Workshop: SOME RECENT ADVANCES IN THEORY & NUMERICS OF DIFFERENTIAL EQUATIONS

Timetable & Book of Abstracts

Gran Sasso Science Institute
September 22–23, 2026

Workshop Timetable

Time	Speaker	Affiliation
	Tuesday, September 22	
09:00 – 09:45	Takayasu Matsuo	The University of Tokyo
09:45 – 10:30	Nicola Guglielmi	Gran Sasso Science Institute
10:30 – 11:00	*Coffee break*	
11:00 – 11:45	Vladimir Georgiev	Università di Pisa
11:45 – 12:30	Vladimir Protasov	Università dell'Aquila
12:30 – 14:00	*Lunch break*	
14:00 – 14:45	Hideo Kubo	Hokkaido University
14:45 – 15:30	Paolo Antonelli	Gran Sasso Science Institute
15:30 – 16:00	*Coffee break*	
16:00 – 16:45	Hiroyuki Takamura	Tohoku University
19:00 – 23:00	*Social dinner*	
	Wednesday, September 23	
09:00 – 09:45	Yoshihiro Ueda	Kobe University
09:45 – 10:30	Norikazu Saito	The University of Tokyo
10:30 – 11:00	*Coffee break*	
11:00 – 11:45	Ramón Plaza	UNAM
11:45 – 12:30	Giorgio Fusco	Università dell'Aquila
12:30 – 14:00	*Lunch break*	
14:00 – 14:45	Daisuke Furihata	The University of Osaka
14:45 – 15:30	Raffaele D'Ambrosio	Università dell'Aquila
15:30 – 16:00	*Coffee break*	
16:00 – 16:45	Tetsuya Ishiwata	Shibaura Institute of Technology

Abstracts

Paolo Antonelli (Gran Sasso Science Institute)

Title: Boundary value problems for quantum fluid models

Abstract: A quantum fluid is a system of interacting particles that exhibits the effects of quantum statistics also at a macroscopic scale. Such models describe various physical phenomena, including superfluidity, Bose-Einstein condensation, the interior of neutron stars (plasmas), or electron transport in semiconductors. The prototypical example, as given by the so-called quantum hydrodynamics (QHD) system, is characterized by a compressible, inviscid, barotropic flow, subject to a stress tensor that depends on the particle density and its derivatives. In this talk, I will first review some fundamental tools for analyzing finite-energy weak solutions of QHD systems. By focusing on the one-dimensional problem, I will then present an existence result for global-in-time solutions to the initial-boundary value problem on the half-line. Finally, I will also discuss possible extensions to the multi-dimensional framework and the analysis of vanishing-dispersion singular limits.

Raffaele D'Ambrosio (Università dell'Aquila)

Title: Geometric numerical integration of perturbed Hamiltonian and port-Hamiltonian problems

Abstract: Geometric numerical integration aims to reproduce, at the discrete level, the structural properties governing the long-time behaviour of dynamical systems. In this talk, we investigate the geometric numerical integration of two specific classes of problems.

We first address Hamiltonian systems subject to small perturbations, including weakly coupled oscillators. The effects of perturbations on invariant structures, periodic dynamics, and energy behaviour are investigated through symplectic Runge-Kutta methods. Moreover, ε-expansions are employed to analyze the dependence of the numerical solution on the perturbation parameter ε. In the perturbative regime, numerical evidence shows that the variation of the Hamiltonian scales linearly with ε, independently of the geometric integrator under consideration.

We then focus on port-Hamiltonian systems, with particular attention to the preservation of passivity and the associated energy-balance structure under time discretisation. Discrete-gradient θ-methods are studied as structure-preserving schemes capable of reproducing, at the discrete level, the interplay among energy storage, dissipation and exchange through the system ports. We investigate the conditions ensuring an exact discrete balance law, as well as the stability properties of the resulting numerical dynamics, using a controlled pendulum as a test problem.

The theoretical analysis is complemented by numerical experiments on selected test problems.

Daisuke Furihata (The University of Osaka)

Title: Structure-Preserving Particle Methods for PDEs via Automatic Differentiation of Voronoi Tessellations

Abstract: We propose a route to structure-preserving particle methods for variational PDEs by differentiating Voronoi discretizations with respect to their generators. In particle methods, moving cells and volumes make the discrete energy non-explicit in particle positions. Once Voronoi adjacency is known, however, vertices, cell volumes, and energy can be differentiated analytically or by automatic differentiation, yielding a particle ODE with direct energy dissipation. I will outline the derivation and show some computation.

Giorgio Fusco (Università dell'Aquila)

Title: On the diffuse analogous of Steiner networks.

Abstract: In two dimensions, minimizers u^ϵ of the Allen-Cahn energy Γ-converge to step functions u^0 characterized by the fact that the jump set J_{u^0} of u^0 is a Steiner network. That is a connected network that minimizes a suitable weighted length. We focus on the relationship between u^ϵ and u^0 for ϵ small but positive. We describe an approach which in various nontrivial cases shows that, for small $\epsilon > 0$, u^ϵ is a diffuse version of u^0. Joint work with Nikolas Alikakos.

Vladimir Georgiev (Università di Pisa and Faculty of Science and Engineering, Waseda University, Tokyo, Japan)

Title: On completeness of modified wave operators for defocusing NLS

Abstract: The talk is based on a joint work with Tohru Ozawa, University of Waseda. We discuss modified scattering for the two-dimensional defocusing nonlinear Schrödinger equation with a gauge – invariant, scattering-critical nonlinearity of order 2. Our goal is to prove that the modified wave operator, defined by

$$\lim_{t \to \pm\infty} U(-t) e^{-i\Phi_t(u)} u(t),$$

where $u(t)$ is a solution to the nonlinear Schrödinger equation, Φ_t is an appropriate phase function and $U(t)$ is the free propagator, is well-defined in L^2_{loc} as well as in every space L^q with $2 < q < \infty$.

This extends Yajima's results on the existence of wave operators in L^q spaces for linear Schrödinger Hamiltonians with short–range potentials.

Nicola Guglielmi (Gran Sasso Science Institute)

Title: Stabilization of neural ODEs.

Abstract: We propose a method to enhance the stability of neural ordinary differential equations (neural ODEs) by controlling error growth under perturbations of the initial value. Since such growth can be bounded in terms of the logarithmic norm of the Jacobian, we seek a minimal perturbation of the weight matrix, in Frobenius norm, that guarantees a prescribed stability bound.
This leads to an eigenvalue optimization problem, which we solve using a nested algorithm and incorporate into the training of the neural ODE. The resulting models are more robust to noisy data and adversarial perturbations.
Numerical experiments on MNIST and FashionMNIST illustrate the effectiveness of the approach.
This work is inspired by joint projects with A. De Marinis, A. Savostianov, S. Sicilia, and F. Tudisco.

Tetsuya Ishiwata (Shibaura Institute of Technology)

Title: Finite-Time Blow-up in Delay Differential Equations with Distributed and State-Dependent Delays

Abstract: Time delays often play an essential role in nonlinear phenomena. Besides generating oscillations and instability, they may also fundamentally change the nonlinear structure of differential equations and lead to finite-time blow-up of solutions. In this talk, we focus on blow-up phenomena in delay differential equations with distributed delays and state-dependent delays. We present recent analytical results describing how these different delay mechanisms interact with nonlinearities to induce blow-up. Numerical simulations illustrating the theoretical results will also be presented.

Hideo Kubo (Hokkaido University)

Title: Asymptotic behavior for wave equations with nonlinear damping and time-fractional boundary dissipation in 1D

Abstract: In this talk, we consider a wave equation with nonlinear damping, time-fractional boundary dissipation, and a nonlinear source term on a bounded one-dimensional interval. The coexistence of the nonlinear damping and the fractional boundary condition prevents the direct application of standard existence theories. To overcome this difficulty, we extend the spatial domain by exploiting symmetry and reformulate the fractional boundary condition as an augmented system. Under suitable growth assumptions on the nonlinear source term, we construct global weak solutions to the extended problem by means of the Galerkin method and then recover solutions to the original problem through the symmetry of the extension. Furthermore, by imposing stronger regularity assumptions on the initial data, we improve the regularity of the global weak solutions and derive their asymptotic behavior.

Takayasu Matsuo (The University of Tokyo)

Title: Measuring the Convergence Rates of Dynamical Systems for Continuous Optimization through Numerical Stability

Abstract: Continuous optimization has a long history of research, and it remains an active field today as a fundamental tool in the era of machine learning. Although discrete optimization methods have reached a considerable level of maturity, both their construction and mathematical analysis often require sophisticated and highly tailored designs. In recent years, another line of research, known as the dynamical systems approach, has attracted attention: one considers a continuous dynamical system underlying a discrete method as its zero-step-size limit and attempts to infer properties of the discrete method through the analysis of the continuous system.

A fundamental difficulty, however, is that the apparent convergence rate of a dynamical system can be changed arbitrarily by a reparametrization of time. Thus, continuous-time convergence rates do not directly correspond to those of discrete methods, for which information-theoretic lower bounds are known. To make meaningful comparisons, one therefore needs a notion of convergence rate that eliminates this arbitrariness associated with time rescaling.

In this talk, I will explain how the concept of numerical stability from numerical analysis provides a useful way to resolve this issue. Simply accelerating a dynamical system does not necessarily lead to a faster discrete optimization method: upon discretization, numerical stability imposes a penalty, and the resulting discrete convergence rate may therefore fail to improve. By making this observation precise, one can associate with each dynamical system an intrinsic quantity that may be called its intrinsic convergence rate. It is then natural to compare dynamical systems in terms of this quantity.

This viewpoint provides a principled way to fix the effective time scale of continuous dynamical systems and thereby enables meaningful comparisons of their convergence behavior.

Ramón Plaza (UNAM)

Title: Existence and stability of viscous-dispersive shock profiles

Abstract: In this talk I will present existence and stability results on viscous-dispersive shock profiles for two different models: isentropic compressible fluids of Korteweg type and viscous quantum-hydrodynamics system with Bohm potential. The focus of the talk will be the interplay between viscosity and dispersion effects, both in the analysis of existence and in the stability study. These are works in collaboration with Corrado Lattanzio (Univ. of L'Aquila), Raffaele Folino (IIMAS-UNAM) and Delyan Zhelyazov (Univ. of Surrey).

Vladimir Protasov (Università dell'Aquila)

Title: TBA

Abstract: TBA

Norikazu Saito (The University of Tokyo)

Title: Generalized Conditional Gradient Method for Fully Discretized Mean Field Games

Abstract: We study convergence rates of the generalized conditional gradient (GCG) method applied to fully discretized Mean Field Games (MFG) systems. While explicit convergence rates of the GCG method have been established at the continuous PDE level, a rigorous analysis that simultaneously accounts for time-space discretization and iteration errors has been missing. In this work, we discretize the MFG system using the finite difference method and analyze the resulting fully discrete GCG scheme. Our estimates show how the convergence rates depend on the mesh sizes and the iteration number, and they reveal a non-uniform behavior with respect to the iteration. Numerical experiments are presented to illustrate the theoretical results and to confirm the predicted convergence behavior.

Hiroyuki Takamura (Tohoku University)

Title: The effect of the initial moment on non-autonomous semilinear wave equations

Abstract: In this talk, I will present a new phenomenon on non-autonomous semilinear wave equations in two space dimensions. For the initial value problem of autonomous equations with small data of compact support, we have two kinds of the lifespan estimate of the solution when the nonlinear power is less than or equal to 2. Such a classification depends on the 0th moment of the initial speed. Our equation has weighted nonlinear terms by one of the characteristic variables which produces many classifications of the lifespan estimates according to the initial moments of higher degrees. This is based on a joint work with M. Kato (Univ. of Hyogo, Japan) and K.Wakasa (Muroran Inst. Tech., Japan).

Yoshihiro Ueda (Kobe University)

Title: Stability of the composite wave for the scalar viscous conservation law

Abstract: We consider the stability of the composite wave for the scalar viscous conservation law. Especially, we focus on the case that the flux function is non-convex. Then the corresponding Riemann problem admits a Riemann solution which consists of an Oleinik shock and a rarefaction wave. In this situation, we will show the asymptotic stability of the composite wave of the viscous Oleinik shock and the rarefaction wave. This is a joint research with Masaya Kageura from Kobe University.