MMNLP – Workshop 2026

Milano, Dipartimento di Fisica, 5–6 March 2026

Program and abstracts

Last updated: March 2, 2026

Wednesday 4 March: Arrival day.

Thursday 5	morning session	
		CHAIRPERSON: VITOLO
09.30 – 10.00	Lorenzoni	
10.00 – 10.30	Drozdov	
10.30 – 11.00	Gaeta	
11.00 – 11.30	Coffee Break	
11.30 – 12.00	Lewanski	
12.00 – 12.30	Perletti	
12.30 – 13.00	Zullo	

Thursday 5	afternoon session	
		CHAIRPERSON: PIZZOCCHERO
14.30 – 15.00	Ortenzi	
15.00 – 15.30	Latini	
15.30 – 16.00	Tassi	
16.00 – 16.30	*Coffee Break*	
16.30 – 17.00	Everyone	*Common discussion on the future of MMNLP*

19.30	Everyone	*Social dinner* alla romana!

Friday 6	morning session	
		CHAIRPERSON: DE SOLE
09.30 – 10.00	Pizzocchero	
10.00 – 10.30	Santini	*Online*
10.30 – 11.00	Guzzetti	
11.00 – 11.30	Coffee Break	
11.30 – 12.00	Saccomandi	
12.00 – 12.30	van Gemst	

Friday 6	afternoon session	
		CHAIRPERSON: ORTENZI
14.30 – 15.00	Pedroni	
15.00 – 15.30	Martina	
15.30 – 16.00	Abenda	
16.00 – 16.30	Tutti	*Conclusions*

Tropical KP Theory on Banana Curves

S. Abenda
Università di Bologna

Abstract: I shall report on the preprint `arXiv:2512.13366`, written in collaboration with T.O. Celik, C. Fevola and Y. Mandelshtam. The Kadomtsev–Petviashvili (KP) equation is the cornerstone of integrable systems, whose solutions reflect deep connections in algebraic geometry. Banana curves are reducible rational curves obtained as a degeneration of hyperelliptic curves. In this work, we relate the family of KP multi–solitons arising from banana curves together with non-special divisors of fixed degree to the combinatorics of the tropical theta divisor of the curve. Using the combinatorics on the tropical curve and its Jacobian, we construct an explicit parametrization of the Hirota variety of banana graphs, which parametrizes all KP tau functions arising from such a graph. Our framework specializes naturally to real and positive settings.

How discretization deforms the symmetry algebra of the Calogero–Moser system

P. Drozdov
Università di Udine

Abstract: In this talk, based on the work `arXiv:2601.10625`, we present the complete structure of the symmetry algebras associated with the N-body Calogero–Moser system and its maximally superintegrable discretization. We show how the discretization naturally leads to a nontrivial deformation of the continuous symmetry algebra, with the discretization parameter playing the rôle of a deformation parameter. This phenomenon illustrates how discrete superintegrable systems can be viewed as natural sources of deformed polynomial algebraic structures. As a byproduct of these results, we also revealed a connection between the above-mentioned symmetry algebras and the Bell polynomials, as a consequence of the trace properties. Joint work with G. Gubbiotti and D. Latini.

Geometry & Perturbations of Integrable Systems

G. Gaeta
Università di Milano

Abstract: We discuss how "split coordinates" suggested by the geometry of group action (in the sense of L.Michel's theory of symmetry breaking) can be used in the analysis of systems in normal form.

We also discuss what the general theory can tell when specialized to the analysis of integrable or superintegrable systems, or their perturbations.

Uniqueness of asymptotic solutions for linear systems of ODEs with isolated singularities of general type

D. Guzzetti
SISSA

Abstract: For a wide class of ODEs, we provide sufficient conditions of existence and uniqueness of a fundamental system of solutions, with specified asymptotic behaviour, in wide sectors centered at an isolated singularity of the coefficients. The crucial fact is that the singularity can be an isolated singularity of general type (so including branching and essential singularity), not just of pole type. In other words, we are dealing with systems with not necessarily meromorphic coefficients.

References: G. Cotti, D. Guzzetti, D. Masoero: Asymptotic solutions for linear ODEs with not-necessarily meromorphic coefficients: A Levinson type theorem on complex domains, and applications. Journal of Differential Equations 428 (2025), 1-58.

On recent developments within the framework of coalgebra symmetry: the $\mathfrak{g}_n$ Lie algebra

D. Latini
Università di Milano

Abstract: Superintegrable systems represent a special subclass of finite-dimensional integrable Hamiltonian systems, characterized by an exceptionally high number of conserved quantities. A Hamiltonian system with N degrees of freedom is said to be integrable if it possesses N functionally independent integrals of motion in involution (including the Hamiltonian itself). It is called superintegrable when additional functionally independent constants of motion exist. The maximally superintegrable (MS) case, corresponding to $N-1$ extra integrals, is particularly interesting since it displays remarkable properties in both classical and quantum mechanics. In two and three dimensions, MS systems with quadratic integrals have been essentially classified [1]. However, in higher dimensions the direct analytic approach rapidly becomes intractable, and this has motivated the development of alternative methods [2]. Among these, the coalgebra symmetry approach [3, 4, 5] has proven to be a very powerful tool, allowing for the systematic construction of higher-dimensional superintegrable models together with their constants of motion, by making use of the coproduct and Casimir invariants of Lie (or Lie-Poisson) (co)algebras. Within this framework, numerous classical and quantum models have been reinterpreted as exhibiting coalgebra symmetry, while many genuinely new ones have also been discovered. In this talk, I will discuss a recent development in the study of superintegrable systems within the framework of coalgebra symmetry. In collaboration with G. Gubbiotti and B. van Geemen [6], we introduced a novel (family of) $n(n+1)/2$-dimensional Lie algebra(s), which we indicated as $\mathfrak{g}_n$, endowed with a polynomial Casimir invariant of arbitrary degree $n \geq 2$. This construction naturally unifies and extends several well-known cases: the $\mathfrak{sl}(2,\mathbb{R})$ and two-photon $\mathfrak{h}_6$ [7] Lie algebras emerge as the specific instances $n=2$ and $n=3$ of the general structure $\mathfrak{g}_n$. Consequently, the associated left and right coalgebraic integrals generalize the previously known ones, providing a unified framework for a general hierarchy of Hamiltonian systems.

References:

[1] W. Jr. Miller, S. Post, P. Winternitz, Classical and Quantum Superintegrability with Applications, J. Phys. A: Math. Theor. **46** (2013) 423001.

[2] J. Kress, K. Schöbel, A. Vollmer, An Algebraic Geometric Foundation for a Classification of Second-Order Superintegrable Systems in Arbitrary Dimension, J. Geom. Anal. **33** (2023) 360.

[3] A. Ballesteros, M. Corsetti, O. Ragnisco, N-dimensional classical integrable systems from Hopf algebras, Czechoslov. J. Phys. **46** (1996) 1153.

[4] A. Ballesteros and O. Ragnisco, A systematic construction of completely integrable Hamiltonians from coalgebras, J. Phys. A: Math. Gen. **31** (1998) 3791.

[5] A. Ballesteros, A. Blasco, F.J. Herranz, F. Musso, O. Ragnisco, (Super)integrability from coalgebra symmetry: Formalism and applications, J. Phys.: Conf. Ser. **175** (2009) 012004.

[6] G. Gubbiotti, D. Latini, B. van Geemen. A novel chain of Lie algebras and its coalgebra symmetry. Preprint arXiv:2512.01791 (2025).

[7] A. Ballesteros, A. Blasco and F. J. Herranz, N-dimensional integrability from two-photon coalgebra symmetry, J. Phys. A: Math. Theor. **42** (2009) 265205.

Leaky Hurwitz numbers and integrability

D. Lewański
Università di Trieste

Abstract: We introduce $(r+1)$-completed cycles k-leaky Hurwitz numbers and establish their chamber polynomiality structure and their wall crossing formulae. For $k=1$ the theorems recover previous results of Shadrin-Spitz-Zvonkine. The specialization for $r=1$ recovers Hurwitz numbers that are close to the ones studied by Cavalieri-Markwig-Ranganathan and Cavalieri-Markwig-Schmitt. The ramifications differ by a lower order torus correction, natural from the Fock space perspective, not affecting the genus zero enumeration, nor the enumeration for leaky parameter values $|k|=1$ in all genera.

The generalised hodograph method for non-diagonalisable integrable s= ystems of hydrodynamic type

P. Lorenzoni
Università di Milano-Bicocca

Abstract: The generalised hodograph method is the main tool to solve integrable systems of hydrodynamic type admitting Riemann invariants. In this talk, based on a joint work with Sara Perletti and Karoline van Gemst, I will explain how to extend the method to regular non-diagonalisable integrable systems of hydrodynamic type exploiting the relation between such systems and F-manifolds with compatible connections.

Multiple Nonlinear Waves by (Quantum) Neural Networks: Checking the AI supremacy

L. Martina
Università del Salento

Abstract: Machine learning techniques appear to be the antithesis of integrable systems: ignorance of the descriptive model is compensated by a powerful ability to establish correlations between data. However, the existence of a well-defined model (a completely integrable system) in the presence of very complex structured data can serve as a testbed for evaluating the validity of certain classes of neural networks. They partially possess information about the model and, perhaps, constitute a valid alternative to numerical integration methods. This perspective can be further strengthened by the application of quantum variational algorithms.

Gradient catastrophes in multidimensional models

G. Ortenzi
Università di Torino

Abstract: The gradient catastrophe is an ubiquitous phenomenon in classical field models: it typically identifies a transition between a purely nonlinear regime and a regime dominated by dissipative or dispersive effects. This transition often exhibits a behavior qualitatively independent on the initial data and, therefore, with a certain degree of universality, depending only on the particular phenomenon observed.

Models in 1+1D has been widely studied while 2+1D and 3+1D models have received less attention partly due to the lack of a general mathematical theory. The presentation focuses on some multidimensional examples from fluid dynamics: the incoherent fluid (in flat and curved spaces) and the shallow water model.

This seminar is based on collaborations with E. Bellino, R. Camassa, G. Falqui, B. G. Konopelchenko, M. Pedroni.

Poisson quasi-Nijenhuis manifolds and Toda lattices

M. Pedroni
Università di Bergamo

Abstract: The relevance of Poisson-Nijenhuis manifolds in the theory of completely integrable systems is well established since the birth of the bi-Hamiltonian approach to integrability. Poisson quasi-Nijenhuis (PqN) manifolds were introduced in 2007, and their relations to finite-dimensional integrable systems have been studied only recently.

In this talk, we present a deformation theorem and an involutivity condition for PqN manifolds. We also show that the closed (or periodic) n-particle Toda lattice, along with its relations with the open (or non periodic) Toda system, can be framed in such a geometrical structure.

These results have been obtained in collaboration with E. Chuño Vizarreta, M. do Nascimento Luiz, G. Falqui, I. Mencattini, and G. Ortenzi.

From semi-Hamiltonian to Darboux-Tsarev systems

S. Perletti
SISSA, Trieste

Abstract: We explain how the extension of the generalised hodograph method, originally formulated for diagonalisable integrable systems of hydrodynamic type, to the regular non-diagonalisable setting leads to the uncovering of the Darboux-Tsarev class. We discuss semi-Hamiltonian properties of such systems and, time permitting, present explicit examples. Based on a joint work with P. Lorenzoni and K. van Gemst.

FLRW cosmologies and integrable systems

L. Pizzocchero
Università di Milano

Abstract: I consider (in arbitrary spacetime dimension) the cosmological models with a Friedmann-Lemaître-Robertson-Walker (FLRW) geometry, in which the contents of the universe consist of non-interacting perfect fluids and of a canonical or phantom scalar field, minimally coupled to gravity and possibly self-interacting. After integrating the evolution equations for the fluids, any model of this kind can be described as a Lagrangian system with two degrees of freedom, where the Lagrange equations determine the evolution of the scale factor and of the scalar field as functions of the cosmic time; some specific cases are known to be integrable systems (see [1, 2, 3, 4, 5, 6] and references therein). After surveying the general cosmological models of this kind, following [6] (and [1]) I will illustrate an integrable case involving a pressureless fluid ("dust") and a phantom scalar field with a suitable, trigonometric self-interaction potential. This integrable model turns out to be equivalent to a pair of decoupled harmonic oscillators or repulsors; in the case of two harmonic oscillators, this implies an intriguing connection between this cosmology and the Lissajous curves. I will also give hints on a more systematic investigation of the FLRW cosmologies of the general kind mentioned before, in order to individuate all cases yielding a separable Hamiltonian system. The present talk is based on joint work with Michela Cimaglia, Davide Fermi, Massimo Gengo and Danilo Latini.

References:

[1] S. Capozziello, E. Piedipalumbo, C. Rubano, P. Scudellaro, *Noether symmetry approach in phantom quintessence cosmology*, Phys. Rev. D **80** (2009), 104030 (10 pp).

[2] P. Fré, A. Sagnotti, A. S. Sorin, *Integrable scalar cosmologies, I. Foundations and links with string theory*, Nuclear Physics B **877**(3) (2013), 1028–1106.

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[6] M. Cimaglia, M. Gengo, L. Pizzocchero, *Cosmologies with perfect fluids and scalar fields in Einstein's gravity: phantom scalars and nonsingular universes*, Universe **10**(12) (2024), 467; https://doi.org/10.3390/universe10120467 (134 pp). (Special Issue Universe: Feature Papers 2024-Cosmology, edited by Jaime Haro Cases and Supriya Pan.)

A road map for nonlinear elastodynamics

G. Saccomandi
Università di Perugia

Abstract: Nonlinear elastodynamics is a classical yet still rapidly evolving field of continuum mechanics, where fundamental questions about wave propagation, dispersion, and dissipation remain open. In this lecture, starting from the full three-dimensional equations for hyperelastic materials, we outline a systematic path leading to reduced nonlinear wave models. Plane longitudinal and transverse waves, antiplane shear motions, and coupled in-plane/antiplane configurations are analyzed through weakly nonlinear and multiple-scale expansions. These reductions naturally yield well-known evolution equations such as KdV-, modified KdV-, NLS-, and Zabolotskaya-type systems, highlighting the deep connection between constitutive assumptions and emergent wave dynamics.

On the Fermi-Pasta-Ulam-Tsingou recurrence of anomalous (rogue) waves in partial differential equations of nonlinear Schrödinger type in $1+1$ and $2+1$ dimensions

P.M. Santini
Università di Roma "La Sapienza"

Abstract: Anomalous (rogue) waves (AWs) are extreme waves of anomalously large amplitude with respect to the surrounding waves, arising apparently from nowhere and disappearing without leaving any trace. The simplest model describing the generation of AWs, due to modulation instability (MI) in nonlinear self-focusing media, is the integrable self-focusing nonlinear Schrödinger (NLS) equation in $1+1$ dimensions. In the space periodic setting, the appearance of NLS AWs is a recurring phenomenon and, in the simplest case of a single unstable mode, this recurrence is a Fermi-Pasta-Ulam-Tsingou (FPUT) type recurrence of linear and nonlinear stages of MI. In this paper we review some of the basic properties of the AW recurrence of FPUT-type in integrable and non integrable partial differential equations of NLS type in $1+1$ and $2+1$ dimensions. Joint work with F. Coppini and P.G. Grinevich.

References:

[1] F. Coppini, P. G. Grinevich, and P. M. Santini, On the Fermi-Pasta-Ulam-Tsingou recurrence of anomalous (rogue) waves in partial differential equations of nonlinear Schrödinger type, Mechanics Research Communications 153 (2026) 104639.

Hamiltonian fluid models for plasmas in the presence of a strong guide field

E. Tassi
CNRS, Observatoire de la Côte d'Azur, Nice, France

Abstract: In many space and laboratory plasmas, as for instance in tokamak devices for thermonuclear fusion, plasma dynamics occurs in the presence of a strongly anisotropic magnetic field. In this situation, the dynamics of the plasma and of the electromagnetic field, can be locally described by means of fluid models in the so-called strong guide field assumption. In this talk I will present an infinite family of such models, derived from a parent model of the so-called drift-kinetic type. By means of an orthogonal transformation, the model equations can be cast in a form which, in the two-dimensional (2D) limit, reduces to that of a system of advection equations for Lagrangian invariants. This helps to reveal the

presence of a noncanonical Hamiltonian structure in the family of models. In particular, in the 2D limit, the corresponding Poisson bracket corresponds to the direct sum of Lie-Poisson brackets analogous to those of the 2D Euler equation for an incompressible fluid. Casimir invariants for the models can then be easily obtained [1, 2]. The above mentioned formulation of the models in terms of Lagrangian invariants also helps to prove global existence and uniqueness of weak solutions in the 2D limit. This last part is work in progress carried out in collaboration with Nicolas Besse.

References:

[1] E. Tassi, *Poisson brackets and truncations in nonlinear reduced fluid models for plasmas*, Physica D **437** (2022), 133338.

[2] E. Tassi, *Generalized Hamiltonian drift-fluid and gyrofluid reductions*, J. Phys. A: Math. Theor. **56** (2023), 335701.

Generalised Dubrovin-Zhang Frobenius manifolds from the relativistic Toda chain

K. van Gemst
Università di Milano-Bicocca

Abstract: In [1, 2], Landau-Ginzburg models were constructed for Dubrovin-Zhang manifolds – Frobenius manifolds obtained as orbit spaces of certain extensions of affine Weyl groups [3]. This was done uniformly across all Dynkin types by modifying the characteristic equation of the Lax operator for the relativistic Toda chain. In this talk, I will describe a generalisation of this method that yields Landau-Ginzburg models for a broader class of Frobenius manifolds. This approach reproduces the Landau-Ginzburg models of [4, 5, 6, 7] as special cases, as well as further generalisations that were out of reach using the methods of those works. Joint work with Alessandro Proserpio.

References:

[1] A. Brini, E_8 spectral curves, Proc. Lond. Math. Soc. (3) 121 (2020), no. 4, 954–1032.

[2] A. Brini and K. van Gemst, Mirror symmetry for extended affine Weyl groups, J. Éc. Polytech. – Math. 9 (2022), 907–957.

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Unified structures and Somos-4 like relations for the τ functions of the Painlevé equation II

F. Zullo
Università di Brescia

Abstract: We present certain general structures related to the solutions of Painlevé equation II and to the solutions of the differential equation satisfied by the corresponding Hamiltonian equations, together with the tau functions. By taking advantage of the Bäcklund transformations we find different explicit rational expressions linking the solutions of Painlevé equation II, Painlevé equation XXXIV and the Hamiltonians with the tau functions. Wronskians among different tau functions and the derivatives of the tau functions themselves will be expressed in terms of rational functions of tau functions too. A non-autonomous Somos-4 type relation solved by these functions is given. For the Somos-4 type relation we consider degenerate cases through the use of suitable parameters inserted into the equations: the autonomous case solvable in terms of Weierstrass elliptic functions, the case corresponding to the Yablonskii-Vorob'ev polynomials, the Airy-type solutions and the more general transcendental case. Joint work with M.G. Naso and E. Vuk.