



**Ministero  
dell'Università  
e della Ricerca**



**UNIVERSITÀ DI PISA**



**Dipartimento  
di Matematica**

DEPARTMENT OF MATHEMATICS, UNIVERSITY OF PISA

RECENT DEVELOPMENTS IN PDES: THEORY AND APPLICATIONS. A  
CONFERENCE IN HONOUR OF VLADIMIR GEORGIEV'S 70TH BIRTHDAY

16-17 February 2026

 [Event Webpage](#)



**BOOK OF ABSTRACTS AND SCHEDULE**

# Schedule

|               | Monday  |               | Tuesday   |
|---------------|---|---------------|---|
| 9:00 - 9:30   | Opening   |               |   |
| 9:30 - 10:20  | <b>Marcati</b>  | 9:00 - 9:50   | <b>Saut</b>   |
| 10:20 - 10:50 |                  | 9:50 - 10:40  | <b>Vega</b>   |
| 10:50 - 11:40 | <b>Berti</b>  | 10:40 - 11:10 |      |
| 11:40 - 12:30 | <b>Cuccagna</b>   | 11:10 - 12:00 | <b>D'Ancona</b>   |
| 12:30 - 12:40 | Group picture  | 12:00- 14:30  |  |
| 12:40 - 14:20 |                | 14:30 - 15:20 | <b>Tarulli</b>  |
| 14:20 - 14:30 | <b>Spagnolo - speech</b>  | 15:20 - 16:10 | <b>Scandone</b>   |
| 14:30 - 15:20 | <b>Colombini</b>  | 16:10 - 16:40 |    |
| 15:20 - 16:10 | <b>Lucente</b>  | 16:40 - 17:30 | <b>Tzvetkov</b>   |
| 16:10 - 16:40 |                | 17:30 - 18:00 | Closing   |
| 16:40 - 17:30 | <b>Michelangeli</b>   |               |   |
| 17:30 - 18:30 | open discussions  |               |   |
|               |   |               |   |
|               |   |               |   |
| 20-23:30      | Social Dinner  |               |   |

The social dinner will be at the restaurant La Clessidra.

# MASSIMILIANO BERTI

SISSA, Trieste

## BIFURCATION OF 3D GRAVITY-CAPILLARY STOKES WAVES VIA EQUIVARIANT CRITICAL POINT THEORY

**Abstract.** Traveling periodic water waves, or Stokes waves, were the first global-in-time solutions discovered for dispersive PDEs. Despite an extensive literature on both 2D and 3D solutions, the following result has remained unnoticed: bifurcation of multiple, truly 3-dimensional gravity-capillary Stokes waves, with arbitrary lattice spatial periods, emerges near any non-resonant 2D Stokes wave. This “clustering phenomenon”, observed in fluid dynamics, is an ultimate consequence of the system’s Hamiltonian structure, its underlying symmetry groups, and topological constraints. The proofs are established via a refined variational Lyapunov-Schmidt reduction combined with Morse-Conley theoretic arguments applied to a functional on a joint topological space invariant under Lie group actions.

This is a joint work with T. Barbieri and M. Mazzucchelli.

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# FERRUCCIO COLOMBINI

University of Pisa

## SOME OLD OR RECENT RESULTS FOR HYPERBOLIC EQUATIONS.

DEDICATED TO VLADIMIR GEORGIEV

**Abstract.** At first we consider the Cauchy problem for second order strictly hyperbolic operators when the coefficients of the principal part depend only on  $t$  and are not Lipschitz continuous, but only “Log-Lipschitz”; one proves that the Cauchy problem is well-posed in  $C^\infty$ , with a loss of derivatives; this result is contained in a paper in collaboration with E. De Giorgi and S. Spagnolo (1979). We then consider weakly hyperbolic operators: we start from a paper by F.C., E. Jannelli, and S. Spagnolo (1983). One considers coefficients depending only on the variable  $t$ , non-negative quadratic form, coefficients in  $C^{k,\alpha}$ : under the latter conditions the Cauchy problem is well-posed in the Gevrey space  $E^s$  for  $s < 1 + (k + \alpha)/2$ . Then, we consider the case of coefficients depending also on  $x$ : we present some results in collaboration with N. Lerner, related to operators with coefficients depending on all the variables, Log-Lip in  $t$  uniformly in  $x$ . In order to prove these theorems we use approximate energy, Littlewood-Paley decomposition and Bony paradifferential calculus.

Concerning hyperbolic equations with coefficients Log-Zygmund continuous depending on time and space, in F.C., D. Del Santo, F. Fanelli, G. Métivier I, we consider the case of an operator with such coefficients Log-Zygmund continuous: one obtains that the Cauchy problem is well-posed with loss of derivatives.

In F.C., D. Del Santo, F. Fanelli, and G. Métivier II, we consider the case of coefficients with Zygmund regularity (not only Log-Zygmund). In this case, the coefficients are Log-Lipschitz continuous, and so the Cauchy problem is well-posed, but with a loss of regularity. Actually, it is possible to prove, again by using the paradifferential calculus, that the Cauchy problem is well-posed without a loss of regularity for initial data  $(u_0, u_1) \in H^{1/2} \times H^{-1/2}$ .

In F. C., D. Del Santo, F. Fanelli, and G. Métivier IV, we consider linear first order systems with coefficients depending on  $x$  and  $t$ . Let the system be uniformly microlocally symmetrizable (see Métivier): also in this case one proves that there is a finite loss of derivatives depending on time.

Consider now the Cauchy problem for second order hyperbolic equations under a weak hyperbolicity assumption. In F. C., E. Jannelli, and S. Spagnolo (‘83) it is proved that if the coefficients depend only on the  $t$  variable and are in  $C^{k,\alpha}$ , then the Cauchy problem is well-posed in the Gevrey space  $E^s$  for  $s < 1 + (k + \alpha)/2$ .

Consider now weakly hyperbolic operators with coefficients depending also on space variables. In F. C. and T.

Nishitani (2020) we consider the Cauchy problem for the equation of second order  $(D_t^2)u - D_x(b(t)a(x)D_x u) = 0$  (note that the one-dimensional assumption is not important). Assume  $b(t) \geq 0$ ,  $b \in C^\infty$ ;  $a(x) \geq 0$ ,  $a \in E^s$  for some  $s > 1$ . Then we prove that the Cauchy problem is well-posed in any Gevrey class of order  $s' > s$ .

Consider now weakly hyperbolic operators of order 3, coefficients depending only on the  $t$  variable. In F.C., N. Orrù, and G. Tagliatela (2021) we consider the Cauchy problem:  $L(t, D_t, D_x)u + M(t, D_t, D_x)u = 0$   $(t, x) \in [-T, T] \times \mathbb{R}$ ,  $D_t^j u(0, x) = u_j(x)$ ,  $j = 0, \dots, m - 1$ ,  $x \in \mathbb{R}$ , where  $L$  is a homogeneous differential operator of order  $m$  with  $C^\infty$  coefficients, weakly hyperbolic. We study the strong hyperbolicity in Gevrey classes and we prove well-posedness for any  $M$  of order  $\leq m - 1$ . In F. C., T. Gramchev, N. Orrù, and G. Tagliatela (2023), we assume that the coefficients of  $L$  of order 3 belong to  $C^2$ , those of order 2 or of order 1 belong to  $C^1$ , whereas the coefficients of order 0 belong to  $L^\infty$ . Then we prove that the Cauchy problem is well-posed in  $C^\infty$ .

Finally, in F. C., N. Orrù, and G. Tagliatela (in progress) we study the strong hyperbolicity in Gevrey classes for similar operators, in particular the optimal index for Gevrey index.

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## SCIPIO CUCCAGNA

University of Trieste

### THE COMBINATION OF VIRIAL ESTIMATES AND KATO SMOOTHING IN ASYMPTOTIC STABILITY PROBLEMS

**Abstract.** Instead of using, as in work of Kowalczyk, Martel, and Munoz, a virial inequality, a Darboux transformation and a second virial inequality, we use a high energy virial inequality, which often is trivial, combined with a Kato smoothing inspired by work of Mizumachi. In the particular example of the generalized KdV this allows to bypass the issue of the strict positivity of certain quadratic forms, which is so central and delicate in the work of Martel and Merle.

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## PIERO D'ANCONA

University of Rome, La Sapienza

### MAGNETIC DYNAMICAL UNCERTAINTY PRINCIPLES.

**Abstract.** A function and its Fourier transform can not be simultaneously localized beyond a certain threshold. Uncertainty principles measure this phenomenon in a quantitative way. Time slices of solutions of the Schrödinger and more general dispersive equations present the same property, and the corresponding quantitative versions are called dynamical uncertainty principles. In this talk I will describe some work in progress, in collaboration with Diego Fiorletta (Roma), concerning such principles for Schrödinger equations perturbed by an electromagnetic potential.

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## SANDRA LUCENTE

University of Bari

### LINEAR PERTURBATION IN NLW

**Abstract.** We investigate nonlinear wave-type equations that can be recast as wave equations with derivatives perturbed by zero-order terms. This framework covers several well-studied cases, including the scale-invariant wave equation. In this setting, we refine existing blow-up results for radial initial data with suitable decay, and identify conditions on the zero-order terms that govern the interplay between the derivative perturbations, the initial data size, and the nonlinearity exponent.

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# PIERANGELO MARCATI

GSSI, L'Aquila

## QUANTUM HYDRODYNAMICS: FROM SCHRÖDINGER MODELS TO PURELY MACROSCOPIC THEORY

**Abstract.** Macroscopic descriptions of quantum phenomena are often formulated using fluid-dynamical models. This approach leads to the study of Euler equations with dispersive terms, commonly referred to as quantum hydrodynamics (QHD). The mathematical theory of these equations was developed several years ago (see [1, 2]) in connection with Schrödinger-type equations (such as the Gross-Pitaevskii equation) through the Madelung transformation. These works established the global-in-time existence of weak solutions satisfying a generalized irrotationality condition. The main analytical tool was an ad hoc theory of polar decomposition. This class of weak solutions includes quantum vortices, and the initial data were assumed to arise from an underlying wave function.

The desire to develop a purely macroscopic theory naturally raises the question of whether a well-posed theory can be constructed for general hydrodynamic initial data, without reference to an underlying wave function.

We discuss these results in one spatial dimension and also present some results in multiple dimensions (see [3, 4]). The key ideas involve wave-function lifting and the introduction of functionals related to chemical potentials. We further show that, in the presence of collisional terms, the system relaxes to fourth-order (quantum) drift-diffusion equations, including the models of Derrida, Lebowitz, Speer, and Spohn (see [5]). Finally, we outline possible future developments, including the study of initial-boundary value problems and the analysis of initial layers.

### References

- [1] Antonelli, P., Marcati, P.: *On the finite energy weak solutions to a system in quantum fluid dynamics*. Commun. Math. Phys. 287(2), 657-686, 2009
- [2] Antonelli, P., Marcati, P.: *The quantum hydrodynamics system in two space dimensions*. Arch. Ration. Mech. Anal. 203, 499-527, 2012
- [3] Antonelli, P., Marcati, P., Zheng, H.: *Genuine hydrodynamic analysis to the 1-D QHD system: existence, dispersion and stability*. Commun. Math. Phys. 383, 2113-2161, 2021
- [4] Antonelli, P., Marcati, P., Zheng, H.: *An intrinsically hydrodynamic approach to multidimensional QHD systems*. Arch. Ration. Mech. Anal. 247, 24, 2023
- [5] Antonelli, P., Marcati, P., Zheng, H.: *The Time-relaxation Limit for Weak solutions to the Quantum Hydrodynamics System*. Arch. Ration. Mech. Anal. 247,73, 2025.

# ALESSANDRO MICHELANGELI

AUBG, American University in Bulgaria & HCM, Bonn

## GROUND STATES AND DISPERSION OF SCHRÖDINGER FLOWS IN REGIMES OF RE-SCALED POTENTIALS APPROXIMATING CONTACT-TYPE INTERACTIONS

**Abstract.** The well-understood spectral and dispersive properties of Schrödinger flows with “nice” (smooth, well-localised) potentials are discussed from the perspective of the asymptotic behaviour emerging when certain physically meaningful re-scalings are implemented in the potentials – precisely, re-scalings yielding point-like or contact-type interactions. The interest is both foundational (connecting the idealisation of quantum-mechanical contact interactions with real-world short-range interactions) and technical (establishing stability and dispersion directly in the contact interaction setting is usually hard). Strikingly, though, this subject is a constellation of unknown answers and open problems, of which the presentation will provide an overview.

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## JEAN-CLAUDE SAUT

University of Paris-Saclay

## ON THIRD ORDER NONLINEAR SCHRÖDINGER EQUATIONS

**Abstract.** We will survey the derivation and the known mathematical results on third order nonlinear Schrödinger equations arising in the theory of water waves and in nonlinear optics and present some new results on the Cauchy problem.

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## RAFFAELE SCANDONE

University of Naples

## POINT INTERACTIONS AND SINGULAR SOLUTIONS TO ELLIPTIC EQUATIONS

**Abstract.** We consider a class of semilinear elliptic equations in punctured domains, and we show that they can be equivalently described in terms of Schrödinger equations with a point (delta-like) interaction. To this aim, we exploit the characterization of the Sobolev spaces adapted to the point interaction, and we revisit some classical tools from the theory of elliptic PDEs. As a consequence, we can use a variational approach to construct infinitely many singular solutions, which in dimension  $d = 2$  are also nodal (i.e., sign changing). Finally, we discuss the symmetry properties of the solutions, confronting “moving planes” and rearrangement techniques. Based on joint works with Filippo Boni, Vladimir Georgiev, Alessandro Michelangeli, and Diego Noja.

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# MIRKO TARULLI

AUBG, American University in Bulgaria

## LOCAL UNIQUENESS OF GROUND STATES FOR ENERGY-SUBCRITICAL GENERALIZED CHOQUARD EQUATIONS

**Abstract.** We study the generalized Choquard (Hartree-Choquard-type) elliptic equation

$$-\Delta Q + Q = I(|Q|^p)|Q|^{p-2}Q \text{ in } \mathbb{R}^n$$

with  $Q \in H_{rad}^1(\mathbb{R}^n)$ , for dimensions  $3 \leq n \leq 5$ , and energy-subcritical exponents  $2 < p < 1 + \frac{4}{n-2}$ , where  $I$  denotes the Riesz potential. Ground states arise as minimizers of a Weinstein-type functional, and uniqueness is classical in the Hartree case  $p = 2$ . For  $p > 2$ , however, standard ODE shooting and Sturm comparison tools are unavailable, and the asymptotics of the nonlocal potential depend on an  $L^p$ -quantity not determined by the Pohozaev constraints. Our main result proves local uniqueness of positive radial minimizers: any two such normalized ground states that are sufficiently close in  $L^2$  must coincide. The argument is based on restricting the Weinstein functional to rays through a ground state and constructing a suitable analytic continuation in a complex neighborhood of the path parameter. A key spectral step is a structural bound for the linearized operator  $L^+$ , namely  $\dim(\ker L^+ \cap H_{rad}^1) \leq 1$ , which we establish via a contradiction argument for an associated radial ODE system after introducing auxiliary integral variables describing the relevant constraints. This is a joint work with Vladimir Georgiev and Georgi Venkov

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# NIKOLAY TZVETKOV

ENS, Lyon

## ALMOST SURE GLOBAL NONLINEAR SMOOTHING FOR THE 2D NLS

**Abstract.** We prove an almost-sure global in time nonlinear smoothing effect for NLS on the two-dimensional torus. For deterministic data, this phenomenon was proved for the NLS on the circle by Erdogan–Tzirakis, which remains unknown on multi-dimensional torus. Our argument is based on a quantitative quasi-invariance by the NLS flow of Gaussian measures with covariance operator  $(1 - \Delta)^{-s}$  for  $s > 2$ . This is a joint work with Chenmin Sun.

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# LUIS VEGA

BCAM, Bilbao

## THE DYNAMICS OF VISCOUS VORTEX FILAMENTS AND THE BINORMAL CURVATURE FLOW

**Abstract.** I'll present some recent work about the connection of vortex filaments/tubes that move according to Navier-Stokes Equation and the binormal curvature flow of curves in 3D. This is a joint work with Marco A. Fontelos and Mikel Ispizua.

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