MARIA GIOVANNA MORA

Born in Parma (Italy) on 1974

EDUCATION

International School of Advanced Studies – SISSA, Ph.D. in Mathematics (2001); thesis *"The calibration method for free-discontinuity problems on small domains"*, advisor Prof. Gianni Dal Maso

Universit`a di Parma, Degree in Mathematics *summa cum laude* (1997)

EMPLOYMENT AND OTHER PROFESSIONAL ROLES

Universit`a di Pavia, Department of Mathematics 2020 – present
Full Professor in Mathematical Analysis

Universit`a di Pavia, Department of Mathematics 2012 – 2019
Associate Professor in Mathematical Analysis

SISSA, Functional Analysis Sector 2004 – 2011
Assistant Professor (with tenure) in Mathematical Analysis

Institute for Mathematics and its Applications, Minneapolis Fall semester 2007
Visiting Professor in the framework of the Thematic Year on Mathematics of Molecular and Cellular Biology

Max-Planck Institute for Mathematics in the Sciences, Leipzig 2001 – 2003
Post-doctoral fellow

• Author of 44 scientific papers published on peer-reviewed journals in Mathematics. According to MathSciNet they have been cited 653 times by 337 authors (h-index 14)

• Long-term invitations for scientific collaboration: Max-Planck Institute for Mathematics in the Sciences, Leipzig, Germany (2005, 2006, 2007); Carnegie Mellon University, Pittsburgh, USA (2008, 2010, 2012, 2016, 2017); Universit´e de Paris Nord, France (2009); Courant Institute, New York University, USA (2009); Universit´e de Paris 6, France (2011, 2018); Universidad Autonoma de Madrid, Spain (2012); SISSA, Trieste, Italy (2013, 2014, 2015, 2016); University of Bath, UK (2016, 2017, 2018); Universitat Aut`onoma de Barcelona, Spain (2018)

• Semi-plenary speaker (invited 40min talk) at the XXI Congresso dell'Unione Matematica Italiana, Pavia, 2–7 September 2019

• Plenary speaker at the Second Joint SIAM/CAIMS Annual Meeting – AN20, virtual conference originally scheduled in Toronto (Canada), 6 – 17 July 2020

• Plenary speaker at the SIAM Conference on Mathematical Aspects of Materials Science – MS20, virtual conference originally scheduled in Bilbao (Spain), 17–27 May 2021

• More than 80 invited talks at conferences (plenary) and research institutes

• PI of the Blue Sky Research Project *Plasticity at different scales: micro to macro*, awarded by the Universit`a di Pavia, 2017–2019 (60,000 Euro). This is an individual grant based on a peer-review evaluation and awarded to 5 scientists working at the University of Pavia in the area of Science and Technology.

• Local unit coordinator of the PRIN 2017 Project *Variational methods for stationary and evolution problems with singularities and interfaces* awarded by the Italian Ministry of Education and Research, 2019–2023 (91,000 Euro)

• Recipient of FFABR grant 2017. This is an individual grant awarded to the best 25% of Italian Associate Professors.

- Member of the Academic Board of the Ph.D. School in Mathematics and Statistics of the Universit`a di Pavia, 2013 – present
- Member of the Academic Board of the Ph.D. School in Mathematics of SISSA, 2004 – 2011
- Advisor of 2 Ph.D. students and 6 Master students, co-advisor of 1 Ph.D. student and 1 Master student
- Lecturer at the 10th Summer School in Analysis and Applied Mathematics, Roma, 21–25 June 2021
- More than 10 years experience in teaching graduate courses on active research topics in the area of Calculus of Variations and Partial Differential Equations (Mathematical Theory of Elasticity, Gamma-convergence, Homogenization, Geometric Measure Theory and BV Functions, Mathematical Theory of Plasticity)

KEY PUBLICATIONS

- M.G. Mora, S. Müller: A nonlinear model for inextensible rods as a low energy Γ-limit of three-dimensional nonlinear elasticity. *Ann. Inst. H. Poincar´e Anal. Nonlin.* **21** (2004), 271–293.

  This paper concerns the rigorous derivation of lower dimensional theories for thin structures in nonlinear elasticity. This is a subject on which I have been working extensively, starting from my postdoc years in Leipzig. Some of my results in this field are quoted in the monograph *Nonlinear problems of elasticity* by S.S. Antman, which is a reference book on elasticity. In the paper on *Annales Poincar´e* we proved that, if the applied forces have a suitable scaling in terms of the rod thickness, the equilibrium configurations of the rod converge, as thickness tends to zero, to minimizers of the von K´arm´an rod model. In subsequent works we extended this result to the dynamical setting.

- M. Lewicka, M.G. Mora, M.R. Pakzad: The matching property of infinitesimal isometries on elliptic surfaces and elasticity of thin shells. *Arch. Rational Mech. Anal.* **200** (2011), 1023–1050.

  This paper concerns the derivation of two-dimensional models for nonlinearly elastic shells. The nontrivial geometry of the shell results in two-dimensional theories that are qualitatively different from the ones for plates, because of the interplay between the intrisic rigidity properties of the shell and its mechanical response to external forces. From a mathematical viewpoint this requires to combine variational techniques with differential geometry tools. In particular, a major question is to determine under which conditions one can construct exact isometries that match a given infinitesimal isometry as first order term. In this paper we give a complete answer to this question in the case of elliptic surfaces. This is the main ingredient to deduce the correct limiting model for shells with an elliptic mid-surface.

- G. Dal Maso, A. DeSimone, M.G. Mora: Quasistatic evolution problems for linearly elastic - perfectly plastic materials. *Arch. Rational Mech. Anal.* **180** (2006), 237–291.

  This is a key result in the mathematical theory of plasticity, as it provides a mathematically sound formulation of the classical theory of small-strain plasticity within the modern framework of the variational theory of rate-independent evolutions. This approach paves the way for a direct use of variational techniques and has then been successfully extended to a number of different models in the context of plasticity.

- J.-F. Babadjian, G.A. Francfort, M.G. Mora: Quasistatic evolution in non-associative plasticity - the cap model. *SIAM J. Math. Anal.* **44** (2012), 245–292.

  Non-associative plasticity is the reference plastic models for geo-materials, such as soils and rocks, and is classically considered to be a non-variational model, even as a static problem. In this paper we showed that this point of view is not correct: we proposed a variational formulation for a rather general model of non-associative plasticity and we developed a corresponding existence theory.

- M.G. Mora: Relaxation of the Hencky model in perfect plasticity. *J. Math. Pures Appl.* **106** (2016), 725–743.

  This article concerns the relaxation of the Hencky model, which is a classical static model of small-strain elasto-plasticity. It also emerges as the incremental minimum problem to be solved at each time step, when approaching the quasi-static evolution problem by time discretization. The paper provides an answer to a fundamental question in the mathematical theory of plasticity: what is the relation between the classical formulation of the Hencky model and the weak formulation that is typically used in the literature? Although this is a very natural question, it has been surprisingly ignored by the mathematical community working on plasticity. The paper shows that the weak formulation is in fact the natural extension of the classical Hencky model and can be deduced through a relaxation process. The result is highly nontrivial, since the space of plastic displacements is not local, so that the usual approximation arguments based on localization and partition of unity do not work here.

- M.G. Mora, L. Rondi, L. Scardia: The equilibrium measure for a nonlocal dislocation energy. *Comm. Pure Appl. Math.* **72** (2019), 136–158.

  My recent research activity concerns the study of nonlocal interaction problems, motivated by dislocation theory. In this paper we characterized the minimizer of a nonlocal energy describing the interaction of positive edge dislocations in the plane, giving a positive answer to the conjecture that positive dislocations tend to form vertical walls. This result is also one of the few examples where the minimizer of a nonlocal energy is explicitly computed and the first one in the case of anisotropic kernels.

- J.A. Carrillo, J. Mateu, M.G. Mora, L. Rondi, L. Scardia, J. Verdera: The ellipse law: Kirchhoff meets dislocations. *Commun. Math. Phys.* **373** (2020), 507-524.

  The focus of this paper is on the role of the kernel's anisotropy on the dimensionality of minimizers for nonlocal energies. In most of the vast mathematical literature on nonlocal systems, the interaction kernel is assumed to be radial, and one of the goals is to show that the corresponding minimizer is radially symmetric. Radial symmetry is also paramount in the identification of the minimizer in the classical case of purely Coulomb interactions. Explicity characterizing the minimizer, or even understanding its shape and general properties, is therefore much more challenging in the case of anisotropic interactions. Motivated by the previous contribution on *Comm. Pure Appl. Math.*, in this article we consider a family of nonlocal interaction kernels, where the strength of the anisotropy is tuned by a parameter α. When $\alpha = 0$, the problem reduces to purely Coulomb interactions, while for $\alpha = 1$ it coincides with the edge dislocation kernel. We characterize explicitly the minimizer for every α, showing in particular that for $\alpha \in (0, 1)$ the minimizer is the characteristic function of a two-dimensional ellipse, that collapses into the semicircle distribution on the vertical axis, as $\alpha \to 1$. This sudden change of dimensionality occuring at $\alpha = 1$ seems to be related to a degeneracy of the differential operator associated with the kernel. This is an intriguing question, that I am currently investigating.

- L. Freddi, P. Hornung, M.G. Mora, R. Paroni: A variational model for anisotropic and naturally twisted ribbons. *SIAM J. Math. Anal.* **48** (2016), 3883–3906.

  This is a recent contribution on the analysis of thin structures in nonlinear elasticity. The motivation comes from a paper by M. Sadowsky in 1930, where the problem was posed of determining the equilibrium configurations of a Möbius strip made of an unstretchable material. He tackled this problem variationally and he deduced by formal arguments the bending energy for a strip whose width is much smaller than the length. This energy, now known as the Sadowsky energy, depends on the curvature and torsion of the centerline of the band, but it is not well-defined at points with zero curvature. In this paper we re-examined the derivation of the Sadowsky energy using Gamma-convergence, showing that the classical Sadowsky functional captures the correct behaviour of minimizers only in those regions where the curvature of the centerline is strictly larger than its torsion. Outside those regions, fine-scale "corrugations" may occur, leading to a relaxation of the zero Gaussian curvature constraint.

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