll J., Wojtaszczyk P., *On homogeneous polynomials on a complex ball*, Trans. Amer. Math. Soc. **276** (1983), p. 107-116.

This is a joint work with Piotr Kot.

$\sim$: *20:00 City Tour* :$\sim$

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Tuesday 21 June 2022

$\boxed{\text{9:30–10:30}}$

On the singularity of random ± 1 and $0/1$ matrices

Alexander Litvak

University of Alberta, Canada

We discuss recent progress on singularity of random matrices with i.i.d. Bernoulli entries.

The talk is partially based on a joint work with K. Tikhomirov.

$\boxed{\text{10:30–11:00}}$

A uniform lower bound on the norms of hyperplane projections of spherical polytopes

Tomasz Kobos

Jagiellonian University in Cracow, Poland

For a given centrally symmetric spherical polytope in the n-dimensional space, satisfying some quite general conditions, we provide a uniform lower bound on the norms of all hyperplane projections in terms of the determinant function of vertices and facets. We apply this result to the case of random spherical polytope with a large number of vertices to obtain a uniform lower bound on the norms of all hyperplane projections, which is true with a high probability. This lower bound is polynomial with the respect to the number of vertices of the random polytope.

$\sim$: *Coffee Break* :$\sim$

11:30–12:00

Weighted Floating Body of Polytopes
Florian Besau
TU Wien, Austria

In this talk I will present a joint work together with C. Schütt and E. M. Werner where we establish asymptotic results for the weighted floating body of d-dimensional convex polytope. The weighted floating body is a generalization of the classical floating body which arises by replacing the Euclidean volume with a measure that has a positive and continuous density function.

In our results we establish an interesting connection between the weighted volume of the weighted floating body and the number of complete flags of the polytope. This flag number is an important combinatorial invariant and is the same as the number of simplices obtained in the barycentric subdivision. An application of our main results shows that the same asymptotic behavior for the volume of the floating body of a convex polytope can be observed also in spherical and hyperbolic geometry.

12:00–12:30

Isoperimetric problems for zonotopes
Zsolt Lángi
Budapest University of Technology, Hungary

Shephard (Canad. J. Math. **26**, 302-321, 1974) proved a decomposition theorem for zonotopes yielding a simple formula for the volume of the zonotope. In this talk we present a generalization of this theorem yielding similar formulas for the intrinsic volumes of the zonotope. Based on this, we investigate isoperimetric type problems for zonotopes generated by a given number of segments. In particular, we solve such problems for parallelotopes and rhombic dodecahedra, and give asymptotic estimates for the solutions of these problems for zonotopes generated by sufficiently many segments. In addition, we present applications of our results to polarization problems on the sphere and a vector-valued Maclaurin-inequality conjectured by Brazitikos and McIntyre in 2021.

Joint work with A. Joós.

12:30–13:00

Monohedral tilings of a smooth convex disc
Viktor Vígh
University of Szeged, Hungary

In this talk we give a complete description about normal monohedral tilings of a convex disc with smooth boundary where we have at most three topological discs as tiles. This result is a far-reaching generalization of earlier results of Kurusa, Lángi and Vígh. Some further partial results are proved for non-normal tilings.

This is a joint work with Kinga Nagy.

∼: *Lunch Break* :∼

15:30–16:30

Some recent results concerning valuations on Lipschitz functions
Andrea Colesanti
Università degli Studi di Firenze, Italy

The first part of the talk will be devoted to an overview on the theory of valuations defined on spaces of functions. We will then focus on valuations on the space of Lipschitz functions defined on the unit sphere of the n-dimensional Euclidean space. No general classification result is known for such valuations, even under the assumption of rotation invariance. After describing some partial results in this direction, we will turn to the smaller class of those valuations which are additionally invariant under the sum of linear functions. For them, we show a homogeneous decomposition result of McMullen type. We will also see that, in fact, no valuations of degree of homogeneity higher than three may exist, and we will present a classification result for the remaining degrees of homogeneity, both in the rotation invariant case, and in the general case.

The original results that I will present were obtained in collaboration with: J. Knoerr, D. Pagnini, P. Tradacete and I. Villanueva.

∼: *Coffee Break* :∼

17:00–17:30

Functional surface area measures and the co-area formula
Liran Rotem
Technion - Israel Institute of Technology, Israel

The surface area measure of a convex body is one of the fundamental constructions in convexity. An extension of this construction to log-concave functions was studied by Colesanti and Fragalà, by Cordero-Erausquin and Klartag, and by myself. I this talk I will describe the previous results on the topic and present for the first time a variation formula for the integral of a log-concave function that holds in complete generality, with no regularity assumptions. As we will see such a formula is intimately related to the co-area formula, and in particular to anisotropic versions of the co-area formula that received very little attention in the literature. As a corollary of our result we will prove that the surface area measures (note the plural) of a log-concave function f determines f uniquely, again with no regularity assumptions.

17:30–18:00

Löwner's problem for log-concave functions
Márton Naszódi
Loránd Eötvös University, and CoGe Research Group, Budapest, Hungary

The class of logarithmically concave functions is a natural extension of the class of convex sets in Euclidean d-space. Several notions and results on convex sets have been extended to this wider class. We study how the problem of the smallest volume affine image of a given convex body L that contains another given convex body K can be phrased and solved for functions.

Joint work with Grigory Ivanov and Igor Tsiutsiurupa.

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Wednesday 22 June 2022

On the volume of Minkowski sum of convex sets
Matthieu Fradelizi

Université Gustave Eiffel, France

I shall show a nice conjecture of T. Courtade on the volume of the Minkowski sum of convex bodies and establish it in dimension 2. Then, I shall prove a weaker versions of it in dimension 3, some other special cases in dimension n and connect it to inequalities between volume of projections of convex bodies.

The talk is based on a joint work with Mokshay Madiman, Mathieu Meyer and Artem Zvavitch.

A quasianalytic-type property of functions in geometric tomography
Dmitry Faifman

Tel Aviv University, Israel

The two ubiquitous functions in geometric tomography associated to a centrally-symmetric n-dimensional convex body are the volume-of-section and volume-of-projection, by/to subspaces of dimension k. Those functions lie in the range of the Radon and cosine transforms, respectively. We will show that when k lies between 2 and n-2, those ranges exhibit a quasianalytic-type property, allowing the unique determination of a function from its values on a small subset. This readily leads to sharpenings of theorems of Funk and Alexandrov, as well as Klain's injectivity theorem from valuation theory.

$\sim$: *Coffee Break* :$\sim$

11:30–12:00

Finite sphere packings in low and high dimensions
Ji Hoon Chun
Technische Universität Berlin, Germany

The Sausage Conjecture of L. Fejes Tóth (1975) states that for all dimensions $d \geq 5$, the densest packing of any finite number of spheres in $\mathbb{R}^d$ occurs if and only if the sphere centers are all placed as closely as possible on one line, i.e., a "sausage´´. We discuss the progress made in the literature, including the result of Betke and Henk (1998) that the Sausage Conjecture is true for all $d \geq 42$. Our work builds upon the methods of Betke and Henk to improve the lower bound to $d \geq 36$ with the aid of interval arithmetic for certain complicated portions.

The Sausage Catastrophe of J. Wills (1983) is the observation that in $d = 3$ and $d = 4$, the densest packing of n spheres is a sausage for small values of n and jumps to a full-dimensional packing for large n without passing through any intermediate dimensions. Let n_d be the smallest value of n for which the densest packing of n spheres in $\mathbb{R}^d$ is full-dimensional. We discuss some upper and lower bounds for n_3 and n_4, including $n_3 \leq 56$ by Wills (1985) and $n_4 < 375{,}769$ by Gandini and Zucco (1992). We present some improvements to the upper bound for n_4 via extending the work of Gandini and Zucco, and also mention some potential future research directions for both the conjecture and the catastrophe.

12:00–12:30

Ulam's problem 19 from the Scottish Book and related problems.
Dima Ryabogin
Kent State University, USA

Ulam's Problem 19 from the Scottish Book asks *is a solid of uniform density which will float in water in every position a sphere?* Assuming that the density of water is 1, one can show that there exists a strictly convex body of revolution $K \subset \mathbb{R}^3$ of uniform density $\frac{1}{2}$, which is not a Euclidean ball, yet floats in equilibrium in every orientation. We will discuss this and related problems suggested by Croft, Falconer and Guy.

∼: 14:00 Conference Lunch at the beach :∼

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Thursday 23 June 2022

Functional Intrinsic Volumes
Monika Ludwig
Technische Universität Wien, Austria

A functional Z defined on a space of real-valued functions $\mathcal{F}$ is called a *valuation* if

$$Z(f \vee g) + Z(f \wedge g) = Z(f) + Z(g)$$

for all $f, g \in \mathcal{F}$ such that $f, g, f \vee g, f \wedge g \in \mathcal{F}$. Here $f \vee g$ is the pointwise maximum of f and g, while $f \wedge g$ is their pointwise minimum. The important, classical notion of valuations on convex bodies is a special case of the rather recent notion of valuations on function spaces.

We present a complete classification of all continuous, epi-translation and rotation invariant valuations on the space of super-coercive convex functions on $\mathbb{R}^n$. This result corresponds to Hadwiger's celebrated theorem on the classification of continuous, translation and rotation invariant valuations on the space of convex bodies. The valuations obtained in our theorem are functional versions of the classical intrinsic volumes. Representations and important properties will be described.

Based on joint work with Andrea Colesanti and Fabian Mussnig

A new necessary condition for satisfying sharp Bezout inequalities
Maud Szusterman
Université Paris Diderot, France

In 2018, Saroglou, Soprunov and Zvavitch introduced a set of inequalities between mixed volumes, involving the simplex, inherited from Bezout inequalities (from algebraic geometry). As implied by Diskant inequality, the simplex can be replaced by any convex body in these inequalities, up to multiplying by n. It is known the simplex is the only minimizer among polytopes, and conjecturally this characterization should hold among all convex bodies. Several necessary conditions for being a minimizer have been derived, excluding bodies (weakly) decomposable bodies, bodies with infinitely many facets, or bodies with at least one smooth point on their boundary. In this talk, I will discuss another excluding condition, involving isoperimetric ratios, reminiscent of Ball's reverse isoperimetric inequality.

∼: Coffee Break :∼

11:30–12:00

General measure extensions of projection bodies

Dylan Langharst

Kent State University, USA

The inequalities of Petty and Zhang are affine isoperimetric-type inequalities providing sharp bounds for $\mathrm{vol}_n^{n-1}(K)\mathrm{vol}_n(\Pi^\circ K)$, where ΠK is a projection body of a convex body K. In this paper, we present a number of generalizations of Zhang's inequality to the setting of arbitrary measures. In addition, we introduce extensions of the projection body operator Π to the setting of arbitrary measures and functions, while providing associated inequalities for this operator; in particular, Zhang-type inequalities. Throughout, we apply shown results to standard Gaussian measure.

12:00–12:30

Towards the Hadwiger Conjecture via Bourgain Slicing

Peter van Hintum

New College, Oxford, United Kingdom

In 1957, Hadwiger conjectured that every convex body in $\mathbb{R}^d$ can be covered by 2^d translates of its interior. For over 60 years, the best known bound was of the form $O(4^d\sqrt{d}\log(d))$, but this was recently improved by a factor of $e^{\Omega(\sqrt{d})}$ by Huang, Slomka, Tkocz and Vritsiou. In this talk, we take another step towards the Hadwiger conjecture by deducing an almost-exponential improvement from the recent breakthrough work of Chen, Klartag and Lehec on Bourgain's slicing problem. More precisely, we prove that, for any convex body $K \subset \mathbb{R}^d$,

$$\exp\left(-\frac{d}{(\log d)^{O(1)}}\right)4^d$$

translates of $\mathrm{int}(K)$ suffice to cover K. Moreover, a positive answer to Bourgain's slicing problem would imply an exponential improvement on the bound for Hadwiger's conjecture.

This talk is based on joint work with Marcelo Campos, Robert Morris, and Marius Tiba.

$\boxed{\text{12:30–13:00}}$

Affine Minkowski valuations
Jakob Henkel
Friedrich Schiller University Jena, Germany

Let W be an irreducible representation of $\mathrm{SL}(n)$ of finite dimension. We ask whether there exists a non trivial continuous and translation invariant Minkowski valuation $\mathcal{K}(\mathbb{R}^n) \to \mathcal{K}(W)$ which is $\mathrm{SL}(n)$ equivariant. Here $\mathcal{K}(\bullet)$ denotes the space of convex bodies in the corresponding vector space. For $W = \mathbb{R}^n$ and $W = (\mathbb{R}^n)^*$ the answer is positive and by a result of Monika Ludwig all such valuations are multiples of the difference body and the projection body respectively. We show that $W = \mathbb{R}$ is the only additional case where such a valuation exists. New examples arise if we omit translation invariance.

This is a joint work with Thomas Wannerer.

$\sim$: *Lunch Break* :$\sim$

$\boxed{\text{15:30–16:30}}$

Diagrams, clustering, and coresets, and their application to the representation of polycrystals
Peter Gritzmann
TU München, Germany

We study geometric diagrams and their relation to constrained clustering with a view towards representing and analyzing polycrystalline materials and their dynamics. We introduce various techniques for converting grain maps into geometric diagrams. In particular, weight-constrained anisotropic clustering allows to compute diagram respresentations from data on the volume, center and moments of the grains which are available through tomographic measurements. Also we develop new coreset techniques, interesting in their own right, which are utilized to significantly accelerate the computations. This effect is demonstrated on 3D real-world data sets.

The talk is based on recent joint work with A. Alpers, M. Fiedler, F. Klemm.

∼: *Coffee Break* :∼

Involving asymmetry measures in geometric inequalities - not only an additional parameter

René Brandenberg

Technical University of Munich, Germany

In recent years, we have succeeded in incorporating asymmetry measures into quite a number of geometric inequalities. In doing so, we have tightened some inequalities, and brought together symmetric and general ends in others. For pairs of well-known inequalities, we were able to show that they are two sides of the same coin, and we succeeded in inverting inequalities where an inversion would not have been possible without additional parameters. It should also be noted that the asymmetry measures used can usually be computed well algorithmically, at least for polyhedra. This talk will give an overview of the results obtained.

Rotational bounds for homeomorphisms with integrable distortion and Hölder continuous inverse

Banhirup Sengupta

Universitat Autònoma de Barcelona, Spain

In this talk I will explain a recent work, in collaboration with Albert Clop and Lauri Hitruhin, where we have obtained sharp spiraling bounds for homeomorphisms with L_p-integrable distortion having Hölder continuous inverse. Our result certainly improves the bounds obtained by Hitruhin for homeomorphisms with integrable distortion without a priori assumption of Hölder continuous inverse. As an application, we estimate the spiraling rate of Euler flows for small times.

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Friday 24 June 2022

9:30–10:30

Some new perspectives on duality
Shiri Artstein-Avidan

Tel-Aviv University, Israel

We discuss some new results, directions and conjectures regarding dualities on families of sets.

10:30–11:00

Anti-balancing vector sums
Gergely Ambrus

Alfréd Rényi Institute of Mathematics, and University of Szeged, Hungary

Vector sum problems have been studied for over a hundred years. The basic balancing question is as follows: given a finite set of unit vectors $u_1, \ldots, u_n \in S^{d-1}$, can we assign signs ± 1 to them so that the signed sum becomes small? Now, we set off to study the dual problem: we are to seek appropriate signs so that the signed sum of the unit vectors has large norm. We study several variants of the question, including signed subset sums. Based on combinatorial, analytic and geometric tools, we give asymptotic bounds as well as sharp estimates in specific cases.

This is a joint work with Bernardo González Merino.

$\sim$: *Coffee Break* :$\sim$

11:30–12:00

Optimal divisions of a convex body
Antonio Cañete
Universidad de Sevilla, Spain

For a given convex body $C \subset \mathbb{R}^d$, and a division of C into n convex subsets $C_1, \ldots, C_n$, we can consider $\text{máx}\{F(C_1), ..., F(C_n)\}$ (or respectively, $\text{mín}\{F(C_1), ..., F(C_n)\}$), where F represents one of these classical geometric functionals: the diameter, the width or the inradius.

In this work we study the divisions of C which minimize (respectively, maximize) that previous value. In particular, we will focus on the existence, uniqueness and balancing behaviour of optimal divisions, bounds for the corresponding optimal values, as well as algorithms leading to these optimal divisions.

This is part of a joint work with Isabel Fernández and Alberto Márquez (Universidad de Sevilla).

12:00–12:30

Discretization of geometric inequalities via the lattice point enumerator
Eduardo Lucas
Universidad de Murcia, Spain

The obtaining of discrete analogues of classical inequalities has seen a significant increase in recent times in the field of Convex Geometry. Among some of the most common measures utilized for this purpose are the cardinality and the lattice point enumerator, i.e., the cardinality of a set intersected with a lattice, often the integer one. Apart from having applications in other fields, like number theory, they sometimes provide alternative ways to further progress in the original setting, due to the fact that some of these inequalities imply their corresponding continuous analogues.

In this talk we will discuss recent progress with regards to the discretization of several well-known inequalities in the field, including the Brunn-Minkowski inequality, the isoperimetric inequality, and the Rogers-Shephard inequality, via the lattice point enumerator. These inequalities are often sharp and imply their original analogues.

This talk is based on joint work with D. Alonso-Gutiérrez, M. A. Hernández Cifre, D. Iglesias, and J. Yepes Nicolás.

12:30–13:00

Rogers-Shephard type inequalities for the lattice point enumerator
Jesús Yepes Nicolas
Universidad de Murcia, Spain

In the late 50s, Rogers and Shephard provided different inequalities for some bodies associated to a convex body K, such as the so-called difference body $K - K :=$ $K + (-K)$. Among others, they showed that

$$\mathrm{vol}(K - K) \leq \binom{2n}{n} \mathrm{vol}(K)$$

and

$$\mathrm{vol}_{n-k}(P_{H^\perp} K)\mathrm{vol}_k(K \cap H) \leq \binom{n}{k}\mathrm{vol}(K),$$

where $\mathrm{vol}(\cdot)$ is the n-dimensional Lebesgue measure and $P_{H^\perp}(\cdot)$ is the orthogonal projection onto the orthogonal complement of the k-dimensional vector subspace H.

In this talk we will discuss various Rogers-Shephard type inequalities for the lattice point enumerator $\mathrm{G}_n(\cdot) := |\cdot \cap \mathbb{Z}^n|$ on $\mathbb{R}^n$. In particular, we will present discrete analogues for this functional of the above classical inequalities, showing furthermore that these new discrete versions for $\mathrm{G}_n(\cdot)$ imply the corresponding results involving the Lebesgue measure.

This is about joint work with David Alonso-Gutiérrez and Eduardo Lucas.

$\sim$: *Lunch Break* :$\sim$

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POSTERS
ABSTRACTS

Spectral clustering of combinatorial fullerene isomers based on their facet graph structure

Artur Bille

Ulm University, Germany

After Curl, Kroto and Smalley were awarded 1996 the Nobel Prize in chemistry, fullerenes have been subject of much research. One part of that research is the prediction of a fullerene's stability using topological descriptors. It was mainly done by considering the distribution of the twelve pentagonal facets on its surface, calculations mostly were performed on all isomers of C_{40}, C_{60} and C_{80}. We suggest a novel method for the classification of combinatorial fullerene isomers using spectral graph theory. The classification presupposes an invariant scheme for the facets based on the Schlegel diagram. The main idea is to find clusters of isomers by analyzing their graph structure of hexagonal facets only. We also show that our classification scheme can serve as a formal stability criterion, which became evident from a comparison of our results with recent quantum chemical calculations.
We apply our method to classify all isomers of C_{60} and give an example of two different cospectral isomers of C_{44}. The only input for our algorithms is the vector of positions of pentagons in the facet spiral.

The Functional Form of Mahler's Conjecture for Even Log-Concave Functions in Dimension 2

Elie Nakhle

Université Paris-Est Créteil, France

Mahler conjectured that the minimum of the volume product among all symmetric convex bodies in $\mathbb{R}^n$ should be achieved for the cube. We present a functional version of the conjecture which involves even log-concave functions and their Legendre transform. Finally, we give the sharp lower bound of the functional volume product and characterize the equality case of this conjecture for functions defined on $\mathbb{R}^2$.

Criteria for positive entropic curvature on discrete spaces

Martin Rapaport

Universite Gustave Eiffel, France

According to the works of Lott-Sturm-Villani, the curvature κ of a manifold can be expressed in terms of the κ-convexity of the relative entropy along Wasserstein geodesics. Such an analogous property on graphs has been first proposed by M. Erbar and J. Maas.

Recently, Paul-Marie Samson has proposed another definition of curvature for graphs based on convexity of rel- ative entropy along the Schrödinger bridges which will be the core of this poster. After explaining all these terms, we will address the following question: How can this curvature be calculated locally on graphs and what kind of consequences globally does it has?

Mean inequalities for symmetrizations of convex sets

Katherina von Dichter

Technische Universität München, Germany

The arithmetic-harmonic mean inequality can be generalized for convex sets, considering the intersection, the harmonic and the arithmetic mean, as well as the convex hull of two convex sets. We study those relations of symmetrization of convex sets, i.e., dealing with the means of some convex set C and $-C$. We determine the dilatation factors, depending on the asymmetry of C, to reverse the containments between any of those symmetrizations, and tighten the relations proven by Firey and show a stability result concerning those factors near the simplex.

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List of Participants

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FINANTIAL SUPPORT

Seville City Guide

Sevilla city is the capital of both Sevilla province and **Andalusia, the southern region of Spain**.

Sevilla is a beautiful and historic city and it's a great destination for your holidays where sun, light, culture, history, folclore and outdoor life are all united under an intense blue and mostly cloudless sky.

1. Monuments of Sevilla city

Sevilla's main monuments are:

- the Cathedral of Sevilla

- the Giralda Tower

- the Alcázar palace and

- the Archive of the Indies

This group of monuments was declared **World Heritage by UNESCO** in 1987.

The Cathedral

Location: The Cathedral of Sevilla Avenida de la Constitucion 41001 Sevilla, Spain Tel. +34 902 09 96 92 +34 954214971 / Fax +34 954228432

'Let us build a church so big that those who see it will think us mad', that is what the cathedral chapter decided in 1401 when the former mosque of Sevilla had to be knocked down. It is one of the last Spanish Gothic cathedrals, and the Renaissance style is already evident there. Its impressive size makes it the third largest in the Christian world, after Saint Peter's in Vatican city and Saint Paul's in London.

The exterior shows off particularly well the artistry of the unknown architect in playing with volumes and spaces. You enter by the Pardoner's door, formerly the majestic entrance of the old mosque and you will see another vestige: the peaceful **Orange tree courtyard**.

Inside the cathedral of Sevilla you will be struck by the size and richness of this universe of stone, stained glass windows and wrought iron work. The lightness of the columns accentuates the height of this hall-church with five spaces and lateral chapels. The simple crossing ogive vaults cover the nave except for the transept crossing where the flamboyant vaults stand 56 m tall. A mirror in the floor lets you appreciate the superb carving.

Inside the Cathedral stands the Tomb of Cristopher Columbus.

The capilla Mayor, of an unparalleled richness, is closed off by splendid 16C plateresque grills. Its immense Flemish retable gleaming with gold (1482-1525) is the largest in Spain (20 m high).

The great sacristy, an attractive 16C room in the form of a Greek cross, houses the superb Renaissance Monstrance by Juan de Arfe. In the plateresque style, the capilla Real impresses by its size.

Many other chapels and the treasure house allow you to admire some wonderful works by such as Murillo, Valds, Leal and Zurbaran.

At least once a year, during the Holy Week of Sevilla, the brotherhoods carry their floats in processions from their church to the cathedral and back.

Giralda Tower

Location: Giralda tower in Sevilla Calle Alemanes 41001 Sevilla, Spain Tel. +34 902 09 96 92 +34 954214471 / Fax +34 954228432

The Giralda tower is the most emblematic monument of Sevilla. This Minaret was constructed by the Moors between 1184 and 1197 up to 76 m. in height. After the reconquest in 1568 the Christians fitted the minaret with the bell tower, reaching a total height of almost 100 m.
The current appearance of a belfry was designed in the 16C by the Cordovan architect Hernn Ruiz, who added the bell chamber and four upper rooms each with their own balconies. A statue symbolising faith stands at the top of the tower and acts as a weathervane, whose nickname Giraldillo also gives its name to the tower.

The subtle, delicate decoration exemplifies perfectly the principles of the Almohad religious movement. It is rigorous, austere and against all forms of luxury. This was the origin of an artistic trend that linked beauty with simplicity.

The Koutoubia tower in Marrakesh, built just before the Giralda tower, served as a model for the latter. Each one of its four sides is divided into three vertical sections decorated in sebka brick. This pattern, when repeated, forms a network of diamond shaped multileaved arcs.

You can climb the 70m bell chamber up a 34 story ramp with a slope that decreases toward the top to facilitate easy climbing. Take your time and enjoy the views of the orange trees in the courtyard, the gargoyles, the pinnacles of the cathedral and the Alcázar. Once there you will be rewarded for your hard efforts as the panoramic view over the town is superb.

The Royal Alcázar palace

The Alcázar Palace (los Reales Alcázares) is definitly one of the most impressive monuments of Sevilla. You should not miss it when visiting the city!!
The Alcázar is a fortified palace of which the construction was ordered by Abd Al Ramn III in the year 913. Because of it's beauty it was chosen as residence by many monarchs in the centuries that followed. It now is the residence of His Royal Majesty Juan Carlos when he visits Sevilla.

Pedro I, 'the cruel' (1350 to 1369), made significant additions to the palace which is one of the most important examples of Mudejar architecture in Sevilla. The numerous rooms, patios and halls vary in architectural styles from the Islamic to Neoclassical. The beautiful gardens and fountains are especially worth visiting.

Some interesting zones within the Alcázar are:

Salon de los Embajadores (The Ambassadors Room): The magnificent dome of the Ambassadors Room is decorated with gilded cedar wood sculptures.

Arcos de Herradura (Horse Shoe): The Ambassadors Room is decorated with tiles and complex plaster work. It has three semetrical arcs each with three horse shoes.

El Patio de la Montera (The Hunting Patio): This was the meeting place of the court before the hunt took place. The faade of the palace of Pedro I is a unique example of Mudejar design.

El Patio del Yeso (The Plaster Patio): This beautiful, ornate garden full of flowers and streams maintains elements of the almohade architectural style of the Moors from the 12 century.

Patio de las Doncellas (Patio of the maidens): This patio was decorated by the best architects in Granada.

Patio del Crucero is above the ancient baths.

Salones de Carlos V (Rooms of Charles V): The rooms and chapel of Charles V are decorated with tapestries and coloured tiles from 16 Century.

El Patio de las Muñecas (The Patio of the Dolls): This patio with its bedrooms and adjacent corridors was the heart of the palace. It takes its name from the two tiny faces that decorate its arcs.

The Gardens of the Alcázar Palace, adorned with fountains and pavilions, provide shelter from the hustle and bustle of Sevilla.

Jardin Inglés (English gardens). These gardens are modelled on those of the British Isles from 18 Century. The door to the Alcoba is of Islamic origin. The park was built in 1909 and the main gardener of the Real Casa de Campo, Juan Gras, was put in charge of planting the flowers. However, there are doubts as to whether his radical style fits in with the surroundings.

Jardin de los Poetas (The Garden of the Poets) The design of this garden is similar to that of the Forestier thanks to the influence of Joaquin Romero Murube. It's most emblematic feature is the two ponds that were inspired by the Arabs and Romans.

Jardin de la Vega Inclan (Garden of Vega Inclan) This is a well designed garden inspired by the Damas even though it lacks the refinement that had once existed. This garden consists of 20 mostly square flower beds that are separated by paths and fountains. These gardens took their inspiration from Islamic culture and the Renaissance.

Jardin de la Alcubilla (Garden of the Reservoir): This garden existed during the time of Charles V.

Archive of the indies

The construction of this building began in the 16th century to be used by traders for their commercial transactions.

In 1785, the premises became the headquarters for the General Archives of the Indies when structural changes were made to accommodate the numerous files and documents.

The archives of the Indies contain references to Spain and her foreign possesions between the 15th and 19th centuries. Inside this sober Renaissance building there is a superb marble 18C staircase. On the upper floor, large rooms

with superb vaulted ceilings contain countless documents relating to the discovery and the colonisation of America. There you will find the signatures of Christopher Columbus, of Magellan, of Cortès, etc.

Torre del Oro

Situated on the banks of the Guadalquivir River, is a building of arabic origin (C. XIII) which once formed part of the city walls. Due to it's close links with spanish maritime history, it was chosen as the site of the **Naval Museum**. This tower marks the entrance to the **Arenal** district; the bullfight sector of Sevilla. Here you can find one of the most emblematic bullrings of Spain, the **Real Maestranza de Caballería bullring** of Sevilla.

Royal Tobacco Factory

It is the city's old tobacco factory. This enormous neoclassical building was built between 1728 and 1771 by order of the royal family and offered room for more than 10,000 (predominantly female) employees. The most famous employee was Carmen, known from the opera of the same name by the French composer Georges Bizet. She was known for the fact that she could roll the cigars between her thighs.

The tobacco factory complex contained its own prison, nursery and courthouse. In addition, it had as many as 116 mills for the tobacco produce and stables for 400 mules that propelled the grinding system.

Since 1949 the factory halls of the old tobacco factory have been part of the University of Sevilla. The inside of the building has been adapted to its new function as a university, but even so, you can still enjoy its authentic atmosphere. Visits are free during your Sevilla city trip.

Plaza de España

Representative of much of the regional architecture, this magnificent construcion is highlighted with polychromatic ceramic tiles. The semicircular plaza has a diametre of 200 metres and is flanked by two spectacular towers and a bordering lake that are especially worth seeing.

It was built because of the Ibero-american Exhibition of 1929, held in Sevilla. Its creator was Aníbal González. He mixed a style inspired by the Renaissance with typical elements from the city: exposed brick, ceramics and wrought iron (worked by Domingo Prida).

Its floor plan is semicircular. It is dominated by 2 towers, one on each side of the enclosed area, which frame the central building where the main rooms are. Between the two towers runs a network of galleries with an arcade of semicircular arches leading to exits in different parts of the square, where a fountain stands.

The large brick building flanked at each end by a high tower has fifty eight benches in recesses decorated with tiles, depicting historic episodes for each province of Spain.

Plaza de España has been used for some of the scenes of episode II of George Lucas' STAR WARS saga Attack of the clones. Anakin Skywalker (Hayden Christensen) and Padmé Amidala (Natalie Portman) have a walk, in the company of R2-D2 (digitally added). Plaza de España has also appeared in the movie Lawrence of Arabia, in a videoclip of Enigma and in many publicity spots.

The poster and logo of the Conference *geOmetry, convExity & anaLysis* are inspired in this beautiful place.

2. Popular districts of Sevilla

In the center of Sevilla can be found more well-known streets such as **Sierpes** or **Campana**, as well as numerous churches, hospitals and renaissance and baroque palaces. Moreover in the **Macarena** district you can find the **Alameda de Hércules**, the **Hospital de las Cinco Llagas** (site of the Parliament of Andalucia), the **Basilica of the Macarena** and the San Lorenzo Church.

The latter house two statues revered by the people of Sevilla: la Virgen de la Esperanza and Jésus del Gran Poder, celebrated during the processions in **Semana Santa**.

Another of the more traditional districts of Sevilla is that of **Triana**, on the other side of the river. Its profound maritime

tradition can be seen in the streets **Pureza**, **Betis** or **Alfarería** and in Plaza del Alto-zano.

The **Isla de la Cartuja** is situated on this bank of the river, where bulidings remaining from the The 1992 Univeral Exhibition add to the existing historical monuments of the **Cartuja** and the **Andalusian Center for Contemporary Art**.

The city of Sevilla has a rich history due to former Arab occupation and it's role as a prosperous commercial port at the time of colonization of the Americas. The many streets and squares of the Andalusian capital ooze fun and energy and there is an interesting mix of **UNESCO World Heritage** buildings and typical districts such as **Triana** or **La Macarena**.

3. Shopping in Sevilla

In the bustling old town you will find the main shoping area with shops of all kinds. In Plaza Nueva and the pedestrian zone in and around Sierpes and Tetuán Streets there are highstreet shops and department stores as well shops selling souvenirs, crafts, leather goods, guitars, flamenco outfits, fans and embroidery. On the other side of the river in the narrow streets of Triana there are numerous specialist ceramic shops.

4. Museums in Sevilla

The convent of Merced Calzada was restored to create the magnificient **Fine Arts Museum** in 1839. Since then, and thanks to its rich assets, it has become the one of the most important museums in Spain after the Prado Museum.

The Museum of Popular Arts and Customs shows the anthropologic and ethnic patrimony of Sevilla, offering examples of costumes, jewels and other objects of social and daily life, recreating several popular sceneries. Located in the mudejar style pavillion on America square

The Archaelogical Museum, located in what was the Fine Arts Pavilion from the 1929 World Exposition, a Neo-Renaissance palace made up of 27 halls displays samples of the Iberian, phonetician and Roman people who were the predecessors to what is now Sevilla.

The interesting **Flamenco Museum** provides the key to understanding the magical world of flamenco dancing. A visit to this museum is an essential for any visitor to Sevilla, for those who want to know more about Andalusian culture, those who want

to understand and experience flamenco dancing, tourists and Andalusians alike. The museum is promoted by flamenco dancer Cristina Hoyos.

5. El tapeo

Museums, art galleries, theme parks, cinemas, theatres and night clubs are only a few of the infinite possibilities that a large city like Sevilla can offer. Not forgetting the city's most tasty and oldest passtime: **'el tapeo'**; which involves going for drinks and snacks (tapas) in various bars.

The name **tapa** originated from the idea of having a slice of ham or a piece of cheese whilst drinking a glass of wine. This was done, in essence, to conserve the aroma of the wine. 'Tapas' include dishes such as 'cocina casera' (home-made dishes),'chacina' (cured meats), 'marisco' (seafood), 'caracoles' (snails), 'pescadito frito' (fried fish), 'revueltos' (scrambled eggs) and 'ensaladas' (salads) which can be found in almost any bar. Another option is to order a 'ración'(a plateful) or, in some places, a 'media ración'(half plate). A 'plateful' would be about six or seven 'tapas' and would cost about that amount.

Typical wines from the Sevilla area include white wines and 'fino' (pale,dry sherries which make good aperitifs). These wines are most easily found in 'bodegas' (characterized by their wine barrels where the wine is stored). Another popular wine found in 'bodegas' is 'manzanilla' (pale,dry,white fortified wine) from Sanlúcar de la Barrameda, 'moscatel' (sweet wine) from Chipiona and 'fino' from Jerez, Puerto de Santa María, Chiclana (Cádiz) and from the Condado County (Huelva). These wines are usually less expensive than other bottled wines and are equally delicious.

What is what?

ADOBO: A sauce with vinegar, garlic, paprika and oregano, where the fisch, usually dogfish, is macerated before be fried.

AJOBLANCO: A cold soup with bread crumbs mixed with vinegar, garlic, olive oil, salt and almonds.

ALI-OLI: Garlic and olive oil, mixed as a sauce similar to mayonaise. Very strong.

CABRILLAS: Bib snails served in a spicy broth.

CAZON A LA MARINERA: This white fish cooked in a sauce with white wine, onions, green peppers, tomato and sometimes potatoes.

COCIDO SERRANO: Stewed meat, bacon, blood sausage, spicy sausage and chickpeas.

COLA DE TORO: Stewed oxtail with onion, tomato and paprika.

COQUINAS: Steamed clams (cockles).

ESPINACAS CON GARBANZOS: Spinach and chickpeas prepared with garlic and spices.

FLAMENQUINES: Rolls of ham, breaded and deep fried.

GAMBAS AL AJILLO: Prawns (shrimps) sauteed in garlic and a lot of olive oil.

GAMBAS REBOZADAS: Breaded, deep-fried shrimps.

GAZPACHO: A cold soup of tomato, cucumber, green pepper, bread, garlic, vinegar, olive oil and salt, all crushed.

HUEVOS A LA FLAMENCA: Eggs baked with tomato, onion and diced ham.

MENUDO: Baked tripe in a hot paprika sauce.

MIGAS: Bread moistened in water and fried with oil and garlic. Can be served with fried bacon, chorizo (spicy sausage) or sardines.

MOLLETE: A soft bread roll.

MONTADITOS: Small sandwiches which can contain almost anything. With shrimp or with chorizo (spicy sausage) are especially tasty.

PAELLA: Golden saffron rice garnished with meat, fish, seafood and/or vegetables.

PAVIA: Fried cod or white fish.

PISTO: Stewed green peppers, onions, tomatoes and courgettes (zucchini).

PRINGÁ: Stewed meat, bacon,spicy sausage and blood sausage mixed together and often served on toast.

SALMOREJO: A thicker version of gazpacho.

TORTILLITAS DE BACALAO O CAMARONES: Fried cod or small shrimps coated in flour, oil and parsley.

URTA A LA ROTEÑA: White fish stew with tomato, peppers and onion.

Where to eat?

San Lorenzo

LA ANTIGUA ABACERIA DE SAN LORENZO This is a must visit, very small and crowded. Try its chacinas. It is not cheap. Teodosio, 53.
LA ESLAVA Again very crowded, but you must try this place. A long selection of sophisticated tapas. Eslava, 3-5, near the church of San Lorenzo.
ALCOY 10 A very good choice, close to the previos ones. Alcoy, 10.
CASA RICARDO (ANTIGUA CASA OVIDIO) Thousands of pictures of the Holy Week. Very good selection of tapas and 1/2 raciones. Hernán Cortés 2.
BODEGA SAN LORENZO It preserves the charming of those old places.

Plaza Nueva, Santa Cruz and surroundings

BECERRITA Very good food in general Recaredo, 9.
SAL GORDA It is a very nice tapas bar with fusion style cuisine. Alcaicería de la Loza, 23.
EL PINTON Nice atmosphere restaurant near La Giralda. Francos, 42.
TABERNA DEL ALABARDERO Zaragoza, 20.
CASA ROBLES Alvarez Quintero, 58.
BODEGA DÍAZ SALAZAR García de Vinuesa, 20.
CASA ROMAN The best jamón (ham) and queso (cheese) in town. Plaza de los Venerables, 1.
LAS TERESAS Good beer and sherry served in this atmospheric bar with hanging cured hams and tiled walls lined with faded corrida photos. It's also worth stopping here for breakfast the morning after. Santa Teresa, 2, to the north of Plaza Santa Cruz.
GIRALDA Even if you speak perfectly Spanish, read the menu in english. We (Sevillians) do not understand the menu in Spanish, but they have probably the best tapas in that neiborghood. Mateos Gago, 1.
LA CAVA DE EUROPA Winner of the award to the best tapa (year 2003). Santa María la Blanca

La Campana and las setas

BACO Cuna. Great restaurant. Cuna 2.
CAÑA BOTA. great variety of tapas and dishes. Orfila, 3.
PERRO VIEJO. Very good atmosphere. Great selection of tapas and dishes. Arguijo, 3.
EL RINCONCILLO Sevilla's oldest bar (founded in 1670) does a fair tapas selection as well as providing a hangout for the city's literati. Manily for historic reasons, there

are better tapas nearby, but the place worths a visit. Gerona 32, by Santa Catalina church.

MERCADO LONJA DEL BARRANCO. Gourmet market with several food stands and cocktail bars. Arjona, s/n.

Alameda de Hercules

CASA MANOLO LEON. C/ Guadalquivir, 8.
FATOUCH. Libanese and several vegetarian options C/Feria, 33.
DUO TAPAS. Calatrava, 10.
BAR ANTOJO. Calatrava, 44.
AL ALJIBE. Alameda de Hércules, 76.
ARTE Y SABOR. Alameda de Hércules, 85.
MANO DE SANTO. Mexican restaurant. Very good margarita de Mezcal. Alameda de Hércules, 90.
LALOLA DE JAVI ABASCAL. Conde de Torrejón, 9.

Triana

LA ANTIGUA The same chain of that antigua in San Lorenzo. Pureza.
LA BARCA DE CALDERON. Paseo de Ntra. Sra. de la O.
. LOLA CAZEROLA. Paseo de Ntra. Sra. de la O.
CASA MANOLO San Jorge, 16.
SOL Y SOMBRA Very good and traditional tapas Castilla.
LA GAMBA BLANCA Good and cheap medias raciones. Febo, 20.
BLANCA PALOMA San Jacinto, 49.
KIOSKO DE LAS FLORES Very good pescaito frito and good view of the river, la torre del oro, and the Cathedral. Calle Betis s/n.

Reina Mercedes

CASA FÉLIX, Breakfasts, menus and tapas. You should taste churros there. Reina Mercedes 51.
BAR BRONCE, good quality and nice terrace. Reina Mercedes 15.
EL HORNO DE REINA MERCEDES, Coffee and cakes. Reina Mercedes 23.
EL TURCO, Turkish style bar. Reina Mercedes 53.
RÍAS GALLEGAS, tapas from Galicia. Reina Mercedes 61.
AVELINO, a beautiful place if the weather is nice. Plaza de los Andes, 1.

6. Province of Sevilla

Monuments and towns of in the province of Sevilla

Sevilla has many places that are worth visiting, such as the roman ruins of **Itálica** in the area of el Aljarafe and Santiponce (birthplace of the emperors Trajano and Adriano), the dolomites of Valencina and the treasure of Carambolo that was discovered in Camas in the 8 and 3 centuries BC.

Carmona is a cute small town, just outside Sevilla and was home to the **Alcázar of King Don Pedro** (now a hotel), a **roman necropolis** and a picturesque centre. Also you can visit **Ecija**, the 'city of towers'.

The town of **Alcala de Guadaira** is closer to the centre of Sevilla and has a castle with 11 towers, eight dolomites and beautiful pine trees of Oromana.

The area of la Sierra Sur of Sevilla is renowned for its outdoor activities, such as **hang gliding** in Montellano, rock climbing in Moron and Algamitas (Sevilla's highest peak), hiking, cycling or horse riding in the **Via Verde** (Green path) in **Coripe** which is an ancient train track that passes through 26 tunnels in an area of exceptional beauty.

Sierra Norte de Sevilla Natural Park

La Sierra Norte de Sevilla is the only natural park in Sevilla. Its countryside is largely made up of oak and cork trees. It is also a great area for outdoor sports such as rock climbing at Cerro del Hierro (in San Nicolás del Puerto), pot holing and hiking.

Enjoy, on foot or bicking, the **Via Verde** (Green Path) of Sierra Norte of Sevilla.

In **Cazalla**, the centre of the national park, there is Cartuja de Cazalla and la Isla de Margarita (the Island of Margarita) which is a recreational area with beautiful countryside. Visit also **Constantina** wich is the second great town in Sierra Norte, and **La Puebla de los Infantes**. In this area you have to taste caldereta de venao (a small cauldron of deer), carne de jabalí (wild boar meat) or faisanes (only on season, discover by yourself).

Las Cascadas del Huéznar (Waterfalls of Hueznar) are a must for all visitors. Throughout the park there are many signposted footpaths for hiking.

More nature in the province

The Roman roads take their name from la Comarca de la Via de la Plata. Cargo from the mines was carried along these roads from Sevilla to Cantabria. It is also one of the most important mining areas in **Castillo de las Guardas**, and has a reserve for wild animals.

Take a river tour to **Sanlucar de Barrameda**, Doñana and Sevilla on the Comarca de Guadalquivir. On the journey the boat docks at two different parts of the Doñana. At the first stop there are footpaths through the beautiful countryside of the national park. Gelves is the only port in Sevilla that offers water sports.

Europe's largest colony of white swans can be found in la Puebla del Rio. The reserve, la **Cañada de los pájaros**, is home to an infinite number of aquatic birds.

7. Useful telephone numbers

The emergency telephone in Europe 112.

Telephone service for Sevilla city administration 010 (toll-free from Sevilla) or (+34) 954 347 161 (International calls) with information on cultural activities and administration; in Spanish, English, French, and Italian.

Ambulancias (Ambulance emergency) 061

Airport 954 449 000

Ayuntamiento (City Hall) 954 590 101

Correos (Post office) 902 197 197

Hospital Virgen del Rocío (Emergencies) 955 01 20 00, 954 248 181

Policlínico Virgen Macarena (Emergencies) 955 00 80 00, 902 505 061

RENFE/Sevilla-Santa Justa (Railway) 902 240 202

Iberia 902 400 500

Plaza de Armas (Bus Station) 954 908 040.

Prado de San Sebastián (Bus Station) 954 417 111

Policía Local (Local Police) 092

Policía Nacional (Police) 091

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