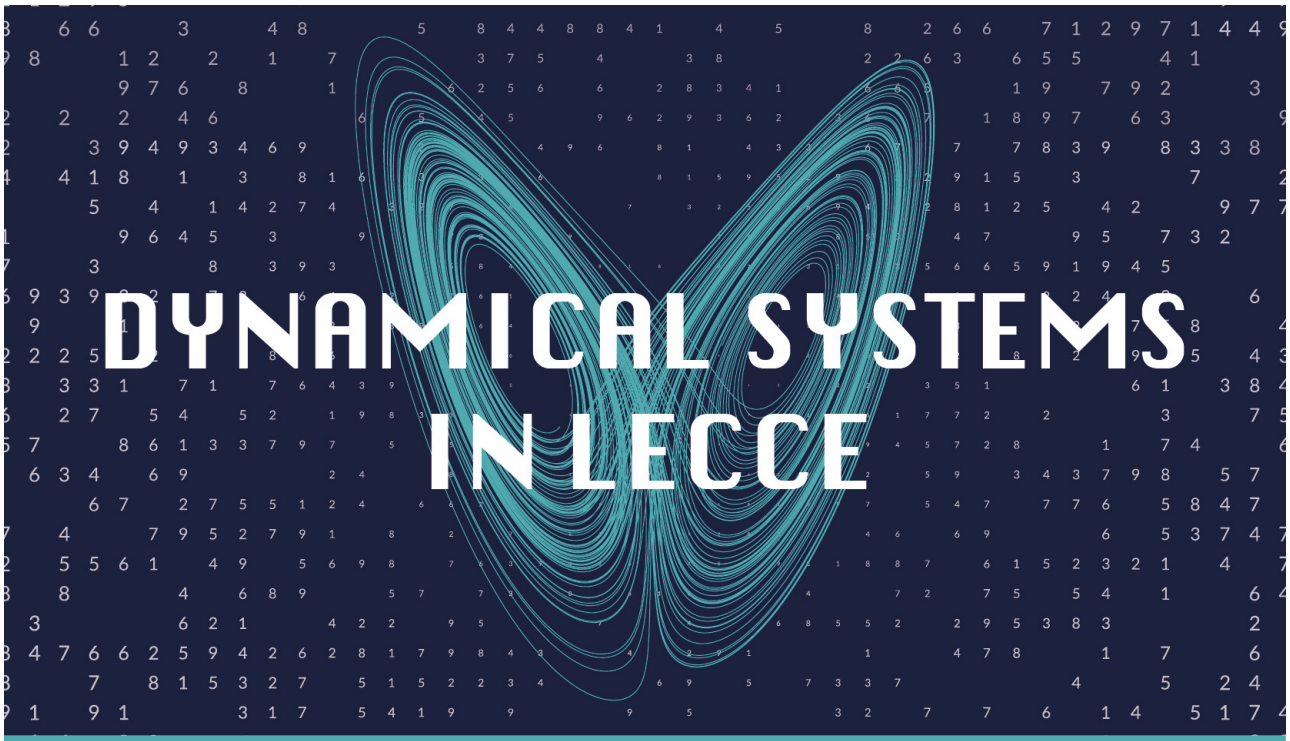

DYNAMICAL SYSTEMS IN LECCE

September 8–10, 2025

Rectorate of the University of Salento
piazza Tancredi 7, Lecce

https://dysy2025.unisalento.it/

70 UNI SALENTO

Dipartimento di Matematica e Fisica
"Ennio De Giorgi"

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Schedule

MONDAY 8	
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	Maria Antonietta Aiello, Deputy-Rector and Rector-elect
	Michele Campiti, Head of the Mathematics and Physics Department
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14,30–14,50	Homburg
14,50–15,10	Bertozzi
15,10–15,40	Coffee Break and Closing

Minicourses

Claudio Bonanno (Università di Pisa, Italy)

The transfer operator and statistical properties of dynamical systems

The first lesson in the modern theory of dynamical systems is that, even when it is impossible to exactly describe the orbits of a system, we can still aim to capture their behaviour statistically. For instance, we may ask how much time a "typical" orbit spends within a particular region of the phase space, or how quickly the system "forgets" its past. In this mini-course, I will address these and related questions, demonstrating how they can be answered through a functional-analytic approach based on the transfer operator. I will also present more recent results on "non-classical" behaviours that arise in certain physical models.

Alessandra Celletti (Università di Roma "Tor Vergata", Italy)

Proper elements, space debris and machine learning

I will provide the basics of perturbation theory. Normal forms will allow us to introduce the so-called proper elements, which are quasi-integrals of motion. I will present a model for describing the dynamics of space debris; I will discuss the main dynamical features, including tesseral and luni-solar resonances. I will show that perturbative methods can be combined with Machine Learning techniques with the aim to analyze the dynamics of groups of objects, for example to classify and cluster space debris generated by break-up events of artificial satellites.

Invited Speakers

Vivina Barutello (Università di Torino, Italy)

On Birkhoff conjecture for Kepler billiards

Keplerian billiards are classical billiards with a Keplerian potential inside. We consider the reflective case, where the particle reflects elastically on the boundary, as well as the refractive one, where the particle can cross the billiard's boundary entering a region with a harmonic potential. In both cases we prove the presence of a symbolic dynamics, at least for high energies, under some assumptions on the boundary of the billiard table and the position of the Keplerian mass inside it.
Coauthors: Stefano Baranzini, Irene De Blasi, Anna Maria Cherubini, Susanna Terracini

Sara Di Ruzza (Università di Palermo, Italy)

Stability and bifurcation of resonances in rings dynamics around small bodies

Recently, ring systems have been discovered around small celestial bodies. Notably, dense and narrow rings have been identified encircling the dwarf planet Haumea, the Centaur Chariklo, and the trans-Neptunian object Quaoar. These rings are observed to occupy a specific dynamical configuration, known as the 1:3 spin-orbit resonance, which correlates the orbital period of a ring particle to the rotation of the central body. We apply perturbation theory to analyze the dynamical behavior of resonances associated with the motion of a particle within a ring around an irregularly shaped celestial object. The central body is modeled as a homogeneous triaxial ellipsoid, rotating about its shortest physical axis, while the massless ring particle is assumed to move within the equatorial plane of the ellipsoid. The particle's dynamics, expressed in epicyclic variables, is associated with a Hamiltonian with two degrees of freedom. We examine the phase-space structure, the libration amplitude around resonances, stability timescales, and the occurrence of bifurcations. In this way, we provide dynamical arguments strongly supporting the observed preference of small bodies for the 1:3 resonance over alternative configurations. Works in collaboration with Alessandra Celletti and Irene De Blasi.

Maximilian Engel (University of Amsterdam, Netherlands - Freie Universität Berlin, Germany)

Transitions between order and chaos in stochastic environments

The talk will present some steps towards a mathematical framework for studying transient (finite-time) phenomena in random dynamical systems. It is a natural property of such systems to exhibit several co-existing, metastable regimes in state space, alternating between order and chaos and, thereby, different time scales of predictability; famous examples include the transition to turbulent fluid flow or metastable chemical configurations. We will discuss methods deploying finite-time Lyapunov exponents, quasi-stationarity and conditioning to capture stochastic transient phenomena, in particular using examples from various fields of applications.

Mar Giralt (IMCCE Observatoire de Paris, France)

An Arnold diffusion mechanism for the Galileo satellites

Motivated by the need of preserving the operational orbital regions around the Earth, natural

perturbations can be exploited to lead the satellites towards an atmospheric reentry at the end of life. In this way, it is possible to dilute the collision probability in the long term and reduce the disposal cost, also if departing from high-altitude regions. In the case of the Medium Earth Orbit (MEO) region, home of the navigation satellites (like GPS and Galileo), the main driver is the third-body perturbation. In this work, we show how an Arnold diffusion mechanism can trigger the eccentricity growth in MEO, so that the pericenter altitude drops into the atmospheric drag domain.

Marco Lenci (Università di Bologna, Italy)

Recent results on global-local mixing for one dimensional expanding maps

Within the context of infinite ergodic theory, I will consider the question of global-local mixing (roughly speaking, the decorrelation between an L^∞ and an L^1 observable) for one-dimensional expanding maps, relative to an infinite measure. Specifically, I will consider classes of full-branched maps of the interval or the real line. After a gentle introduction, I will give an overview of recent and less recent theorems, showing that, while global-local mixing is expected to be a general result, the techniques to prove it may differ quite a bit.

Iacopo Longo (Imperial College, London, UK)

Nonautonomous Differential Equations in the Presence of Bounded Noise

Nonautonomous systems subject to noise arise naturally in many applied contexts. Particularly relevant are those featuring time-dependent parameters and uncertainties, which may drive the emergence of tipping points. In this talk, we focus on the case of **bounded noise**, a more realistic modelling assumption given that physical quantities typically remain within finite bounds. Unlike unbounded noise, bounded perturbations allow for the identification of qualitative dynamical changes through the interaction of localised structures.

The dynamics of such systems can be captured topologically via **deterministic set-valued dynamical systems**, which evolve initial conditions under all admissible noise realisations, abstracting from probabilistic details. However, as these systems operate on the space of all compact subsets—a space lacking Banach structure—they pose substantial analytical and numerical challenges. In particular, bifurcation analysis of attractors remains a significant obstacle.

To address this, we introduce a **nonautonomous generalisation of the boundary map**, enabling the study of nonautonomous invariant sets by tracking the evolution of their boundaries. This provides a tractable framework for detecting structural transitions in the presence of bounded noise.

Contributed Talks

Nicola Bertozzi (Università di Pisa, Italy)

Exponential Decay of Correlations for a family of suspension flows

It is a well-known fact in dynamical systems that the geodesic flow on the modular surface exhibits exponential decay of correlations (Ratner 1986), the proof involving algebraic and representation theory-related tools. In 1998, Chernov explored the possibility of showing the same result through a more classical and general dynamical argument, involving Markov partitions. Later, Dolgopyat proposed a method for proving exponential decay of correlations for geodesic flows on negatively curved compact surfaces. The talk shows how to adapt this method to the case of the flow on the modular surface, which is not compact. In particular, this flow is conjugated to a specific suspension flow (Bonanno, Del Vigna, Isola 2024): we study a generalization of this system.

Tullio Ceccherini-Silberstein (Università del Sannio, Italy)

A Garden of Eden theorem for Smale spaces

I'll discuss endomorphisms of Smale spaces and present a Garden of Eden type theorem and related surjunctivity results for such dynamical systems. This includes applications in Symbolic Dynamics and in the Theory of Anosov diffeomorphisms. Joint work with M. Coornaert (Strasbourg).

Haritha Cheriyath (Centre for Mathematical Modeling, University of Chile, Chile)

Word Deletion in Symbolic Dynamics

We consider perturbations of subshifts from a given ambient shift space. Unlike in smooth dynamics, such perturbations are unusual in the discrete setting of symbolic dynamics. However, this seemingly simple problem of deleting a word from a subshift yields a diverse range of unexpected connections, for instance, in coding theory, non-transitive games or ergodic theory.

In this talk, we explore several natural questions within this framework: How does topological entropy change under such perturbations? When can two perturbations be conjugate? We provide answers to these questions in the context of coded systems.

Pedro Campos Christo Rodrigues Pereira (IMECC - UNICAMP, Brazil)

Invariant tori in polynomial systems - an extension of Hilbert's 16th problem

Hilbert's 16th problem, on the maximum number of limit cycles of planar polynomial vector fields of a given degree, has been one of the most important driving forces for new developments in the qualitative theory of vector fields. Increasing the dimension, one cannot expect the existence of a finite upper bound for the number of limit cycles of, for instance, 3D polynomial vector fields of a given degree. As an extension of such a problem in the 3D space, we investigate the number of isolated invariant tori in 3D polynomial vector fields. Based on a recently developed averaging method for detecting invariant tori, we provide a mechanism for constructing 3D polynomial vector fields with H normally hyperbolic invariant tori from

a given planar one with the same number of hyperbolic limit cycles. New results and open questions concerning the dynamics on those tori are also explored.

Pedro Augusto da Silva Morelli (CMC-USP - Università di Roma "Tor Vergata", Italy)

On Besov Spaces and Dynamics

In this talk I will explain how to employ the functional approach to study spectral and statistical properties on symbolic dynamics by understanding the spectrum of the transfer operator acting on a family of Besov spaces of distributions. This is a joint work with Mateus Marra and Daniel Smania.

Alessia Francesca Guido (Università di Roma "Tor Vergata", Italy)

Effective stability estimates close to resonances: an application to rotational dynamics

For near-integrable Hamiltonian systems, Nekhoroshev's theorem provides action confinement for exponentially long times under certain conditions that allow some freedom in parameter choice. We use perturbation theory to reduce the norm of the perturbing function, and we develop an optimization algorithm maximizing stability time in the non-resonant case. As the system is approaching resonances, we study stability estimates defining sequences of Diophantine frequencies for both 1D and 2D non-autonomous Hamiltonian systems. Applied to spin-orbit and spin-spin-orbit models, our methods yield stability results for orbits in the vicinity of resonances.

Ale Jan Homburg (Leiden Unversity, Netherlands)

Intermittent two-point dynamics at the transition to chaos for random maps

The general problem I'm considering is to describe the transition in random dynamical systems when the top Lyapunov exponent crosses zero with a parameter. I will describe results for toy models of iterated function systems on an interval, and for random circle endomorphisms. The transition here is characterized by intermittent dynamics and infinite stationary measures for the two-point system.

Daniele Lotito (IBM Research, Ireland)

Neural learning rules from associative networks theory

Associative networks theory is increasingly providing tools to interpret update rules of artificial neural networks. At the same time, deriving neural learning rules from a solid theory remains a fundamental challenge. We make some steps in this direction by considering general energy-based associative networks of continuous neurons and synapses that evolve in multiple time scales. We use the separation of these timescales to recover a limit in which the activation of the neurons, the energy of the system and the neural dynamics can all be recovered from a generating function. By allowing the generating function to depend on memories, we recover the conventional Hebbian modeling choice for the interaction strength between neurons. Finally, we propose and discuss a dynamics of memories that enables us to include learning in this framework. (DOI)

Gaia Marangon (Università di Padova, Italy)

Klein-Gordon-Wave and Schrödinger-Wave: a Normal Form Approach to Dark Matter Dynamics

Motivated by strong requests from astrophysical observations, we compare three dynamical models, all describing the evolution of a massive field and a massless one, coupled through a Yukawa interaction. We adopt a Hamiltonian perturbative approach: we compute the Hamiltonian normal form of a Klein-Gordon-Wave system to second order and find that its first-order approximation results in a Schrödinger-Wave system. In the limit of vanishing perturbative parameter a Schrödinger-Poisson system is derived. A second-order approximation of the Klein-Gordon-Wave system provides successive corrections, while higher-order approximations can be obtained by iterating our constructive procedure. Joint work with Antonio Ponno and Lorenzo Zanelli (University of Padova).

Eugen Mihailescu (Institute of Mathematics of the Romanian Academy, Romania)

Amalgamated pressure for multipotentials and random dynamics

We will present a new notion of amalgamated pressure for multipotentials along sets of trajectories generated by a semigroup of maps, namely $P^A(\Phi, \mathcal{Y}, G_1)$. If the set of generators G_1 is a finite set of conformal maps, we obtain a formula for the Hausdorff dimension $HD(Y)$ for sets Y on which the G_1-Lyapunov exponents are positive. Next we study the case when G_1 is a finite set of C^2 maps on a manifold M such that there exist partial stable and unstable cone fields. We apply the amalgamated pressure of the unstable multipotential Φ^u, to estimate the Hausdorff dimension of the slices of Y with submanifolds transversal to the stable cones. The amalgamated pressure is applied also to random dynamics. We show that our amalgamated pressure is smaller than or equal to the random pressure for the associated random dynamical system.

Barbara Prinari (University at Buffalo, United States)

Novel features in a dynamical system approach to triadic reciprocal determinism of social cognitive theory

Triadic reciprocal determinism (TRD) is a theoretical framework in social cognitive theory (SCT) which accounts for the continuous, bidirectional interplay among an individual's behavior, personal factors, and the environment [1]. In [2] a dynamical systems approach to model TRD was introduced. In this talk we will discuss some novel features of the dynamical system, the most prominent being the existence and the properties of lower-dimensional equilibria (LDE), in which one of the two TRD variables grows unbounded (either to large positive or large negative values) and the other two variables reach a bounded equilibrium. We will also discuss the basins of attraction of LDEs, and present a systematic characterization of the asymptotic states of the dynamical system in the space of initial conditions.

[1] A. Bandura, The self system in reciprocal determinism, American Psychologist 33(3), 334–358 (1978)
[2] M. Lo Schiavo, B. Prinari, I. Saito, K. Shoji, and C.C. Benight, A deterministic dynamical system approach to triadic reciprocal determinism of social cognitive theory, Math. Comp.

Simul. 159, 18–38 (2019)

General Information

Venue

The workshop will be held in the *Conference Room* of the Rectorate at the University of Salento, located at Piazza Tancredi, 7, Lecce.

Social Program

Monday, at 18,00.
A guided tour of Lecce with a professional guide. The cost will depend on the number of participants but is expected to be around € 5 per person, to be paid in cash to the guide.

Tuesday, from 18,00 to 20,30. A discussion on equal opportunities in STEM, focused on the movie **Hidden Figures** (2016), will be presented in collaboration with the *University CineClub*. Institutional greetings by the President of the Equal Opportunity Committee of the Province of Lecce and Soroptimist - Maglie. Introduction by Alessia De Blasi, PhD student in film studies.

Tuesday, from 21,00. Social dinner at the restaurant "Mediterraneo" (formerly "La Locanda del Centro") at Via Federico D'Aragona, 8, Lecce. The cost of the dinner is €35 per person.

Nearby Pubs and Restaurants

The pub "**Birrattieri**" (*Via Benedetto Cairoli 7a*, 3 mins away from the Rectorate) will propose a special formula for € 15 or a 10% discount on the *à la carte menu* (note that participants must show their badge to access the discount).

The area is full of pubs and restaurants, we list just a few. Please keep in mind that many places are closed either on Monday or on Tuesday, changing with the season, and it is always better to check in advance.

Pietrabianca Vino e Cucina (3 mins walk) at Via Benedetto Cairoli, 25, 73100 Lecce LE, open 12,00 – 15,00 and 19,00 – 23,00

Caffè Letterario di Lecce (4 mins walk) at Via Guglielmo Paladini, 46, open 19,00 – 02,00

La Sapore (4 mins walk) at Via Marco Basseo, 36, open 18,00 – 00,00

Animaterrae (4 mins walk) at Via Marco Basseo, 31, open 19,30 – 23,00

Volo Restaurant (5 mins walk) at Via Guglielmo Paladini, 9, 73100 Lecce LE, open 12,00 – 14,30 and 19,00 – 23,30

00 Doppiozero (6 mins walk) at Via Guglielmo Paladini, 2, open 08,30 – 00,30

La Cucina di Mamma Elvira (11 mins walk) at Via Ludovico Maremonti, 33, open 12,00 – 15,00 and 19,00 – 23,30 (closed on Tuesday)

Tranquillo (9 mins walk) at Piazza Sant'Oronzo, 12, open 09,00 – 01,00

Boccon Divino Lecce (5 mins walk) at Via Giuseppe Libertini, 17, open 11,30 – 15,00 and 18,30 – 23,30

AlVentuno (12 mins walk - near Santo Oronzo square) at Via Giacomo Matteotti, 21a, open 07,30 – 01,30

Taula (7 mins walk) at Via Giuseppe Palmieri, 1/a, open 12,00 – 15,00 and 19,00 – 23,00 (closed on Wednesday)

Tipico Restaurant (8 mins walk) at Via dei Verardi, 7, open 12,00 – 15,00 and 19,00 – 22,00

Osteria 203 (9 mins walk) at Viale Francesco Lo Re, 39, open 12,30 – 15,00 and 19,30 – 23,00 (closed on Tuesday)

La Vecchia Osteria da Totu (11 mins walk) at Viale Francesco Lo Re, 9, open 12,30 – 14,30 and 19,30 – 23,30 (closed on Monday)

Trattoria San Lazzaro (17 mins walk) at Piazzetta Girolamo Congedo, 7, open 19,30 – 23,00

List of Participants

Vivina **Barutello** (page 6)	Università di Torino, Italy
Alexander **Baumgartner**	Centro Ennio De Giorgi, SNS Pisa, Italy
Nicola **Bertozzi** (page 8)	Università di Pisa, Italy
Claudio **Bonanno** (page 5)	Università di Pisa, Italy
Giovanni **Calvaruso**	Università del Salento, Italy
Tullio **Ceccherini-Silberstein** (page 8)	Università del Sannio, Italy
Alessandra **Celletti** (page 5	Università di Roma "Tor Vergata"), Italy
Haritha **Cheriyath** (page 8)	Centre for Mathematical Modeling, University of Chile, Chile
Antonio **Chiloiro**	Università del Salento
Pedro Campos **Christo Rodrigues Pereira** (page 8)	IMECC - UNICAMP, Brazil
Giampaolo **Cristadoro**	Università di Milano - Bicocca, Italy
Pedro Augusto **da Silva Morelli** (page 9)	CMC-USP/Uniroma2 Tor Vergata, Italy
Sara **Di Ruzza** (page 6)	Università di Palermo, Italy
Anargyros **Dogkas**	Università di Pisa, Italy
Cinzia **Elia**	Università di Bari, Italy
Maximilian **Engel** (page 6)	University of Amsterdam, Netherlands - Freie Universität Berlin, Germany,
Mar **Giralt** (page 6)	IMCCE Observatoire de Paris, France
Alessia Francesca **Guido** (page 9)	Università Tor Vergata, Italy
Ale Jan **Homburg** (page 9)	Leiden Unversity, Netherlands
Marco **Lenci** (page 7)	Università di Bologna, Italy,
Iacopo **Longo** (page 7)	Imperial College, London, UK
Daniele **Lotito** (page 9)	IBM Research, Ireland
Gaia **Marangon** (page 10)	Università di Padova, Italy
Eugen **Mihailescu** (page 10)	Institute of Mathematics of the Romanian Academy, Romania
Simone **Paleari**	Università degli Studi di Milano, Italy
Tiziano **Penati**	Università degli Studi di Milano, Italy
Gaia **Pozzoli**	Università di Milano-Bicocca, Italy
Barbara **Prinari** (page 10)	University at Buffalo, United States
Giuseppe **Pucacco**	Università di Rome Tor Vergata, Italy
Sharvari **Tikekar**	Università di Pisa, Italy
Cesare **Tronci**	University of Surrey, UK
Pierandrea **Vergallo**	Università di Messina, Italy
Raffaele **Vitolo**	Università del Salento, Italy
Chiara **Zimbardi**	Università del Salento, Italy