The dispersion tensor in some different classes of microstructures

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In this talk, we use Bloch decomposition to introduce higher order macrocoefficients, namely the dispersion tensor or the Burnett coefficients in different classes of microstrucures: periodic types, perforated and non-perforated, and the generalized Hashin–Shtrikman non-periodic structures. We also study the dependence of the fourth-order tensor in terms of the microstructure.

References

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[3] L. Bălilescu, C. Conca, T. Ghosh, J. San Martín, M. Vanninathan, *The dispersion tensor and its unique minimizer in Hashin-Shtrikman micro-structures*, Archive for Rational Mechanics and Analysis (2018), 230 (2), pp. 665–700.

Analysis and Control in Poroelastic Systems with Applications to Biomedicine

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We present new results related to well-posedness, sensitivity analysis, and optimal control problems for quasi-static nonlinear poroelastic systems with applications in biomechanics. The PDE systems under consideration represent nonlinear, implicit, degenerate evolution problems, which fall outside of the well-known implicit semigroup monotone theory. We also consider scenarios where the local, accurate, 3D poroelastic PDE systems are coupled with systemic, 0D, lumped models of the remainder of blood circulation, in order to account for the global features of the problem. We address questions related to the solution methods of these multiscale coupled problems via staggered algorithms, and provide a detailed comparison between functional iterations and an energy-based operator splitting method in terms of how they handle the nonlocal interface conditions. Our results have applications in biology, medicine and bio-engineering, including tissue perfusion, fluid flow inside cartilages and bones, and design of bioartificial organs.

Nonlocal nonlinear diffusion equations. Smoothing effects, Green functions, and functional inequalities

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We establish boundedness estimates for solutions to generalized porous medium equations of the form

$$\partial_t u + (-\mathfrak{L})[u^m] = 0 \qquad \text{in } \mathbb{R}^N \times (0,T),$$

where $m \geq 1$ and $-\mathfrak{L}$ is a linear, symmetric, and nonnegative operator. The wide class of operators we consider includes, but is not limited to, Lévy operators. Our quantitative bounds take the form of precise L^1–L^∞-smoothing effects, and their proofs are based on the interplay between a dual formulation of the problem and estimates on the Green function of $-\mathfrak{L}$.

In both the linear ($m = 1$) and nonlinear ($m > 1$) setting, we explore equivalences between smoothing effects and Gagliardo-Nirenberg-Sobolev inequalities. This is in turn equivalent to heat kernel estimates in the linear case, from which our needed Green function estimates can be deduced.

The presentation is based on a joint work with Matteo Bonforte (Universidad Autónoma de Madrid, Spain).

Multipliers techniques for discrete wave equations

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In this talk, we present several results concerning the observability and controllability problem for the finite differences, quadratic and discontinuous Galerkin finite elements semi-discretisation of the wave equation on both uniform and non-uniform meshes. For each approximation method, we obtain the corresponding Pohozaev identity by multipliers techniques. In the non-uniform mesh case, we also give upper bounds for the error terms (with respect to the continuous case) allowing to conclude uniform observability inequalities with respect to the mesh size parameter.

Monotonicity Properties of the p-Torsional Rigidity in Convex Domains

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For any bounded and convex set $\Omega \subset \mathbb{R}^N$ $(N \geq 2)$ with smooth boundary, $\partial\Omega$, and any real number $p > 1$, we denote by u_p the *p-torsion function* on Ω, that is the solution of the *torsional creep problem*: $\Delta_p u = -1$ in Ω, $u = 0$ on $\partial\Omega$, where $\Delta_p u := div(|\nabla u|^{p-2}\,\nabla u)$ stands for the p-Laplace operator. Our aim is to investigate the monotonicity with respect to p for the *p-torsional rigidity* on Ω, defined as $T_p\,(\Omega) := \int_\Omega u_p dx$. This is a joint work with Cristian Enache and Denisa Stancu-Dumitru.

Asymptotic profiles for inhomogeneous classical and nonlocal heat equations

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We study the large-time behaviour of solutions to inhomogeneous heat equations in the whole space, with a diffusion operator which may be local or nonlocal both in space and time. We find that the asymptotic profiles depend strongly on the space-time scale and on the time behaviour of the spatial L^1 norm of the forcing term. Some of our results are surprising even for the classical heat equation in the somewhat studied case in which the right-hand side is globally integrable in space and time. On the other hand, our assumptions on the source term allow for the space integral to grow to infinity as time goes to infinity. This is joint work with Noemí Wolanski (IMAS-UBA-CONICET, Argentina) and Carmen Cortázar (PUC, Chile).