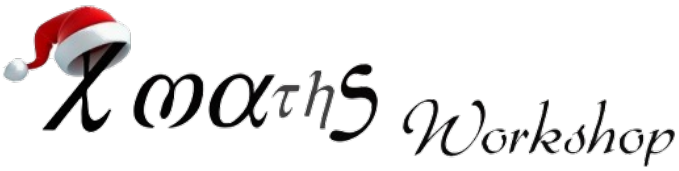

Università degli Studi di Bari Aldo Moro,
Dipartimento di Matematica

December 21-22, 2021

ABSTRACTS

Giuliano Angelone (Università degli Studi di Bari Aldo Moro): Hearing the shape of a quantum boundary condition

In a famous paper of 1966 entitled "Can one hear the shape of a drum?", Mark Kac described an interesting inverse spectral problem involving some bounded regions of the plane. Remarkably, even after more than fifty years, this problem is only partially solved. After briefly reviewing some historical results, in this talk I will describe the connection of this classical problem with quantum mechanics. In particular, I will introduce a related problem, regarding the isospectrality of quantum boundary conditions associated with a one-dimensional billiard, which turns out to be exactly solvable: by examining a generalized parity symmetry, boundary conditions can be indeed classified in two groups according to their spectral properties.

Giovanni Scala (Uniwersytet Warszawski): Entanglement witnesses: overview of the technique and a new construction

In Entanglement theory, it is still open the question if a given quantum state is separable or entangled. To tackle this problem many separability criteria have been derived in the last decades. In this talk, we discuss the mathematical methods that have been developed to detect entanglement, as well as the state of the art of the problem, and we introduce our promising multipartite separability criteria based on the Hanh-Banach theorem.
Specifically, via the correlation tensor we construct the related entanglement witnesses and show how they unifies known criteria as the realignment criterion, the De Vincente's criterion, the SIC-POVM criterion and the others. Interestingly, our criteria is linear in the density operator, and thus, we find unexplored classes of entanglement witnesses.
For further information see the following papers.

References

[1] G. Sarbicki, G. Scala, D. Chruscinski: *Family of multipartite separability criteria based on a correlation tensor*, Phys. Rev. A **101**, 012341 (2020).

[2] G. Sarbicki, G. Scala, D. Chruściński: *Enhanced realignment criterion vs linear entanglement witnesses*, J. Phys. A Math. Teor. 53, 455302 (2020).
[3] G. Sarbicki, G. Scala, D. Chruściński: *Detection power of separability criteria based on a correlation tensor: a case study*, preprint (2020) arXiv:2012.04359

Leander Stecker (Universität Hamburg): Connections with Skew-Torsion and the Canonical Submersion

We recall the classic theorems of de Rham and Berger regarding the holonomy of a manifold. In comparison we will see that a metric connection with parallel skew-torsion and reducible holonomy admits a locally defined Riemannian submersion. We finally show how this submersion connects geometries in the case of $3-(\alpha,\delta)$-Sasaki and quaternionic Kähler manifolds. Joint work with I. Agricola (Marburg) and G. Dileo (Bari).

Luca Schaffler (KTH Royal Institute of Technology in Stockholm): Point configurations, phylogenetic trees, and dissimilarity vectors

In 2004 Pachter and Speyer introduced the higher dissimilarity maps for phylogenetic trees and asked two important questions about their relation to the tropical Grassmannian. Multiple authors answered affirmatively the first of these questions, showing that dissimilarity vectors lie on the tropical Grassmannian, but the second question, whether the set of dissimilarity vectors forms a tropical subvariety, remained opened. In this seminar we give a negative answer to this question and propose a weighted variant of the higher dissimilarity map for which the weighted dissimilarity vectors form a tropical subvariety of the tropical Grassmannian in exactly the way that Pachter-Speyer envisioned. Moreover, we provide a geometric interpretation of this tropical subvariety in terms of configurations of points on rational normal curves. This is joint work with Alessio Caminata, Noah Giansiracusa, and Han-Bom Moon.

Shoam Karwa (Imperial College London): Non-Archimedean Mirror Symmetry

The SYZ conjecture of Mirror Symmetry roughly states that Calabi-Yau varieties come in pairs and they admit dual special Lagrangian torus fibrations over the same base with a discriminant locus of codimension ≥ 2. In this talk, we will see how one can reformulate this conjecture in the world of Berkovich spaces via non-archimedean torus fibrations. Using this framework, we will then compute the periods of degenerations of Calabi-Yau varieties in the complex setting and discuss interesting applications of this idea. The talk will be a gentle introduction to the field motivated by many examples.

Antonella Falini (Università degli Studi di Bari Aldo Moro): An Ensemble Learning for the Change Detection task

In this talk we will consider the task of change detection in bitemporal hyperspectral images. Several "difference"-images will be constructed by using elementary transformations, usually employed to enhance or reduce brightness and contrast. For each "difference"-image

a saliency detection algorithm, based on non-negative matrix factorizations and on the use of the Gaussian Mixture Model clustering, is performed. The best outputs firstly are automatically selected according to a semi-supervised novelty-detection technique, secondly, they are used in a weighted ensemble method based on the use of linear discriminant analysis. The final change-detection map is constructed as a binary-map. The proposed approach is tested on several benchmark datasets and the results are compared with the state-of-the-art methods.

Dayana Savostianova (Gran Sasso Science Institute): Universal adversarial attacks via matrix norms

Deep Neural Networks are widely used in different Machine Learning applications and, in particular, in computer vision problems. However, this approach is quite vulnerable to adversarial attacks. In recent years it was shown that there exist universal adversarial perturbations such that these attacks not only cause high rates of misclassification on the chosen model, they also have transferability properties. In this talk, I will give a broad introduction to the area of universal adversarial attacks and I will describe the application of matrix norms to this problem with the goal of incorporating the knowledge of intrinsic and structural non-homogeneity of the real data.

Samantha Bove (Istituto Tumori Bari "Giovanni Paolo II" - IRCCS): A machine-learning approach for the nodal status prediction in clinically negative breast cancer patients

Nowadays, about 98.6% of breast cancer female patients survive within 5 years after diagnosis. Nevertheless, this rate decreases to 84.4% in case of axillary lymph nodes metastasis. For this reason, a timely and careful detection of the nodal status is extremely important, especially in clinically negative patients characterized by an early-stage breast cancer and whose nodal positivity is difficult to diagnose. In this study, we devised a machine learning model to predict the nodal status of 142 clinically negative breast cancer patients belonging to the Istituto Tumori "Giovanni Paolo II" of Bari. For each patient, a primary tumor ultrasound image acquired at diagnosis and several clinical features were collected. Particularly, from each ultrasound image, four different frames containing the intra-tumoral and/or peritumoral region were extracted and their texture was analyzed by means of radiomic features computed on four different gray-level occurrence matrices. First, clinical and radiomic features were evaluated separately developing two different machine learning models based on an SVM classifier. Afterward, their predictive power was estimated jointly implementing a soft voting technique. All the radiomic-based models, additionally, were trained on the sub-set of features selected by a genetic algorithm within a leave-one-out cross-validation procedure. The proposed model represents a promising non-invasive procedure for the nodal status prediction in clinically negative patients.

Domenico Pomarico (Istituto Tumori Bari "Giovanni Paolo II" - IRCCS): Analysing breast cancer Invasive Disease Event prediction through an explainable artificial intelligence approach

Accurate but poorly interpretable machine learning approaches have been widely proposed to investigate breast cancer and related invasive disease events (IDEs), such as recurrence, contralateral and second tumours. In this study, we design and implement an explainable artificial intelligence (XAI) framework to investigate IDEs within a cohort of 486 breast cancer patients enrolled at the IRCCS "Giovanni Paolo II" in Bari, Italy. Firstly, we exploit several state-of-the-art machine learning models, such as Random Forest, Support Vector Machine, Naïve Bayes and XGBoost, to predict IDEs within 5 and 10 years from the first tumor diagnosis. Then, an XAI framework based on Shapley values computation allows us to identify the breast cancer patients' features driving towards IDEs. Basically, Shapley values evaluate the contribution provided by features alone and in cooperation with other features to estimate the IDE risk for each patient individually. The designed framework represents the first building block of a potential fully automated XAI support tool for clinical practice.

Lorenzo Liverani (Politecnico di Milano): Stability of coupled dissipative-antidissipative systems

There are many instances in the literature of systems of (ordinary or partial) differential equations, one of which is dissipative and the other one conservative. The coupling allows the transfer of dissipation, so that the solution becomes globally stable as time tends to infinity. In this talk I will focus instead on the energy transfer in a linear system made by two coupled equations, the first one dissipative and the second one *antidissipative*. Specifically, we will consider the simple (yet not so simple) model

$$\begin{cases} \ddot{u} + u + \dot{u} = b\dot{v} \\ \ddot{v} + v - \epsilon\dot{v} = -b\dot{u}, \end{cases}$$

and study how the competition between the damping and the antidamping mechanisms affect the whole system, in dependence of the coupling parameter b. This analysis has been the object of the recent paper [1]. I will conclude by showing that similar behaviors can be observed also in more complex systems of coupled PDEs arising in mathematical physics.

References

[1] M. Conti, L. Liverani, V. Pata, *A note on the energy transfer in coupled differential systems*, Commun. Pure Appl. Anal. **20** (2020), 1821–1831.

Francesco Esposito (Università della Calabria): The Hopf boundary lemma for singular elliptic problems

In this talk we consider positive solutions to some semilinear and quasilinear elliptic problems involving singular nonlinearities. We provide an Hopf type boundary lemma via a suitable scaling argument that allows to deal with the lack of regularity of the solutions up to the boundary.

Nicola de Nitti (FAU Erlangen-Nürnberg): Nonlocal-to-local singular limits for conservations laws

We present some recent results on the problem of approximating a scalar conservation law by a conservation law with nonlocal flux. As convolution kernel in the nonlocal flux, we consider an exponential-type approximation of the Dirac distribution. We prove that the (unique) weak solution of the nonlocal problem converges strongly in $C(L^1_{loc})$ to the unique entropy solution of the local conservation law. This talk is based on joint works with G. M. Coclite, J.-M. Coron, A. Keimer, and L. Pflug.

Paola Zurlo (Università degli Studi di Bari Aldo Moro): Classical and noncommutative de Finetti's theorems

The investigation of distributional symmetries was initiated by de Finetti's celebrated theorem, which shows that any finite joint distribution of sequences of two-point valued exchangeable random variables is obtained by randomization of the binomial distribution. This result has since found several generalizations both in classical and noncommutative settings. Also motivated by the key role played in physics by the CAR algebra, we carry out a careful study of the (minimal) infinite graded tensor product of a given C^*-algebra with itself, which is acted upon in a natural way by the group of finite permutations. Invariant states for this action turn out to be automatically even and extreme invariant states are characterized as infinite products of a single even state on the C^*-algebra. As a consequence, the extreme symmetric states of the (minimal) graded tensor product are sufficiently many to separate its points, allowing us to prove weak ergodicity of the permutation action. Finally, a version of de Finetti's theorem for graded processes is established, for in this case invariant states correspond to exchangeable quantum stochastic processes.
The original results presented in this talk are based on a joint work with V. Crismale and S. Rossi.

Maria Elena Griseta (STIIMA-CNR Bari): Spreadability for Quantum Stochastic Processes, with an Application to Boolean Commutation Relations

In this talk, we investigate spreadability for quantum stochastic processes, studying the structure of the involved monoids acting on the index-set of all integers $\mathbb{Z}$, that is that generated by left and right hand-side partial shifts, the monoid of all strictly increasing maps whose range has finite complement, and finally the collection of all strictly increasing maps of $\mathbb{Z}$. We show that such three monoids are strictly ordered, and the second-named one is the semidirect product between the first and the action of $\mathbb{Z}$ generated by the one-step shift and we see that spreadability can be directly stated in terms of invariance with respect to the action of the first monoid.
Concerning the stochastic processes involving the concrete boolean C^*-algebra generated by the annihilators acting on the boolean Fock space, we study their spreadability directly in terms of the invariance under the monoid generated by all strictly increasing maps whose range has finite complement.
Finally, we present the version of the Ryll–Nardzewski theorem for the boolean case, establishing that spreadable, exchangeable and stationary stochastic processes coincide, and describing their common structure.
This is a joint work with V. Crismale and F. Fidaleo.