BOOK OF ABSTRACTS

SS5 - Applied Functional Analysis, Integration Theories, and Related Topics

2nd Joint Meeting Brazil-Italy in Mathematics

September 9, 2026

Messina, Italy

Organizers:

Sonia Mazzucchi, University of Trento
Marcia Federson, University of São Paulo

SS5

LIMIT THEOREMS FOR STOCHASTIC VOLTERRA PROCESSES VIA MARKOVIAN LIFTS

Stefano Bonaccorsi
Department of Mathematics, University of Trento, Italy

Stochastic Volterra equations model dynamics with memory but are typically non-Markovian, making their long-time analysis challenging. In this talk, we introduce a Markovian lift that embeds such equations into an infinite-dimensional state space.

Under weak kernel singularity and polynomial memory decay, we establish polynomial ergodicity and a law of large numbers with explicit rates, and we derive a central limit theorem under additional mixing conditions. Several examples illustrate the results. This is joint work with L. A. Bianchi, O. Canadas, and M. Friesen.

References

[1] L.A. Bianchi, S. Bonaccorsi, M. Friesen, *Limits of stochastic Volterra equations driven by Gaussian noise*, Stoch. Partial Differ. Equ. Anal. Comput. 13 (2025), no. 2, 585–630.

[2] L.A. Bianchi, S. Bonaccorsi, M. Friesen, O. Cañadas, *Limit theorems for stochastic Volterra processes* Stoch. Partial Differ. Equ. Anal. Comput. (2026).

E–mail: `stefano.bonaccorsi@unitn.it`.

SS5

Lie Symmetries of SDEs and Integration by Parts Formulas for Stochastic Processes

Francesco De Vecchi
Department of Mathematics, University of Pavia

In this talk, we discuss various notions of symmetry for stochastic differential equations (SDEs), highlighting their connections to established invariance properties of well-known stochastic models. In particular, we focus on the notion of infinitesimal symmetry for SDEs, which generalizes the classical Lie symmetry analysis of deterministic differential equations. Subsequently, we demonstrate how this geometric framework allows for the constructive derivation of explicit integration by parts formulas for the laws of solutions of symmetric SDEs, and we present several concrete examples illustrating these results.

This talk is based on joint work with Susanna Dehò, Paola Morando, and Stefania Ugolini.

References

[1] Dehò, S., De Vecchi, F. C., Morando, P., and Ugolini, S. (2026). *Random rotational invariance of integration by parts formulas within a Bismut-type approach.* Journal of Mathematical Physics, 67(1).

[2] De Vecchi, F. C., Morando, P., and Ugolini, S. (2025). *Integration by parts formulas and Lie symmetries of SDEs.* Electronic Journal of Probability, 30, 1-41.

E–mail: `francescocarlo.devecchi@unipv.it`.

2nd Joint Meeting Brazil-Italy
in Mathematics
Messina, 7–11 September 2026

SS5

States and Propagators in the Kuelbs–Steadman Hilbert Space

Márcia Federson [1]
Department of Mathematics, University of São Paulo

We investigate the functional-analytic structure of the Kuelbs-Steadman Hilbert space $KS2[IRn]$ and its role as a natural setting for the operator-theoretic formulation of quantum states and propagators. The intrinsic coefficient representation underlying the $KS2[IRn]$ inner product induces a reproducing kernel Hilbert space structure that accommodates evaluation-type functionals and integral-kernel observables beyond the scope of the classical $L2[IRn]$ framework. Within this setting we develop a spectral and trace-class theory of density operators and obtain a characterization of Gaussian (covariance) states in terms of the coefficient structure. At the same time, the Gross-Kuelbs rigging permits the rigorous treatment of oscillatory objects such as Fresnel kernels and Schrödinger propagators, which appear as phase deformations of the $KS2[IRn]$ coefficient pairing. This leads to a structural dichotomy in which Gaussian structures correspond to quantum states, while Fresnel-type constructions encode oscillatory propagation.

References

[1] M. Federson; T.L. Gill. A Natural Hilbert Space for Gaussian States and Fresnel Propagators. Submitted, 2026.

[2] M. Federson and T.L. Gill, Feynman Propagators as Hilbert Space Matrix Elements in $KS^2[\mathbb{R}^n]$. Submitted, 2026.

[1]Supported by CNPq.
E–mail: `federson@icmc.usp.br`.

SS5

Characterization of the (fractional) Malliavin–Watanabe–Sobolev spaces $\mathcal{D}^{\alpha,2}$ via the Bargmann–Segal norm

Martin Grothaus
Department of Mathematics, RPTU University Kaiserslautern–Landau

Wolgang Bock
Department of Mathematics, Linnaeus University

Motivated by an open question going back to P. Malliavin and P.-A. Meyer (and closely related to the foundational work of S. Watanabe) on whether Malliavin–Watanabe–Sobolev regularity admits a characterization in terms of a holomorphic Laplace image similar as for Hida distributions, we establish a characterization of the spaces $\mathcal{D}^{\alpha,2}$ for all $\alpha \in \mathbb{R}$ via the Bargmann–Segal norm of the S-transform. More precisely, we express $\mathcal{D}^{\alpha,2}$-regularity, $\alpha > 0$, of $F \in L^2(\mu)$, as well as dual regularity of distributions, in terms of integrability, differentiability and growth properties of the function

$$(0,1) \ni \lambda \longmapsto \int_{\mathcal{S}'_{\mathbb{C}}} |SF(\lambda u)|^2 \, d\nu(u)$$

involving integer-order derivatives in λ for $\alpha \in \mathbb{N}$ and Riemann-Liouville fractional derivatives/integrals for non-integer α. Here ν is the Gaussian Bargmann–Segal measure. This yields practical criteria for both positive and negative (including fractional) orders of Malliavin regularity and thereby bridges Malliavin calculus and Bargmann–Segal techniques from white noise analysis. Applications are worked out for Donsker's delta, self-intersection local times of Gaussian processes, and Gauss kernels.

References

[1] W. Bock, M. Grothaus, *Characterization of the (fractional) Malliavin–Watanabe–Sobolev spaces $\mathcal{D}^{\alpha,2}$ via the Bargmann–Segal norm*, https://doi.org/10.48550/arXiv.2603.04594, 2026.

E–mail: `grothaus@rptu.de`.

SS5

Chernoff solutions of the heat and the Schrödinger equation in the Heisenberg group

Sonia Mazzucchi, *Andrea Pinamonti*
Department of Mathematics, University of Tento

Nicoló Drago
Department of Mathematics, University of Genova

In this talk I shall describe the application of Chernoff's theorem to construct explicit solutions for the heat and Schrödinger equations on the Heisenberg group $\mathbb{H}_d$. These results provide, on the one hand, a new connection between the heat equation and Brownian motion on $\mathbb{H}_d$ and, on the other hand, the rigorous mathematical construction of the Feynman path integral for the Schrödinger equation..

References

[1] N. Drago, S. Mazzucchi, A. Pinamonti, *Chernoff solutions of the heat and the Schrödinger equation in the Heisenberg group*, Journal of Differential Equations 464 (2026), : 114193.

E–mail: sonia.mazzucchi@unitn.it.

SS5

Slow and Fast Dynamics in Measure FDEs with State-Dependent Delays through Averaging and its Applications to Extremum Seeking

Jaqueline Mesquita [1]
State University of Campinas, Brazil

Tiago Oliveira
State University of Rio de Janeiro, Brazil

Henrique C. dos Reis
University of Brasília, Brazil

In this talk, we investigate a new class of equations called measure functional differential equations with state-dependent delays. We establish the existence and uniqueness of solutions and present a discussion concerning the appropriate phase space to define these equations. Also, we prove a version of periodic averaging principle to these equations. This type of result was completely open in the literature for many years, due to the difficulty. These equations involving measure bring the advantage to encompass others such as impulsive, dynamic equations on time scales and difference equations, expanding their application potential. Additionally, we apply our theoretical insights to a real-time optimization strategy, using extremum seeking to validate the stability of an innovative algorithm under state-dependent delays. This application confirms the relevance of our findings in practical scenarios, offering valuable tools for advanced control system design. This is a joint work with Tiago Oliveira and Henrique C. dos Reis

[1]This work received the financial support of FAPESP.
E–mail: `jaquegm@unicamp.br`.

SS5

Oscillation theory for linear evolution processes

M.Ap. Silva
Departamento de Matemática, Universidade Tecnológica Federal do Paraná, 80230-901, Curitiba PR, Brazil

We introduce the theory of pullback oscillation for linear evolution processes $\{S(t,s) : (t,s) \in \mathcal{P}\} \subset \mathcal{L}(X)$ acting on a Banach space X. A point $x \in X\backslash\{0\}$ pullback oscillates at time $t_0 \in \mathbb{R}$ if, for every $\zeta \in X^*$ and every $r \leq t_0$, there exist $s_1 < s_2 < r$ such that $\zeta(S(t_0,s_1)x)\zeta(S(t_0,s_2)x) < 0$. Necessary and sufficient conditions to obtain pullback oscillatory behavior are derived using a geometric interpretation of the closed conic hull.

Theorem 1 (Theorem 3.7 - Sufficient Condition). *Let $t_0 \in \mathbb{R}$, $x \in X\backslash\{0\}$ and $\{S(t,s) : (t,s) \in \mathcal{P}\}$ be a linear evolution process in $\mathcal{L}(X)$. If $-x \in \overline{con}(\gamma_p(x,\sigma))$ for all $\sigma \leq t_0$, where $\gamma_p(x,\sigma)$ is the pullback orbit of x at time σ, then x pullback oscillates at time t_0.*

Theorem 2 (Theorem 3.10 - Necessary Condition). *Let $x \in X\backslash\{0\}$, $t_0 \in \mathbb{R}$ and $\{S(t,s) : (t,s) \in \mathcal{P}\}$ be a linear evolution process in $\mathcal{L}(X)$. If x pullback oscillates at time t_0, then $-x \in \overline{con}(\gamma_p(x,t_0))$.*

Proposition 3 (Proposition 3.14 - Sufficient Condition via Pullback ω-limit). *Let*

$$-x \in \bigcap_{\sigma \leq t_0} \omega(x,\sigma)\backslash\{0\}$$

with $t_0 \in \mathbb{R}$, and $\{S(t,s) : (t,s) \in \mathcal{P}\}$ be a linear evolution process in $\mathcal{L}(X)$. Then, x pullback oscillates at time t_0.

Theorem 4 (Theorem 3.21 - Equivalence for Autonomous Systems). *Let $x \in X\backslash\{0\}$ and $\{S(t,s) : (t,s) \in \mathcal{P}\}$ be an evolution process in $\mathcal{L}(X)$ satisfying the autonomous condition $S(t,s) = S(t-s,0)$ for all $(t,s) \in \mathcal{P}$. Then, x strongly oscillates if and only if x pullback oscillates at any time t_0.*

References

[1] M.Ap. Silva, E.M. Bonotto, M. Federson, *Oscillation theory for linear evolution processes*, J. Differential Equations, 440 (2025), 113464.

[2] J. Tabor, *Oscillation theory of linear systems*, J. Differential Equations, 180 (2002), 171–197.

E–mail: `mariellesilva@utfpr.edu.br`.

SS5

Maximal L^p concentration of the Wigner and Born–Jordan distributions

Federico Stra, *S. Ivan Trapasso*
Department of Mathematical Sciences "G. L. Lagrange", Politecnico di Torino

Erling A. T. Svela
Department of Mathematical Sciences, Norwegian University of Science and Technology

The *Wigner distribution* Wf of $f \in L^2(\mathbb{R}^d)$ is one of the most popular time-frequency representations in signal analysis, with a prominent role in many problems and applications of quantum mechanics. It was introduced by Wigner in 1932 as a quasi-probability distribution on phase space, and $Wf(x, \xi)$ can be interpreted as the Fourier transform of the two-point autocorrelation, as a special case of the *short-time Fourier transform* (STFT), or as the joint time-frequency energy density localized near a phase space point $(x, \xi) \in \mathbb{R}^{2d}$,

An uncertainty principle prevents Wf from being too localized within a domain $\Omega \subset \mathbb{R}^{2d}$ in phase space, therefore it is natural to investigate whether optimal phase-space concentration on a prescribed domain can be achieved. A natural choice is to maximize $\|Wf\|_{L^p(\Omega)}$ under the constraint $\|f\|_{L^2(\mathbb{R}^d)} = 1$. In this seminar I present some results in this direction recently obtained in collaboration with Erling Svela (NTNU) and Ivan Trapasso (PoliTo).

In [1] we show the existence of optimizers for the concentration of the Wigner distribution in any dimension and for every $p \in [1, \infty]$. This solution is partially generalized to the treatment of the τ-Wigner distribution, which is an asymmetric variant. In dimension 1 we also address the concentration problem for the *Born–Jordan distribution*, which is the τ-average of the τ-Wigner. The main technique is a decomposition into profiles based on *concentration-compactness*, coupled with an asymptotic interference formula.

In [2] we extend to higher dimensions the study of the concentration of the Born–Jordan distribution. The behavior changes drastically below and above a *critical exponent* $p_*(d)$. We completely settle the problem in dimension 2, as well as the subcritical and supercritical cases in higher dimension. The only case left open is the critical regime in dimension greater than 2, which most certainly requires more sophisticated techniques.

References

[1] F. Stra, E. A. T. Svela, S. I. Trapasso: "On the existence of optimizers for nonlinear time-frequency concentration problems: the Wigner distribution", *Journal de Mathématiques Pures et Appliquées* 212 (2026), DOI: `https://doi.org/10.1016/j.matpur.2026.103919`, arXiv: `https://arxiv.org/abs/2510.18683`.

[2] F. Stra, E. A. T. Svela, S. I. Trapasso: "On the existence of optimizers for nonlinear time-frequency concentration problems: the Born–Jordan distribution", submitted (2026), arXiv: `https://arxiv.org/abs/2605.10535`.

E–mail: `federico.stra@polito.it`.