Sesión "Análisis de Ecuaciones Diferenciales Parciales"

Coordinadores: **S. Alarcón, L. Iturriaga y F. Mahmoudi**

Control of parabolic systems and application to a hierarchical control problem

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Abstract

This talk is meant to be a brief overview of the control of linear parabolic equations and systems, using the heat equation as a model. As we will see, the control problem is equivalent to an observability inequality for the adjoint equation. We will present a strategy based on Carleman estimates to prove observability for equations and systems. Then, we will apply these ideas to a multi-objective control problem for a fourth-order parabolic equation, where we assume that we can act on the equation through a hierarchy of controls.

This is a joint work with Maurício C. Santos.

Least energy solutions for a planar Neumann problem

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Abstract

We study the asymptotic behavior of the L^∞ norm of least energy solutions u_p to the following semi linear Neumann problem

$$\begin{cases} \Delta u = u, \ u > 0 & \text{in } \Omega, \\ \dfrac{\partial u}{\partial \nu} = u^p & \text{on } \partial\Omega, \end{cases}$$

where Ω is a smooth bounded domain in $\mathbb{R}^2$. The main result of this work is a positive answer to the conjecture that the L^∞ norm of u_p satisfies

$$\lim_{p\to\infty} \|u\|_{L^\infty(\partial\Omega)} = \sqrt{e}.$$

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Some nonlocal logistic population model with nonzero boundary condition

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Abstract

A classic model of behaviour of species in a domain Ω is given by

$$\begin{cases} -\Delta u = u(\lambda - b(x)u^p) & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega. \end{cases} \qquad (P_1)$$

where $u(x)$ is the population density in $x \in \Omega$ for a some species, Ω represents the habitat of the species, $\lambda \in \mathbb{R}$ is the rate of population growth y b is a positive function denoting the carrying capacity, in others words, $b(x)$ describes the effect of limiting population agglomeration.

In this presentation we study some type of equations that generalize the model the behaviour of species inhabiting in some habitat. For our purpose using a priori bounded techniques we obtain a positive solution to a family of non local partial differential equations with non homogeneous boundary conditions.

Work in collaboration with M. Souto and Pedro Ubilla.

Vórtices en la ecuación de Euler en dos dimensiones

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Abstract

Presentaremos un resultado sobre soluciones de la ecuación de Euler en un dominio dos dimensional con vorticidad concentrada, que relaciona el movimiento de los puntos de concentración con las soluciones del sistema de Kirchoff-Routh. Esta relación ya se conoce, pero obtenemos expansiones más precisas que las de [1], que permiten en particular describir la velocidad del fluido cerca de los vórtices.

Este trabajo es en colaboracin con Manuel del Pino (U. de Chile), Monica Musso (Pontifica Universidad Católica de Chile) y Juncheng Wei (University of British Columbia).

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Interior regularity for fractional systems

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Abstract

We study the regularity of solutions of elliptic fractional systems of order $2s$, $s \in (0,1)$, where the right hand side f depends on a nonlocal gradient and has the same scaling properties as the nonlocal operator. Under some structural conditions on the system we prove interior Hölder estimates in the spirit of [1]. Our results are stable in s allowing us to recover the classic results for elliptic systems due to S. Hildebrandt and K. Widman [2] and M. Wiegner [3]. This is a joint work with L. Caffarelli.

References

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Regularidad elíptica para la fractura incompresible

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Abstract

Se construyen extensiones de divergencia nula de un campo de velocidades prescrito en la frontera de un dominio bidimensional con agujeros circulares. La condición Dirichlet corresponde al crecimiento de cavidades circulares en un material neo-Hookeano. Para la extensión se usa el método de Dacorogna y Moser [1] y se analiza como depende su regularidad Schauder de la geometría del dominio. Esto permite encontrar cotas inferiores para la carga de transición a la segunda etapa de la fractura de materiales incompresibles confinados: la coalescencia de cavidades.

Trabajo en colaboración con Víctor Cañulef.

References

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Multiplicidad de soluciones que cambian de signo para una ecuación semilineal

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Abstract

Estudiaremos las soluciones del problema

$$\Delta u + f(u) = 0, \quad x \in R^N, N \geq 2,$$

dando condiciones en f para que existan al menos dos soluciones radialmente simétricas con un número prescrito de ceros. Estas soluciones tienen condición inicial $u(0)$ en un intervalo específico, por lo que podremos dar condiciones en f tales que el problema tenga cualquier cantidad dada de soluciones con un número prescrito de ceros.

Trabajo conjunto con Carmen Cortázar y Marta García-Huidobro.

Well-posedness of Dispersive equations

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Abstract

In this talk, we discuss about the well-posedness theory of dispersive equations via analytic methods. Since 1993, Bourgain [1] introduced the *Fourier restriction norm method* to investigate the low regularity well-posedness of KdV and nonlinear Schrödinger equations, and Kenig-Ponce-Vega [4] and Tao [8] further developed this theory. I introduce my recent well-posedness results based on the *Fourier restriction norm method*, particularly, well-posedness of fifth-order KdV-type equations [2, 5, 6, 3] and the cubic nonlinear Schrödinger equation [7].

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An isoperimetric inequality for fundamental tones of clamped plates under compression

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Abstract

In this work, we ask the question, among domains of equal volume, what is the shape of the domain for which the first eigenvalue of the clamped plate under compression is a minimum. Previously, the Rayleigh conjecture for the clamped plate has been proved by Nadirashvili [2, 3] in 2-d and, Ashbaugh and Benguria[1] in dimensions $2, 3$ showing that this is least when the domain is a ball, following previous results due to Talenti [4]. For the clamped plate problem under compression it is reasonable to conjecture that the first eigenvalue is a minimum when the domain is a ball, for at least small values of the compression parameter. We prove that this is true and present related open questions.

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On the equivalence of viscosity and weak solutions for the non-homogeneous p-Laplace equation

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Abstract

We study the relation between viscosity and weak solutions for non-homogeneous p-Laplace equations with a lower order term depending on x, u and ∇u, both in the degenerate and in the singular case, that is, we consider the equations

$$-\mathrm{div}\big(|\nabla u|^{p-2}\nabla u\big) = f(x, u, \nabla u),$$

defined in an open and bounded set $\Omega \subset \mathbb{R}^n$ and for $1 < p < \infty$.

We prove that any locally bounded viscosity solution constitutes a weak solution, extending results presented in Juutinen, Lindqvist and Manfredi [2] and Julin and Juutinen [1] for the homogeneous case. Moreover, we provide a converse statement in the full case under extra assumptions on the data.

This work can be found in [3].

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Potential reconstruction for a class of hyperbolic systems from incomplete measurements

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Abstract

In this talk, we study the reconstruction of spatially dependent potentials in n coupled hyperbolic equations in cascade from $n-1$ components of the solution of the system. More precisely, we use the Bukhgeim-Klibanov method to prove local uniqueness and Lipschitz stability for this inverse problem. The main tool is a Carleman estimate for a cascade system with a missing observation.

This result has been obtained in collaboration with Nicolás Carreño (Universidad Técnica Federico Santa María) and Axel Osses (Universidad de Chile).

References

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Local strong decay in some nonlinear dispersive equations with supercritical scattering

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Abstract

In this talk I will discuss some recent works in collaboration with Alejo (Florianopolis), and Poblete (U Austral) and Pozo (UFRO). First, we will show that all small solutions in the energy space of the generalized 1D Boussinesq equation must decay to zero as time tends to infinity, strongly on slightly proper subsets of the space-time light cone. Our result does not require any assumption on the power of the nonlinearity, working even for the supercritical range of scattering. No parity assumption on the initial data is needed. In a second part, we will also study the decay of small solutions of the Born-Infeld equation in 1+1 dimensions, a quasilinear scalar field equation modeling nonlinear electromagnetism, as well as branes in String theory and minimal surfaces in Minkowski space-times. From the work of Whitham, it is well-known that there is no decay because of arbitrary solutions traveling to the speed of light just as linear wave equation. However, even if there is no global decay in 1+1 dimensions, we are able to show that all globally small solutions do decay to the zero background state in space, inside a strictly proper subset of the light cone. We prove these results by constructing Virial identities related to a momentum law, in the spirit of previous works by Kowalczyk, Martel and Muñoz.

References

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Estabilidad en el espacio de energía de las soluciones tipo 2-solitón para la ecuación de sine-Gordon

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Abstract

En este charla probamos que tres soluciones diferentes, de tipo 2-solit'on, de la ecuaci'on de sine-Gordon (SG), son orbitalmente estables en el espacio de energ'ia natural del problema. Probaremos este resultado sin utilizar la t'ecnica de scattering inverso para la ecuación, la cual requiere condiciones extras de decaimiento. Las tres soluciones que estudiamos se denominan de manera general 2-kink, kink-antikink y breather de SG. Para probar este resultado, usaremos transformaciones de Bäcklund bien escogidas que permitan reducir la estabilidad de estas soluciones al caso del origen en espacio, en el espíritu del resultado de Alejo y Muñoz para el caso de la ecuación modificada de Korteweg-de Vries; sin embargo, veremos que SG presenta diversas nuevas dificultades que deberemos resolver apropiadamente. Posibles conexiones a un resultado de estabilidad asintótica ser'an también discutidos.

Este es un trabajo en colaboración con C. Muñoz.

References

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Existence, nonexistence and multiplicity results for fully nonlinear nonlocal Dirichlet problems

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Abstract

In this talk we review various existence, nonexistence and multiplicity results for Dirichlet problems associated to nonlocal Hamilton-Jacobi equations. This study is accomplished by a careful analysis of the principal eigenvalues of the elliptic operator. Resonance phenomena and anti maximum principles.

The relation between Willmore surfaces and the Cahn-Hilliard equation

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Abstract

In the literature there are many results relating the Allen-Cahn energy and minimal surfaces, for instance the famous Γ-convergence result by Modica and Mortola. Similar results are known for the Willmore functional which approaches, for ε small, the Willmore energy. In the talk, we will present the PDE counter-part of these results, that is we will present some entire solutions to the Cahn-Hilliard equation in dimension 2 and 3, whose zero-level set is close to some prescribed Willmore curve, in dimension 2, or surface, in dimension 3. Moreover, we will say a few words about the monotonicity of our solution in dimension 2, and we will see the relation of the issue with a famous long-standin conjecture of De Giorgi for the Allen-Cahn equation.

Pérdida de condiciones iniciales para dos clases de ecuaciones parabólicas nolineales con término gradiente dominante: casos completamente nolineal y fraccionario

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Abstract

Presentaremos un estudio de propiedades cualitativas de ecuaciones parabólicas no-lineales cuyo crecimiento con respecto al gradiente hace que el término correspondiente "domine" la ecuación. Específicamente, mostraremos que el fenómeno de *pérdida de condiciones iniciales* (*loss of boundary conditions*, LOBC) ocurre para dos problemas modelo a valores iniciales y de frontera.

El primer modelo es un problema completamente nolineal (*fully nonlinear*):

$$
\begin{aligned}
&u_t - \mathcal{M}^-(D^2 u) = |Du|^p \quad \text{en } \Omega \times (0,T), \\
&u|_{\partial\Omega \times (0,T)} = 0, \qquad u(\cdot,0) = u_0 \in C^1(\overline{\Omega}).
\end{aligned}
\tag{1}
$$

Aquí $\Omega \subset \mathbf{R}^N$ es un dominio acotado de frontera regular, $T > 0$; $\mathcal{M}^-$ es el operador (minimal) de Pucci, $\mathcal{M}^-(X) = \inf\{\mathrm{tr}(AX)|\lambda \mathrm{Id} \le A \le \Lambda \mathrm{Id}\}$, donde A y X son matrices simétricas de $N \times N$ y $0 < \lambda \le \Lambda$; y $p > 2$. El segundo problema es de carácter no-local:

$$
\begin{aligned}
&u_t + (-\Delta)^s u = |Du|^p \quad \text{en } \Omega \times (0,T), \\
&u|_{\mathbf{R}^N \setminus \Omega \times (0,T)} = 0, \qquad u(\cdot,0) = u_0 \in C^\beta(\overline{\Omega}),
\end{aligned}
\tag{2}
$$

donde Ω y T son como antes, $(-\Delta)^s$ denota el operador conocido como Laplaciano fraccionario con $s \in (0,1)$ (cf. [4]) , p satisface

$$
s + 1 < p < \frac{s}{1-s},
\tag{3}
$$

y $\beta < \frac{p-2s}{p-1}$.

Para cada uno de nuestros problemas modelo mostramos que *a)* existe un tiempo pequeo $T^* > 0$ que depende esecialmente solo de la condición inicial u_0 (específicamente, de $\|u_0\|_{C^1(\overline{\Omega})}$ de $\|u_0\|_{C^\beta(\Omega)}$, respectivamente) tal que la solución satisface la condición de frontera en en el sentido clásico (i.e. punto a punto); y *b)* LOBC ocurre para u_0 suficientemente grande, específicamente de una condición dada en términos de una función propia de $\mathcal{M}^-$ y $(-\Delta)^s$, respectivamente. El anterior es un trabajo conjunto con el Prof. Alexander Quaas [5].

Definiciones y comentarios adicionales. La noción *generalizada* de condición de frontera (a la que también se le denomina "de viscosidad" – *boundary conditions in the viscosity sense*) consta en que sub- y supersoluciones satisfagan la ecuación hasta la frontera en aquellos puntos donde no se satisface la desigualdad correspondiente para el valor de la función; e.g., para (1), una subsolución satisface la condición de borde en el sentido de viscosidad si

$$
\min \left\{ u(x,t), u_t(x,t) - \mathcal{M}^-(D^2 u(x,t)) - |Du(x,t)|^p \right\} \le 0 \text{ para toda } (x,t) \in \partial\Omega \times (0,T)
$$

La definición correspondiente para supersoluciones de (1) y para sub- y supersoluciones de (2) es análoga (cf. [3]). Esta noción se origina en los problemas de control óptimo

que subyacen a las ecuaciones (1) y (2), y se ha utilizado para obtener la existencia de soluciones definidas globalmente en el tiempo, i.e., para todo $T > 0$ ([1], [2]). LOBC ocurre si en algún punto se satisface la desigualdad para la ecuación mientras que la desigualdad para el valor de la solución falla.

Para los resultados de LOBC (parte b)), adaptamos un argumento originalmente empleado para la llamada *ecuación de Hamilton-Jacobi viscosa* en [6], cuyo término de difusión es el Laplaciano en el contexto de soluciones clásicas. La principal dificultad es la falta de regularidad de las soluciones vicosas, que a priori son sólo continuas. Sorteamos esta dificultad mediante una regularización por convolución "inf-sup".

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Theory of light-matter interaction in nematic liquid crystals

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Abstract

I will present qualitative properties of global minimizers of the Ginzburg-Landau energy which describes light-matter interaction in the theory of nematic liquid crystals. This model depends on two parameters: $\epsilon > 0$ which is small and represents the coherence scale of the system and $a \geq 0$ which represents the intensity of the applied laser light. In particular we are interested in the phenomenon of symmetry breaking as a and ϵ vary. We show that when $a = 0$ the global minimizer is radially symmetric and unique and that its symmetry is instantly broken as $a > 0$ and then restored for sufficiently large values of a. Symmetry breaking is associated with the presence of a new type of topological defect which we named the *shadow vortex*. The symmetry breaking scenario is a rigorous confirmation of experimental and numerical results obtained earlier in [1].
.

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Existence, nonexistence and multiplicity results for fully nonlinear integro-differential Dirichlet problems.

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Abstract

In this talk we report various existence, nonexistence and multiplicity results for Dirichlet problems associated to nonlocal Hamilton-Jacobi equations. This study is accomplished by a careful analysis of the principal eigenvalues of the elliptic operator. Resonance phenomena and anti maximum principles are also established.

This is a joint work with Gonzalo Dávila and Alexander Quaas (UTFSM).

References

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Existence of solution of some p, q-laplacian system under local superlinear conditions.

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Abstract

Using a priori bounds, we establish the existence of a positive radial solution for the following class of quasi–linear elliptic system

$$\begin{cases} -\Delta_p u = f(|x|, u, v) & \text{in} \quad B, \\ -\Delta_q v = g(|x|, u, v) & \text{in} \quad B, \\ (u, v) = (0, 0) & \text{on} \quad \partial B, \end{cases}$$

where the nonlinearities f, $g \in C(B \times [0, +\infty)^2 \, ; [0, +\infty))$ are superlinear at zero, and local(in some sense) superlinear at $+\infty$. Here B is the unity ball in $\mathbb{R}^N$ and $1 < p$, $q \leq 2$.

This is a joint work with Patricio Cerda (USACH-Chile) and Marco Aurelio Souto (UFCG-Brasil).

Non-existence of minimizers for the TFDW functional and related problems

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Abstract

It is a well-known fact in physics that a neutral atom can bind at most one or two additional electrons. But proving such a bound on the maximum positive ionization is still an open problem in many-body quantum mechanics. Recently, we were able to prove such a bound in several approximate models for the full quantum theory: the Thomas-Fermi-Dirac-von Weiszäcker density functional and Müller's density matrix functional. In this talk, I will give an overview of the known results and techniques, illustrate our method in a simplified model and give the basic ideas behind the proof.

This talk is based on joint work with R. L. Frank and P. T. Nam (LMU Munich).