Mechanics Research Communications 93 (2018) 1–3

Contents lists available at ScienceDirect

Mechanics Research Communications

journal homepage: www.elsevier.com/locate/mechrescom

Mechanics from the 20th to the 21st century: The legacy of Gérard A. Maugin

Anyone who has met Gérard Maugin in person would readily admit that he was a *larger than life* individual. He had a boundless appetite for life and for science and his contributions and achievements are too many to recall here. A recent list of his 350+ peer-reviewed articles and 15 books can be found in the Editorial written by Pouget [32], one of his long-time collaborators. Further detailed accounts of Gérard Maugin, the man and the scientist, can be found in the introductions to the special issues dedicated to his 60th [27] and 70th [6] birthdays.

Gérard had a strong personality, which allowed him much intellectual freedom to pursue avenues that might have appeared to be outside of the mainstream at a given time, only to become widespread later. In this way, he came to be recognized as a *precursor* or a major early player in diverse fields such as continuum mechanics in general relativity, nonlinear elastic wave propagation, mechanics of soft electro- and magneto-sensitive solids, configurational forces, theory of growth, and many others.

With this special issue of *Mechanics Research Communications*, we would like to celebrate the influence that his work and personality exerted on a whole generation of researchers in the broad field of Continuum Mechanics. He made a profound impact on the field, through his phenomenal output of research papers and books of course, but also with his participation in and expert leadership of countless conferences, workshops, advanced schools, grants, consortia, and executive boards.

At *Mechanics Research Communications*, where he was a dedicated member of the editorial advisory board and a regional editor for many years, he contributed with a special issue [21] on Eshelbian mechanics of materials, five regular research papers [4,15,22,18,23] covering various topics in elasticity and continuum thermo-mechanics, and three masterful reviews [24–26] recounting both the achievements and intricate history of topics close to his heart: solitons, configurational mechanics, and internal state variables in thermomechanics.

Gérard would be proud and delighted to see that many of his friends and collaborators have contributed to the thirty outstanding papers in this special issue. The contributions span a tremendous breath of areas of continuum mechanics, showing the diversity of scientific topics that he contributed to and inspired research on. Specifically:

Agosti et al. [1] discuss the fundamental issue of how to handle soft materials with pre-stressed reference configurations. They derive a strain energy function for an initially stressed Mooney–Rivlin material, from which they obtain the constitutive relations for the material.

Bacigalupo et al. [2] develop a novel strategy for identification of higher-order continua (e.g., a Cauchy heterogeneous material) with an equivalent Mindlin elastic continuum. Although based on asymptotic homogenization methods, the proposed approach yields a simpler implementation, which provides reasonable accuracy when benchmarked against numerical solutions.

Ben Amar [3] discusses models for singularity formation in soft tissues due to resorption or drying. Via asymptotic techniques, a local analysis of cracks in 2D finite-strain elasticity is presented, showing how surface tension, anisotropy and resorption/drying set the dynamics of crack propagation in tissues such as an embryo.

Berezovski [5] applies the notion of internal variables, following a long line of research by Gérard, to derive evolution equations for deformation and rotation in microstructured solids. This approach handles both dissipative solids (parabolic problems) and non-dissipative solids (hyperbolic problems) within the same thermodynamic dual-internal-variables framework.

Detmann [7] discusses continuum models for porous media having anywhere from one to three pore fluids present. In particular, certain macroscopic material parameters are computed, from measurable microscopic counterparts by micro-macro considerations, with applications to the propagation of acoustic waves.

DiCarlo [8] makes a “major serendipitous contribution to continuum mechanics” by showing how stress in continuum mechanics can be uniquely specified in terms of molecular quantities. DiCarlo’s approach allows for direct computation, which effectively yields a hierarchical multiscale method for computing stress in continua.

Dorfman and Ogden [9] pay homage to Gérard’s work in electrodynamics of continua (“electroelasticity”) by considering the influence of a radial electric field generated by compliant electrodes on the curved surfaces of a dielectric electroelastic tube subject to radially symmetric finite deformations.

Elettro et al. [10] present a combined modeling–experimental study of the effect of gravity on the buckling and coiling of an elastic fiber submerged in a liquid drop. It is shown that, when a drop resting on an elastic fiber is large enough, the gravitational forces due to its weight are comparable to surface tension forces. This effect, in turn modifies the windlass mechanism, leading to two possible steady states and a bifurcation diagram in terms of tension and end-shortening.

https://doi.org/10.1016/j.mechrescom.2018.06.003

Engelbrecht et al. [11] apply Gérard's beloved Boussinesq paradigm to wave propagation in biomembranes made of lipids. Specifically, wave propagation is examined in these microstructured solids, showing how the biomechanical properties of the membranes set the soliton generation and propagation dynamics.

Epstein [12] defines a new notion of homogeneity for a special class of functionally graded materials known as laminates. Specifically, he seeks to introduce a rigorous approach to quantitatively measure the density of continuous defects in such materials.

Eremeyev et al. [13] address the topic of discontinuity propagation in micromorphic continua. In particular, by deriving the acoustic tensor, they obtain exact conditions on when acceleration waves can propagate within such a nonlinear elasticity theory.

Goriely [14] presents an elegant study of five ways to model active processes in elastic solids, building upon Gérard's studies of *anelasticy*, to understand growth and remodeling in living systems from a continuum mechanics perspective.

Keiffer et al. [16] study acoustic shock and acceleration wave dynamics in inhomogeneous fluids through a combined theoretical–computational approach. Staying close to Gérard's interest in such singular surfaces in inhomogeneous materials, they show that exact amplitude expressions can be derived and validated numerically for some specific density profiles.

Lazar and Agiasofitou [17] delve into a favorite topic of Gérard's: Eshelbian mechanics. Specifically, they study the $\boldsymbol{J}$- M- and $\boldsymbol{L}$-integrals for single dislocations in isotropic elastic materials. These integrals usually arise in configurational mechanics from the balance laws expressing translational, scaling, and rotational invariances, respectively. Specifically, expressions and physical interpretations for the M-integral are obtained.

López-Realpozo et al. [19] analyze mechanical and electrical imperfect contacts in piezoelectric composites. They develop the effective properties of such materials using an asymptotic homogenization method (benchmarked against numerical simulations), showing that imperfect contact weakens all effective properties with electric imperfections having a stronger effect.

Margolin and Hunter [20], inspired by Gérard's interest in continuum thermodynamics, discuss the velocity probability distribution functions with respect to the finite size of a thermodynamic system. They present a geometric renormalization coarsening technique, which yields results that put into question notions of local thermodynamic equilibrium and whether these notions satisfy invariance principles.

Ostoja-Starzewski and Khayat [28] present a thermodynamics-based derivation of the equations of motion of certain viscoelastic ("Oldroyd-B") fluids capable of hyperbolic heat conduction. Specifically, one and two thermal-relaxation models are be obtained by the thermodynamic principles of Edelen and Zeigler, respectively.

Parisio et al. [29] implement configurational forces into an open-source, C++-based, object-oriented finite element platform. A set of introductory examples to be solved numerically by this approach is developed, highlighting how configurational mechanics can be used in the analysis of thermo-hydro-mechanical coupled processes.

Petsos et al. [30] apply concepts of higher-order-gradient continuum models, which Maugin and Aifantis developed over the years, to a varied set of phenomena—necking in cold drawing, spinodal decomposition in diffusive phase transformations and energy transfer in neuronal microtubules—governed by this set of related continuum models.

Porubov et al. [31] provide an elegant theoretical discussion of how distributed feedback control can be applied to a spatially extended system to obtain a target traveling wave solution. The featured example is the well-known sine-Gordon equation, showing that nonlinearity can be handled by the proposed control approach.

Pucci and Saccomandi [33] present a generalization of an equation of nonlinear acoustic waves. Within isotropic incompressible nonlinear elasticity, they derive, using a multiple scales asymptotic expansion, an equation governing finite-strain waves with an anti-plane shear (a topic Gérard showed significant interest in) superposed to a general plane motion. They further show that this new equation can support waves of permanent form.

Rajagopal [34] contributes a note on the linearization of implicit constitutive relations, with respect to the gradient of displacement, within the context of non-linear Cauchy elasticity. Counterintuitively, it is shown that it is possible to develop nonlinear relationships between the stress and strain, still under the small displacement gradient assumption, under the present generalizations.

Rubin and Safadi [35] reconsider the constraint of elastic incompressibility in growing elastic materials. Using the method of Lagrange multipliers, they develop the constraint response, showing that the constraint does work for the case of growing materials, in contrast to conventional material response.

Salupere and Ratas [36] generalize the discrete spectral analysis approach, developed by Salupere during his days in Paris with Gérard, to 2D problems. They apply their generalized method to the Kadomtsev–Petviashvili (KP) equation, showing how different wave structures emerge from certain initial pulses and how temporal periodicity and symmetry of the solutions lead to recurrences of the initial conditions.

Starosvetsky and Vainchtein [37] consider the classical Fermi–Pasta–Ulam (FPU) lattice; however, they allow the chain to have alternating "stiffer" and "softer" bonds. Via a multiple-scales analysis (in the limit of severe elastic modulus mismatch between bonds), they derive conditions under which the system supports solitary waves.

Tian et al. [38] develop a novel numerical method for studying post-buckling within the Föppl–von Kármán plate theory. They combine the so-called asymptotic numerical method with a Taylor meshless approach to efficiently solve for the quasi-perfect bifurcation response of such a plate.

Tsagrakis et al. [39] apply the theory of gradient elasticity, developed in part by Maugin and Aifantins, to the mechanics of disclinated micro crystals, specifically obtaining singularity-free stress fields.

Yang et al. [40] study the frequency dependence of electromagnetic radiation from a finite vibrating piezoelectric body. They approximate the charge by a vibrating electric dipole, to the lowest order pertubatively. This allows for a simple, yet effective, way of calculating the power, its frequency dependence, and resonances of the system.

Zhu and Dai [41] derive uniqueness conditions for dynamic solid-solid phase transitions. Within a strain-gradient continuum model with an internal variable, a traveling-wave solution is obtained, which sets the propagation condition for phase boundaries. The relationship between the propagation speed of the phase boundary and the loading rate remarkably agrees with experimental fits.

Zurlo and Truskinovsky [42] develop a new theory of the mechanics of surface growth, including both non-incremental and incremental approaches. They discuss analytically tractable examples based on 1D bars on a Winkler foundation, which shed light on the roles of compatible and incompatible plastic strains.

Finally, we make no apologies for the title of this special issue. Some might find it a bit extravagant, but we know that it is in line with Gérard's ambition as a scientist; he would have loved it. He is greatly missed, not only as a scientific researcher and colleague, but also as a *bon vivant*, a good company with sharp wit and intellect, always a pleasure to talk with and learn from.

Each paper in this special issue was peer-reviewed by experts who did not take part in the special issue as authors. We are most

grateful to the Editor-in-Chief of *Mechanics Research Communications*, Professor Anthony D. Rosato, for his continued support in putting this special issue together.

Ivan C. Christov*
School of Mechanical Engineering, Purdue University, West Lafayette, IN 47907, USA

Michel Destrade
School of Mathematics, Statistics and Applied Mathematics, NUI Galway, University Road, Galway H91 TK33, Ireland

*Corresponding author.
E-mail address: christov@purdue.edu (I.C. Christov)

References

[1] A. Agosti, A.L. Gower, P. Ciarletta, The constitutive relations of initially stressed incompressible Mooney–Rivlin materials, Mech. Res. Commun. (2018), doi:10.1016/j.mechrescom.2017.11.002.
[2] A. Bacigalupo, M. Paggi, F. Dal Corso, D. Bigoni, Identification of higher-order continua equivalent to a Cauchy elastic composite, Mech. Res. Commun. 93 (2018) 11–22.
[3] M. Ben Amar, Creases and cracks in finite elasticity, Mech. Res. Commun. 93 (2018) 23–29.
[4] N. Benkaci, G.A. Maugin, Numerical computation of the *J* integral for piezo-ceramic materials, Mech. Res. Commun. 28 (2001) 41–48.
[5] A. Berezovski, Internal variables associated with microstructures in solids, Mech. Res. Commun. 93 (2018) 30–34.
[6] F. dell'Isola, J. Pouget, M. Rousseau, Gérard A. Maugin: Engineering scientist. Celebrating his 70th anniversary, Arch. Appl. Mech. 84 (2014) 1221–1227.
[7] B. Detmann, On models for porous media containing one, two or three pore fluids and the determination of associated macroscopic material parameters, Mech. Res. Commun. 93 (2018) 35–40.
[8] A. DiCarlo, A major serendipitous contribution to continuum mechanics, Mech. Res. Commun. 93 (2018) 41–46.
[9] L. Dorfmann, R.W. Ogden, The effect of deformation dependent permittivity on the elastic response of a finitely deformed dielectric tube, Mech. Res. Commun. 93 (2018) 47–57.
[10] H. Elettro, A. Antkowiak, S. Neukirch, The heavy windlass: Buckling and coiling of an elastic rod inside a liquid drop in the presence of gravity, Mech. Res. Commun. 93 (2018) 58–61.
[11] J. Engelbrecht, T. Peets, K. Tamm, Solitons modelled by Boussinesq-type equations, Mech. Res. Commun. 93 (2018) 62–65.
[12] M. Epstein, Laminated uniformity and homogeneity, Mech. Res. Commun. 93 (2018) 66–69.
[13] V.A. Eremeyev, L.P. Lebedev, M.J. Cloud, Acceleration waves in the nonlinear micromorphic continuum, Mech. Res. Commun. 93 (2018) 70–74.
[14] A. Goriely, Five ways to model active processes in elastic solids: active forces, active stresses, active strains, active fibers, and active metrics, Mech. Res. Commun. 93 (2018) 75–79.
[15] S. Imatani, G.A. Maugin, A constitutive model for material growth and its application to threedimensional finite element analysis, Mech. Res. Commun. 29 (2002) 477–483.
[16] R.S. Keiffer, P.M. Jordan, I.C. Christov, Acoustic shock and acceleration waves in selected inhomogeneous fluids, Mech. Res. Commun. 93 (2018) 80–88.
[17] M. Lazar, E. Agiasofitou, Eshelbian dislocation mechanics: ***J***-, *M*-, and ***L***-integrals of straight dislocations, Mech. Res. Commun. 93 (2018) 89–95.
[18] M. Lazar, G.A. Maugin, A note on line forces in gradient elasticity, Mech. Res. Commun. 33 (2006) 674–680.
[19] J.C. López-Realpozo, R.O. Caballero-Pérez, R. Rodríguez-Ramos, R. Guinovart-Dáz, J. Bravo-Castillero, H. Camacho-Montes, Y. Espinosa-Almeyda, F.J. Sabina, P.C. Vinh, Analysis of mechanical and electrical imperfect contacts in piezoelectric composites, Mech. Res. Commun. 93 (2018) 96–102.
[20] L.G. Margolin, A. Hunter, Discrete thermodynamics, Mech. Res. Commun. 93 (2018) 103–107.
[21] G.A. Maugin, Eshelbian mechanics of materials, Mech. Res. Commun. 29 (2002) 447.
[22] G.A. Maugin, Remarks on the Eshelbian thermomechanics of materials, Mech. Res. Commun. 29 (2002) 537–542.
[23] G.A. Maugin, On canonical equations of continuum thermomechanics, Mech. Res. Commun. 33 (2006) 705–710.
[24] G.A. Maugin, Solitons in elastic solids (1938–2010), Mech. Res. Commun. 38 (2011) 341–349.
[25] G.A. Maugin, Sixty years of configurational mechanics (1950–2010), Mech. Res. Commun. 50 (2013) 39–49.
[26] G.A. Maugin, The saga of internal variables of state in continuum thermo-mechanics (1893–2013), Mech. Res. Commun. 69 (2015) 79–86.
[27] W. Muschik, Gérard A. Maugin, 60 years young, J. Non-Equilib. Thermodyn. 29 (2004) 205–208.
[28] M. Ostoja-Starzewski, R. Khayat, Oldroyd fluids with hyperbolic heat conduction, Mech. Res. Commun. 93 (2018) 108–113.
[29] F. Parisio, D. Naumov, O. Kolditz, T. Nagel, Material forces: an insight into configurational mechanics, Mech. Res. Commun. 93 (2018) 114–118.
[30] G. Petsos, A. Konstantinidis, E.C. Aifantis, On the role of higher order deformation gradients in necking, spinodal decomposition and neuron firing, Mech. Res. Commun. 93 (2018) 119–123.
[31] A.V. Porubov, I.D. Antonov, D.I. Indeitsev, A.L. Fradkov, Mechanical system allowing distributive control with feedback, Mech. Res. Commun. 93 (2018) 124–127.
[32] J. Pouget, Remembrance of Gérard Maugin, Wave Motion 72 (2017) A1–A12.
[33] E. Pucci, G. Saccomandi, A remarkable generalization of the Zabolotskaya equation, Mech. Res. Commun. 93 (2018) 128–131.
[34] K.R. Rajagopal, A note on the linearization of the constitutive relations of non–linear elastic bodies, Mech. Res. Commun. 93 (2018) 132–147.
[35] M. Rubin, M.M Safadi, Elastic incompressibility in growing materials – a constraint that does work, Mech. Res. Commun. 93 (2018) 138–140.
[36] A. Salupere, M. Ratas, On the application of 2D discrete spectral analysis in case of the KP equation, Mech. Res. Commun. 93 (2018) 141–147.
[37] Y. Starosvetsky, A. Vainchtein, Solitary waves in FPU lattices with alternating bond potentials, Mech. Res. Commun. 93 (2018) 148–153.
[38] H. Tian, M. Potier-Ferry, F. Abed-Meraima, A numerical method based on Taylor series for bifurcation analyses within Föppl–von Karman plate theory, Mech. Res. Commun. 93 (2018) 154–158.
[39] I. Tsagrakis, I.S. Yasnikov, E.C. Aifantis, Gradient elasticity for disclinated micro crystals, Mech. Res. Commun. 93 (2018) 159–162.
[40] G. Yang, J. Du, J. Wang, J. Yang, Frequency dependence of electromagnetic radiation from a finite vibrating piezoelectric body, Mech. Res. Commun. 93 (2018) 163–168.
[41] P. Zhu, H.-H. Dai, Uniqueness condition for dynamical phase transitions in a shape memory alloy bar, Mech. Res. Commun. 93 (2018) 169–173.
[42] G. Zurlo, L. Truskinovsky, Inelastic surface growth, Mech. Res. Commun. 93 (2018) 174–179.