
# RoMAnS: Research on Mathematical Analysis and Semingroups

On the occasion of Silvia Romanelli's 70th Birthday
Bari, July 8-9, 2021

# Book of Abstracts and Program

# RoMAnS: Research on Mathematical Analysis and Semigroups.

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**Speakers**

Francesco ALTOMARE, *Università degli Studi di Bari Aldo Moro*
Wolfgang ARENDT, *Universität Ulm*
Piermarco CANNARSA, *Università degli Studi di Roma "Tor Vergata"*
Joel COHEN, *University of Maryland*
Flavia COLONNA, *George Mason University*
Angelo FAVINI, *Alma Mater Studiorum Università di Bologna*
Jerome A. GOLDSTEIN, *University of Memphis*
Gisèle Ruiz GOLDSTEIN, *University of Memphis*
Davide GUIDETTI, *Alma Mater Studiorum Università di Bologna*
Maria Rosaria LANCIA, *Sapienza Università di Roma*
Luca LORENZI, *Università di Parma*
Gabriela MARINOSCHI, *Romanian Academy*
Giorgio METAFUNE, *Università del Salento*
Alain MIRANVILLE, *Université de Poitiers*
Delio MUGNOLO, *FernUniversität in Hagen*
Diego PALLARA, *Università del Salento*
Abdelaziz RHANDI, *Università degli Studi di Salerno*
Fulvio RICCI, *Scuola Normale Superiore di Pisa*

**Organizers**

Anna Maria Candela, *Università degli Studi di Bari Aldo Moro*
Silvia Cingolani, *Università degli Studi di Bari Aldo Moro*
Genni Fragnelli, *Università degli Studi di Bari Aldo Moro*
Sandra Lucente, *Università degli Studi di Bari Aldo Moro*
Addolorata Salvatore, *Università degli Studi di Bari Aldo Moro*

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## PROGRAM

**Thursday, July 8**

**Aula I, Dipartimento di Matematica**
**Campus Ernesto Quagliarello, via E. Orabona 4**
**Università degli Studi di Bari Aldo Moro**

8.45-9:00 **Registration**

9.00-9:30 **Opening**

- Prof. Stefano Bronzini, Magnifico Rettore dell'Università degli Studi di Bari Aldo Moro
- Ammiraglio Giovanni Nicosia, Marina Militare Italiana
- Prof. Eugenio Scandale, Presidente dell'Accademia Pugliese delle Scienze
- Prof. Domenico Di Bari, Presidente della Scuola di Scienze e Tecnologie (UniBa)
- Prof.ssa Addolorata Salvatore, Direttore del Dipartimento di Matematica (UniBa)
- Prof.ssa Franca Tommasi, Università degli Studi di Bari Aldo Moro
- Prof. Rainer Nagel, Eberhard Karls Universität Tübingen

Chairwoman: ***Silvia Cingolani***

9.30-10.05 **Jerome A. Goldstein:** *Silvia Romanelli and Mathematical Finance*

10.10-10.45 **Alain Miranville:** *Mathematical models for glial cells*

10.50-11.15 *Coffee break*

11.15-11.50 **Fulvio Ricci*:** *On invariance of the Schwartz space under spherical transforms*

11.55-12.30 **Abdelaziz Rhandi:** *Bi-Kolmogorov type operators and weighted Rellich inequalities*

12.35-13.10 **Piermarco Cannarsa*:** *Bilinear control for evolution equations*

13.15 *Lunch at Caffè Vergnano*

Chairman: ***Jerome A. Goldstein***

15.00-15.35 **Giorgio Metafune:** *$L^p$-estimates for Baouendi-Grushin operators*

15.40-16.15 **Luca Lorenzi*:** *On systems of Kolmogorov equations*

16.20-16.45 *Coffee break*

16.45-17.20 **Diego Pallara:** *On the spectrum of Ornstein-Uhlenbeck operator*

17.25-18.00 **Gabriela Marinoschi*:** *Semigroup approach of the chemotaxis flow*

18.05-18.40 **Angelo Favini*:** *Degenerate Integro-Differential Equations: Direct and Inverse Problems*

20.30 *Social Dinner at Palace Hotel*

**NOTE:** The speakers with * will give their talk via Microsoft Teams

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## PROGRAM

**Friday, July 9**

**Aula I, Dipartimento di Matematica**
**Campus Ernesto Quagliarello, via E. Orabona 4**
**Università degli Studi di Bari Aldo Moro**

Chairwoman: ***Gisèle Ruiz Goldstein***

9.00-9.35 **Francesco Altomare:** *On the convergence of sequences of positive linear operators and functionals on bounded function spaces*

9.40-10.15 **Davide Guidetti*:** *Linear and fully nonlinear Cauchy Dirichlet problems with fractional time derivative*

10.20-10.40 *Coffee break*

10.45-11.20 **Maria Rosaria Lancia:** *On Venttsel problems in irregular domains: results and open problems*

11.25-12.00 **Flavia Colonna:** *Weighted Composition Operators between Banach Spaces of Analytic Functions - Overview and New Trends*

12.05-12.40 **Delio Mugnolo:** *Linear hyperbolic systems with general boundary conditions*

12.45 *Lunch at Caffè Vergnano*

Chairwoman: ***Anna Maria Candela***

15.00-15.35 **Wolfgang Arendt:** *Semigroups: From Hilbert space to continuous functions*

15.40-16.15 **Joel Cohen*:** *The transience of certain regular trees*

16.20-16.45 *Coffee break*

16.45-17.20 **Gisèle Ruiz Goldstein:** *Silvia Romanelli and General Wentzell Boundary Conditions*

17.25 **Closing**

**NOTE:** The speakers with * will give their talk via Microsoft Teams

# RoMAnS: Research on Mathematical Analysis and Semigroups.

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## ABSTRACTS

### On the convergence of sequences of positive linear operators and functionals on bounded function spaces

*F. Altomare*
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The talk will report the main results recently obtained in [2]. Of concern are some simple criteria about the convergence of sequences of positive linear operators and functionals in the framework of spaces of bounded functions which are continuous on a given subset of their domain.

Among other things, some applications concerning the behaviour of the iterates of Bernstein operators defined both on $[0,1]$ as well as on $d$-dimensional simplices and hypercubes ($d \geq 1$) are discussed.

A final section treats the behaviour of integrated arithmetic means with respect to a probability Borel measure on a convex compact subset $K$ of a locally convex space. As a consequence, a general weak law of large numbers for sequences of $K-$valued random variables is derived.

Most of the results extend previous ones contained in [1] and [3, Section 1.3].

#### References

[1] F. Altomare, On some convergence criteria for nets of positive linear operators, *J. Math. Anal. Appl.* **398**, 542-552 (2013).

[2] F. Altomare, *On the convergence of sequences of positive linear operators and functionals on bounded function spaces*, to appear in *Proc. Amer. Math. Soc.*, 2021.

[3] F. Altomare, M. Cappelletti Montano, V. Leonessa and I. Raşa, *Markov Operators, Positive Semigroups and Approximation Processes*, de Gruyter Studies in Mathematics, **61**, Walter de Gruyter GmbH, Berlin/Munich/Boston, 2014.

### Semigroups: From Hilbert space to continuous functions

*W. Arendt*
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Form Methods lead in a most efficient way to semigroups on Hilbert space. We show examples where the semigroup also operates on spaces of continuous functions: The Laplacian with Robin boundary or Ventzell boundary conditions, the Dirichlet-to-Neumann operator.

### Bilinear control for evolution equations

*P. Cannarsa*
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Bilinear control systems are receiving increasing attention in recent years, as they can be used to study problems for which an additive control action would be unrealistic. For such systems, in infinite dimension, weaker controllability properties can be expected than for systems with additive controls. For instance, exact controllability is out of question due to a well-known negative result by Ball, Marsden, and Slemrod back in the 80's. Nevertheless, one can seek to steer states to special targets either in finite or infinite time. In this talk, I will present recent results from joint papers with Fatiha Alabau-Boussouira and Cristina Urbani, where the above problem is addressed for evolution equations of the form $u'(t) = Au(t) + p(t)Bu(t)$ with $A$ and $B$ linear operators in a Hilbert space and $p(t)$ a single-input control. Applications to parabolic equations in one space dimension will also be discussed.

**The transience of certain regular trees**

*J. Cohen*
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We are going to be looking at random walks on trees. For us a tree is an infinite locally finite connected graph with no loops, and with a chosen vertes $e$ called the root. A random walk assigns to each edge of the graph two probabilities, one in each direction of the edge, so the for any vertex the sum of the outward probabilities the edges touching that vertex is 1. These probbilities are outward if the direction is away from $e$, and inward if it heads towatd $e$. A path is a finite set of vertices each one attached by an edge to the next. If no vertex is repeated, then we say that the path is a geodesic. In a tree, there is a unique geodesic path between any two points and the length of that path is defined as the *distance* between those vertices.

The "walk" part of a random walk imagines an object starting at some point $v$ and moving along any path to end at a vertex $w$, and assign to it the probability which is the product of the probabilities of its edges along the path. Fixing $v$ and $w$ and a natural number $n$, we look at the set of all paths of length $n$ going from $v$ to $w$ and add up the probabilities of all these paths in the direction of the walk. (Of all these paths only one is a geodesic.) That number is the probability that a path starting at $v$ will be at $w$ after $n$ steps. The question studied is this:

Fix a finite set $K$ of vertices, and add up the probabilities of all the paths of length $n$ starting at $v$ and finishing in $K$. As $n$ increases if this probability goes to 0, then the random walk is *transient*. Otherwise it it *recurrent*.

So a random walk being transient says that with probability 1 the endpoints of paths of increasing length will be outside any fixed finite set, that is, the endpoints move to infinity.

For any positive integer $d$, the homogeneous tree of degree $d$, is one in which every point has exactly $d$ neighbors. We're going to be looking only at homogeneous trees. A homogeneous tree is called *isotropic* if all the probabilities of the edges are exactly $\frac{1}{d}$. A weaker condition is *semi-isotropic*, which means that away from the root, any two vertices have exactly the same probabilities. More precisely, let $v, w$ be vertices at least 2 away from the root. Then their neighbors can be called $v_1, v_2, ..., v_d$ and $w_1, w_2, ..., w_d$ in such a way that $p(v, v_i) = p(w, w_i)$ and $p(v_i, v) = p(w_i, w)$. The outward probabilites from the root can all be asumed to be $\frac{1}{d}$. Let $p$ be the greatest probability from each vertex.

Our main result is

Theorem 1: Let $T$ be a homogeneous semi-isotropic a) For $d = 2$, if $p > \frac{1}{2}$ and represents the outward direction, then the tree is transient; otherwise it is recurrent. b) For $d \geq 3$, the tree is transient except in the case that $p \geq \frac{1}{2}$ and is almost always the probability of each edge facing the direction of the root.

**Weighted Composition Operators between Banach Spaces of Analytic Functions - Overview and New Trends**

*F. Colonna*
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A class of operators that has been thoroughly studied in recent years is the weighted composition operators for the prominent role these operators play in the determination of the isometries of several well-known Banach spaces.

For complex-valued analytic functions $u, \varphi$ defined on the open unit disk $\mathbb{D}$ in $\mathbb{C}$ with $\varphi(\mathbb{D}) \subseteq \mathbb{D}$, the weighted composition operator with symbols $u$ and $\varphi$ is defined on the set of analytic functions on $\mathbb{D}$ by

$$W_{u,\varphi} f = u(f \circ \varphi).$$

In this talk, after highlighting the main developments of the study of such operators on several well-known Banach spaces of analytic functions, we provide a framework that unifies the settings in published works. We provide the topological and function theoretic conditions needed on the Banach space $X$ of analytic functions on $\mathbb{D}$ for the weighted composition operator with domain $X$ and target space a class of weighted type Banach spaces to be bounded, or compact. A special effort is made to single out the conditions that lead to an approximation of the essential norm in terms of the symbols and of the norm of the point-evaluation functionals on the space. The main goal of our work is thus to provide boundedness and compactness criteria, as well as estimates of the operator norm and the essential norm (and in several cases, derive exact formulas) of such operators that are valid for many functional Banach spaces all at once, where the axiomatic conditions needed can be easily checked on a case by case basis.

We also discuss recent developments in higher dimensions and on spaces of harmonic mappings.

**Degenerate Integro-Differential Equations: Direct and Inverse Problems.**

*A. Favini*
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Possibly degenerate integro-differential equations in Banach spaces are studied. Some applications to partial differential equations are described.

**Silvia Romanelli and Mathematical Finance**

*J.A. Goldstein*
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Silvia Romanelli was inspirational and essential for the extensive joint collaborative research she did with Angelo Favini, Gisèle Goldstein, and Jerry Goldstein (FGGR), plus her collaboration with Gisèle and Jerry Goldstein and Rosa Maria Mininni (GGMR), and further collaborations involving the Goldsteins as well as others, including Giuseppe Coclite, Davide Guidetti, Enrico Obrecht, and many others.

We will indicate the essential roles (explicit as well as hidden) she played in this research, with some emphasis on the rigorous theory associated with the Black-Merton-Scholes stock option equation and the Cox-Ingersoll-Ross zero coupon bond equation, the main deterministic non stochastic PDEs of mathematical finance. This work started in Bari in the late 1990s and continues in Bari today.

**Silvia Romanelli and General Wentzell Boundary Conditions**

*G. Ruiz Goldstein*
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Silvia Romanelli was the heart and soul of what became a long research program on boundary conditions in partial differential equations. Her presentation (based on her paper with A. Attaliente) at the Louisiana State University Conference in 1993 sparked our interest in degenerate boundary conditions. Through a series of summer visits to the University of Bari and the University of Bologna, the long a productive collaboration of Angelo Favini, Jerry Goldstein, Silvia Romanelli and me grew. The main focus became boundary conditions, and our 2002 paper "The heat equation general Wentzell boundary conditions" in the Journal of Evolution Equations was the culmination of many years of joint collaboration and has become a seminal paper on such boundary conditions. This collaboration would never have been possible without Silvia's persistence, organizational skills and mathematical expertise.

The Favini, G. Goldstein, J. Goldstein, Romanelli team functioned like a mathematical family, and over the years the family grew to include a variety of coauthors including Giuseppe Coclite, Ciprian Gal, Davide Guidetti, Genni Fragnelli, Enrico Obrecht, K. Taira, as well as many of our former students. In this talk I will summarize our main results and emphasize the essential role Silvia has played in the mathematical life of this subject. On a more personal note, I will emphasize the role Silvia has played as a mathematical role model for me and many other women-how to balance life, motherhood and career and do an AMAZING job at all of them.

**Linear and fully nonlinear Cauchy Dirichlet problems with fractional time derivative**

*D. Guidetti*
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We recall a theorem of maximal regularity for a mixed linear Cauchy-Dirichlet problem, with a Caputo time derivative $D_t^\alpha u$, with $\alpha \in (0,2)$. This is the basis for a result of local existence and global uniqueness for the mixed-Cauchy Dirichlet problem

$$\begin{cases} D_t^\alpha u(t,x) = F(t,x,(D_x^\beta u(t,x))_{|\beta|\le 2}), & (t,x) \in [0,T]\times\Omega, \\ u(t,x') = g(t,x'), & (t,x') \in [0,T]\times\partial\Omega, \\ D_t^k u(0,x) = u_k(x), & k<\alpha, x\in\Omega. \end{cases}$$

Here $F$ is a suitably smooth and

$$\sum_{|\gamma|=2} D_{p_\gamma} F(t,x,(p_\beta)_{|\beta|\le 2})\xi^\gamma \ge \nu(t,x,(p_\beta)_{|\beta|\le 2})|\xi|^2, \quad \forall \xi\in\mathbb{R}^n,$$

with $\nu(t,x,(p_\beta)_{|\beta|\le 2}) > 0$. These results are extensions of known (and classical, at least in the linear case) facts in the case $\alpha = 1$.

**On Venttsel problems in irregular domains: results and open problems**

*M. R. Lancia*
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Some results on semilinear Venttsel problems, possibly non autonomous, in irregular domains of fractal type are presented. Open problems will be discussed.

**On systems of Kolmogorov equations**

*L. Lorenzi*
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In this talk we will illustrate some results on systems of parabolic equations with unbounded coefficients defined in $\mathbb{R}^d$, in the context of both the space of bounded and continuous functions and $L^p$-spaces related to the Lebesgue measure.

**Semigroup approach of the chemotaxis flow**

*G. Marinoschi*
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We present a study of the well-posedness of a nonlinear parabolic-elliptic system with cross-diffusion, by a semigroup approach in dual spaces. The system consists in two equations

$$u_t - \Delta\beta(u) + \nabla \cdot (b(u)\nabla v) = 0 \text{ in } (0,T) \times \Omega, \tag{1}$$

$$v - \Delta v = c(u) \quad \text{ in } (0,T) \times \Omega, \tag{2}$$

where $\Omega$ is either an open bounded subset of $\mathbb{R}^d$, or $\Omega = \mathbb{R}^3$, with Neumann or Dirichlet boundary conditions in the first case, and with initial data. The study of this system is motivated by the numerous applications related to models of aggregation, bacteria pattern formation, embryogenesis, models in physiology and disease, ecology or sociology and especially to chemotactic movement of populations. We prove existence, uniqueness and specific properties of the chemotaxis flow (1)-(2) by a semigroup approach in the dual space $(H^1(\Omega))'$ or $H^{-1}(\Omega)$ for bounded domains. This approach allows us to consider singular data which may be of relevance in applications. The proofs are led for larger classes of parameters $\beta$, $b$ and $c$. In the case of the whole 3D domain, existence is proved working in $H^{-1}(\mathbb{R}^3)$, while arguments for the uniqueness are developed in a Beppo Levi space.

**$L^p$-estimates for Baouendi-Grushin operators**

*G. Metafune*
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We prove $L^p$ estimates for the Baouendi-Grushin operator $\Delta_x + |x|^\alpha \Delta_y$ in $L^p(\mathbb{R}^{N+M})$, $1 < p < \infty$, where $x \in \mathbb{R}^N,\ y \in \mathbb{R}^M$.

When $p = 2$ more general weights belonging to the Reverse Hölder class $B_2(\mathbb{R}^N)$ are allowed.

**Mathematical models for glial cells**

*A. Miranville*
Université de Poitiers
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Our aim in this talk is to discuss mathematical models for glial cells and energy metabolism in the brain. In particular we discuss the existence of global in times solutions for a Cahn-Hilliard type model.

**Linear hyperbolic systems with general boundary conditions**

*D. Mugnolo*
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I will discuss hyperbolic systems of one-dimensional partial differential equations under general, possibly dynamic boundary conditions. I will present a rather flexible formalism that allows for the study of a large class of evolution equations, either on individual 1-dimensional intervals or on networks. Sufficient conditions for both forward and backward well-posedness will be studied. If time allows, I am going to present a treatment of the Lord-Shulman's model of second sound in networks. This is joint work with Marjeta Kramar Fijavž (Ljubljana) and Serge Nicaise (Valenciennes).

**On the spectrum of Ornstein-Uhlenbeck operator**

*D. Pallara*
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The spectrum of the Ornstein-Uhlenbeck operator is described in $L^p$ spaces on $R^n$, both with respect to the Lebesgue and the Gaussian measure.

**Bi-Kolmogorov type operators and weighted Rellich inequalities**

*A. Rhandi*
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In this talk we consider the symmetric Kolmogorov operator $L = \Delta + \frac{\nabla \mu}{\mu} \cdot \nabla$ on $L^2(\mathbb{R}^N, d\mu)$, where $\mu$ is the density of a probability measure on $\mathbb{R}^N$. Under general conditions on $\mu$ we prove first weighted Rellich's inequalities with optimal constants and deduce that the operators $L$ and $-L^2$ with domain $H^2(\mathbb{R}^N, d\mu)$ and $H^4(\mathbb{R}^N d\mu)$ respectively, generate analytic semigroups of contractions on $L^2(\mathbb{R}^N, d\mu)$. We deduce that $d\mu$ is the unique invariant measure for the semigroup generated by $-L^2$ and as a consequence we describe the asymptotic behaviour of such semigroup and obtain some local positivity properties. As an application we study the bi-Ornstein-Uhlenbeck operator and its semigroup on $L^2(\mathbb{R}^N, d\mu)$.

This is a joint work with D. Addona, F. Gregorio and C. Tacelli.

**On invariance of the Schwartz space under spherical transforms**

*F. Ricci*
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Spherical analysis is an important part of harmonic analysis of functions and operators on Lie groups and homogeneous spaces. It is a natural replacement of Fourier analysis when a given invariance condition

is strong enough to imply commutativity of the algebras of invariant functions and of equivariant operators. We present recent results on the so-called Schwartz correspondence for spherical transforms on groups with polynomial volume growth

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