

LisMath Seminar Day, June 26, 2018

Venue: FCUL, Department of Mathematics, room 6.2.33

Schedule/Topics

- 10h-10h30: Pedro Oliveira (IST)
Cosmic no-hair in spherically symmetric black hole spacetimes
- 10h40-11h10: Alexandra Symeonides (FCUL)
Invariant and quasi-invariant measures for Euler equations
- 11h20-11h50: João Dias (FCUL)
Supercharacters for algebra groups and their geometric relations
- 12h-12h30: Filipe Gomes (FCUL)
Supercharacter Theories and Multiplicative Ramification Graphs
- 14h-14h30: Hillal M. Elshehabey (IST)
Mathematical Modeling and Numerical Simulation of an Anaerobic Digester
- 14h40-15h10: Pedro Pinto (FCUL)
The Bounded Functional Interpretation and Proof Mining
- 15h20-15h50: Juan Pablo Quijano (IST)
Sheaves and functoriality of groupoid quantales
- 16h-16h30: Fábio Silva (FCUL)
Patience Sorting monoids and their combinatorics
- 16h40-17h10: Sílvia Reis (FCUL)
Generically Stable Types and Banach Spaces

Topics/Speakers/Abstracts:

- Cosmic no-hair in spherically symmetric black hole spacetimes

Speaker: Pedro Oliveira (IST)

Abstract:

We analyze in detail the geometry and dynamics of the cosmological region arising in spherically symmetric black hole solutions of the Einstein-Maxwell-scalar field system with a positive cosmological constant. More precisely, we solve, for such a system, a characteristic initial value problem with data emulating a dynamic cosmological horizon. Our assumptions are fairly weak, in that we only assume that the data approaches that of a subextremal Reissner-Nordström-de Sitter black hole, without imposing any rate of decay. We then show that the radius (of symmetry) blows up along any null ray parallel to the cosmological horizon ("near" i^+), in such a way that $r = +\infty$ is, in an appropriate sense, a spacelike hypersurface. We also prove a version of the Cosmic No-Hair Conjecture by showing that in the past of any causal curve reaching infinity both the metric and the Riemann curvature tensor asymptote those of a de Sitter spacetime. Finally, we discuss conditions under which all the previous results can be globalized.

- Invariant and quasi-invariant measures for Euler equations

Speaker: Alexandra Symeonides (FCUL)

Abstract:

We will discuss how invariant (or quasi-invariant) probability measures can be used to show existence of statistical solutions for the two-dimensional Euler equation (or a slight modification of it), both in the periodic and non periodic case. For initial data in the support of the measures, these solutions are globally defined in time and they are unique. This is joint work with Ana Bela Cruzeiro (IST-UL)

- **Supercharacters for algebra groups and their geometric relations**

Speaker: João Dias (FCUL)

Abstract:

Given any algebra group over any finite field one has a supercharacter theory constructed by P. Diaconis and I.M. Isaacs. And we may ask three questions:

- How does the supercharacter theory behave with respect to change of field (i.e. finite field extensions);
- Does there exist an object that contains all supercharacter theory for all changes of field;
- If the answer to the second question is positive, does there exist a group and a supercharacter theory that has the information given by that object.

In this talk I will give a brief introduction to the supercharacter theory and give the answer to the questions above.

- **Supercharacter Theories and Multiplicative Ramification Graphs**

Speaker: Filipe Gomes (FCUL)

Abstract:

Supercharacter theories are generalizations of the usual character theory of a group. In this talk, we construct graded graphs using restriction and superinduction of supercharacters and use them to determine the extreme supercharacters of direct limits of certain groups. We mention the infinite unitriangular group as a particularly important example of this construction.

- **Mathematical Modeling and Numerical Simulation of an Anaerobic Digester**

Speaker: Hillal M. Elshehabey (IST)

Abstract:

Anaerobic digestion is a bacterial process, carried out in the absence of oxygen, used to convert the organic fraction of large volumes of slurries and sludge into biogas and a digested product. The objective of this work is to perform a numerical modeling of the fluid dynamics process inside an anaerobic digestion tank and numerical simulations of the model, which might indicate properly sized extra piping and pumping systems, in order to minimize the deposition of inert materials. This research is being developed within a consulting project for Valorlis - Valorização e Tratamento de Resíduos Sólidos, SA.

In this seminar, we begin by presenting the mathematical model which describes the behavior of the pseudo-plastic fluid in the tank, where parameters such as temperature and total solids content are compatible with several experimental cases reported in the literature [1, 2, 3, 4, 5] and have been validated by Valorlis. The influence of such parameters in the fluid behavior will be discussed in simpler, classical geometries.

Following [6], we propose alternative conditions for outflow. The benefits of using the directional do-nothing boundary condition comparing with the classical one [6] will be presented for the proposed non-Newtonian model and for some benchmark problems [6, 7], including a comparison with the Newtonian model.

Finally some simulations for the problem proposed by Valorlis will be shown for the steady and unsteady cases.

References

- [1] L. De Baere, B. Mattheeuws, State-of-the-art 2008 - Anaerobic digestion of solid waste, *Waste Management World* July, 2008.
- [2] J. M. Langner, Investigation of non-Newtonian flow in anaerobic digesters, Master thesis in Mechanical Engineering, University of Manitoba, Canada (2009).
- [3] N. Eshtiaghi, F. Markis, S. Yap, J. Baudez and Slatter, Rheological characterisation of municipal sludge: A review, *Water Research* (2013), 1-18.
- [4] P. A. López-Jiménez, J. Escudero-González, T. M. Martínez, V. F. Montañán, C. Gualtieri, Application of CFD methods to an anaerobic digester: The case of Ontinyent WWTP, Valencia, Spain, *Journal of Water Process Engineering*, 7 (2015), 131-140.
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- [6] M. Braack and P. B. Mucha, Directional do-nothing condition for the Navier-Stokes equations, *Journal of Computational Mathematics*, 32, No.5 (2014), 507-521.
- [7] S. Turek and Schaefer, Benchmark computations of laminar flow around cylinder; in *Flow Simulation with High-Performance Computers II*, *Notes on Numerical Fluid Mechanics* 52, 547-566, Vieweg 1996.

- The Bounded Functional Interpretation and Proof Mining

Speaker: Pedro Pinto (FCUL)

Abstract:

Proof mining is the research program that aims to analyse proofs of mathematical theorems in order to extract hidden quantitative information - such as rates of convergence, rates of metastability and rates of asymptotic regularity. Proof theoretical tools like Kohlenbach's monotone functional interpretation ([1]), a variant of Gödel's Dialectica, are of standard use. A newer functional interpretation was introduced by Ferreira and Oliva in 2005 ([2]), dubbed the bounded functional interpretation (BFI). The focus of my research was the better understanding of the BFI in the context of proof mining. I will show a general technique that allows the elimination of weak sequential compactness arguments in the analysis of certain types of proofs. It also gives a better understanding of previous quantitative results done Kohlenbach ([3]) where this argument was already eliminated. This technique was also employed to produce a first quantitative version of Bauschke's theorem ([4]). Other results, in the context of the proximal point algorithm ([5], [6]), were also analysed with the BFI and their first quantitative versions were obtained. These results are new and the first practical application of the BFI in the proof mining program.

Bibliography:

- [1] Kohlenbach, Ulrich. Applied proof theory: proof interpretations and their use in mathematics. Springer Science & Business Media, 2008.
- [2] Ferreira, Fernando, and Paulo Oliva. Bounded functional interpretation. *Annals of Pure and Applied Logic* 135.1-3 (2005): 73-112.
- [3] Kohlenbach, Ulrich. On quantitative versions of theorems due to FE Browder and R. Wittmann. *Advances in Mathematics* 226.3 (2011): 2764-2795.
- [4] Bauschke, Heinz H. The approximation of fixed points of compositions of nonexpansive mappings in Hilbert space. *Journal of Mathematical Analysis and Applications* 202.1 (1996): 150-159.
- [5] H.K. Xu, Iterative algorithms for nonlinear operators. *J. Lond. Math. Soc.* 66(1) (2002): 240-256.
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- Sheaves and functoriality of groupoid quantales

Speaker: Juan Pablo Quijano (IST)

Abstract:

This talk has two main aims, one being the study of functoriality of groupoid quantales, which is accomplished in the étale case (in a sense completing the previously ongoing program concerning quantales of étale groupoids), and the other being to provide steps for addressing a similar program for quantales of non-étale groupoids, in this case studying sheaves for a suitable subclass of open groupoids, namely those with “étale covers”.

- Patience Sorting monoids and their combinatorics

Speaker: Fábio Silva (FCUL)

Abstract:

Monoids arising from combinatorial objects have been intensively studied in recent years. Important examples include the plactic, the sylvester, the Chinese, the hypoplactic, the Baxter, and the stalactic monoids, which are, respectively, associated to the following combinatorial objects: Young tableaux, binary trees, Chinese staircases, quasi-ribbon tableaux, pairs of twin binary trees, and stalactic tableaux.

In this talk we present two monoids which arise in a similar way, the left Patience Porting monoid (lPS monoid), also known in the literature as the Bell monoid, and the right Patient Sorting monoid (rPS monoid), that are, respectively, associated to lPS tableaux and rPS tableaux.

Several properties regarding the monoids mentioned in the first paragraph have been considered. Naturally, we pose the same kind of questions for the lPS and rPS monoids. In this seminar, we will discuss some of our results, which include:

- presentations, growth, identities and automacity regarding both monoids;
- Robinson-Schensted-Knuth-type correspondences for the two types of tableaux;
- formulas to count both the number of each type of tableaux for given evaluations, as well as the Bell numbers, together with a hook length formula’;
- the cyclic shift graph of the finitely ranked rPS monoids and the diameter of their connected components.

- **Generically Stable Types and Banach Spaces**

Speaker: Silvia Reis (FCUL)

Abstract:

We discuss the notion of generically stable types in the framework of dependent theories in continuous first order logic. We will also mention some applications of this framework to structures arising in functional analysis, Banach spaces in particular.