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Original
Preface to the Special Issue in Memory of Prof. Gaetano Giaquinta / Federico, Salvatore; Grillo, Alfio. - In: MATHEMATICS AND MECHANICS OF SOLIDS. - ISSN 1081-2865. - STAMPA. - (2018). [10.1177/1081286518766746]

Availability:
This version is available at: 11583/2723263 since: 2020-06-03T00:15:40Z

Publisher:
SAGE PUBLICATIONS

Published
DOI:10.1177/1081286518766746

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09 November 2022

Preface to the Special Issue in Memory of Prof. Gaetano Giaquinta (1945-2016)

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Mathematics and Mechanics of Solids, 2020, Vol. 25(5), 1042-1045

DOI: 10.1177/1081286518766746

Published online 2018-05-11

This special issue of *Mathematics and Mechanics of Solids* is dedicated to the memory of our *maestro* and mentor Gaetano Giaquinta, Professor of Structure of Matter at the University of Catania, Italy, who passed away on the 13$^{\text{th}}$ of August 2016, after a long battle against cancer.

Gaetano Giaquinta was born in Catania, Italy, on the 28$^{\text{th}}$ of November 1945, and received his *laurea* in Physics on the 20$^{\text{th}}$ of November 1968, after defending a thesis entitled "*Josephson Currents in Superconducting Junctions with a non-Conventional Insulator*" [1]. With his pioneering work, Gaetano Giaquinta was the one who initiated the research on Superconductivity at the University of Catania [2].

Since the early years of his career, the scientific and academic life of Gaetano Giaquinta was characterised by many recognitions both at the national and at the international level. From 1972 to 1991, he held numerous invited seminars and lectures in congresses, workshops, international schools, and prestigious universities and scientific institutions. Moreover, from 1969 to 2013, he authored several articles and monographs, published in scientific journals and book series.

Having been educated as a theoretical physicist with a strong background in Quantum Mechanics and, in particular, in Structure of Matter and Solid State Physics, Gaetano Giaquinta's main scientific interests were electronic tunnelling and phonon spectroscopy, thermodynamic fluctuations of the order parameter in superconductors of type I, excitonic superconductivity in metal-dielectric coupled systems and in biological systems, Kosterlitz-Thouless-Berenzinskii transitions in two-dimensional superconductors, granular and mesoscopic superconductors, quantum size effect in degenerate semiconductors, high temperature superconductivity, vortex-antivortex pair dissociation in two-dimensional superconductors and gauge theories. From 2002 to 2009, his research turned to Continuum Mechanics and Biomechanics and, in particular, to problems involving growth, remodelling and transport phenomena in biological tissues. The last years of his scientific activity, from 2009 to 2012, were devoted to some fundamental aspects of Analytical Mechanics and Electromagnetism. He served the scientific community as an organiser of symposia and conferences, as a reviewer for scientific journals and as a book editor.

Our relationship with Prof. Giaquinta started with him as the Physics professor whom everyone was talking about, and us as undergraduate students, and then evolved into a relationship of research collaboration and, naturally, as the very strong friendship between a professor and his last disciples.

In his career as a professor at the University of Catania, Prof. Giaquinta taught several courses of Physics in different study programmes, these ranging from Medicine to Geology, Physics and Engineering. His "home-faculty", however, was the Faculty of Engineering, where he felt that he had the mission of "making" engineers. His idea was that each student had to be a person of culture and an intellectual. In his courses of Physics I (Mechanics and Thermodynamics), Physics II (Electromagnetism), Structure of Matter and Solid State Physics, he polarised his audience. Faithful to the Latin etymology *universitas studiorum* (the *totality* of the possible courses of study) of "university", he would enrich his Physics classes with Philosophy, Literature, History, Art, Latin and Greek. Most students continuously showed manifestations of sheer love for him, even though some others could just not get used to his eclectic teaching style. Many were those students who came all the way from other programmes and even other faculties to attend a lecture of this "living legend".

The list of anecdotes on Prof. Giaquinta's lectures is virtually endless, and we shall report just a few. At the beginning of each course, he used to state that:

> *"The course is based on three principal languages and one auxiliary language. The principal ones are Latin, Sicilian and English. The auxiliary one is Italian."*

Although he was exaggerating, some lectures were really like that, and for most students those were the most memorable. One of the first questions that he would ask his students in the first lecture of a course was: *"What is a vector?"*, to which there was always that diligent, but unlucky student, who would confidently answer: *"An entity endowed with magnitude, direction and sense!"*. At that point Prof. Giaquinta would smile and say: *"No, my dear: it is an element of a vector space"*.

Sometimes, during oral exams (which were normal examination practice in Italy), Prof. Giaquinta would take his copy of *Mechanics* [3] or of *The Classical Theory of Fields* [4] by Landau and Lifshitz and would tell the examinee:

> *"Swear on Landau's book that you shall not say nonsense!"*

Once, he asked a student to enunciate the Second Principle of Thermodynamics. The student had stumbled into a topic that he had not quite understood, but quite confidently recited that *"it is impossible to transfer heat from a low-temperature body to a high-temperature body"*. Prof. Giaquinta patiently tried to guide him towards the correct answer, but the student continued rephrasing exactly the same idea over and over again, until Prof. Giaquinta exclaimed:

> *"Spontaneously! You must add* spontaneously*! Otherwise it means that the electric company is stealing your money to make your fridge work!"*

In love with Analytical Mechanics, in his lectures he always cited Lagrange's *Méchanique Analitique* and the works by Maupertuius, Poisson, D'Alembert and Hamilton, and he educated his students since the first-year Physics I course to Lagrangian and Hamiltonian Mechanics. Two of his favourite mottoes were "*Physics—where the Action is!*" [5] and the quotation of Dirac's sentence: *"*[...] *there are reasons for believing that the Lagrangian one* [formulation] *is the most fundamental"* [6]. His first lecture in any of his courses would always be on Hamilton's Principle of Stationary Action, the search for extrema of the action functional and the derivation of the Euler-Lagrange equations. Thus, for all of his students, the basics of Mechanics and Electromagnetism coincided with the Euler-Langrange equations associated with the Lagrangian function of the problem at hand. Furthermore, the key-concepts of modern physics known as gauge theories, symmetry breaking and its dynamic restoring were always present in his speeches and lectures.

After a pause from scientific life due to severe health problems, Prof. Giaquinta returned on the stage of science in 2002 and then, until 2012, he was again surrounded by *Laurea* and PhD students. This last period of his activity started with Alfio Grillo (AG), who was his *Laurea* and PhD student as well as post-doctoral fellow, and continued with Dr. Giandomenico Zingali, Diego M. Borrello, Dr. Marco Caruso and Marco Coco. All through these years, Salvatore Federico (SF) was a faithful and permanent "tangential affiliate" of the group.

Around 2002, in fact, Prof. Giaquinta's career as a theoretical physicist had an unexpected shift from Quantum Mechanics to Continuum Mechanics. At that time, we (SF and AG) were moving our first steps in this field. Prof. Giaquinta guided us from the vantage point of an experienced researcher, professor and mentor. This all started when AG was working on a growth mechanics problem that had been suggested by Prof. Marcelo Epstein (The University of Calgary) and SF. With the idea of reinterpreting the results of Prof. Marcelo Epstein and Prof. Gérard A. Maugin [7] under the light of the methods of Classical Field Theory acquired from the lectures held by Prof. Giaquinta, AG and SF turned to Prof. Giaquinta for advise and help. As an expert of the subject, he offered his supervision and, with the collaboration of Prof. Walter Herzog (The University of Calgary) and Prof. Guido La Rosa (University of Catania), we produced our first team work [8].

Some years later, while AG was a PhD student of Prof. Giaquinta, SF invited AG and Prof. Giaquinta to contribute to his research project on the microstructural modelling of articular cartilage (this project was conducted in collaboration with Prof. Walter Herzog and Prof. Guido La Rosa). In 2004, during a meeting that involved SF, Dr. Sang-Kuy Han (at the time, visiting PhD student at the University of Catania from Prof. Herzog's group), AG and Prof. Giaquinta, SF showed an image that reported the distribution of the orientation of the collagen fibres in a sample of articular cartilage. Together with that image, which was obtained

experimentally, SF also showed an empirical curve of sigmoidal shape that described the mean orientation angle of the collagen fibres as a function of the coordinate running from the bone-cartilage interface to the articular surface. When Prof. Giaquinta saw those figures, he exclaimed:

> *"This is a structural phase transition and it has to be describable by a Ginzburg-Landau free energy ..."*

The suggestions given by Prof. Giaquinta were very useful for producing our first team work on a microstructurally consistent mechanical model of articular cartilage [9]. However, the model of articular cartilage based on the Ginzburg-Landau free energy [10, 11] became reality only many years later and after several discussions between AG and Prof. Giaquinta. This model led to a "conclusive" team work on the subject, authored by AG, SF and Dr. Melania Carfagna (AG's former PhD student) [12].

Although Prof. Giaquinta could dedicate to Continuum Mechanics only the last years of his career, his interest for this field of research made him undertake the organisation of the eighth edition of the international seminar *Geometry, Continua and Microstructure - GCM8*, which was held in Catania, Italy, from the 10^{th} to the 12^{th} of October 2008 (www.dmfci.unict.it/users/gcm8/). Together with Prof. Gérard A. Margin, Prof. Milan V. Mićunović and Prof. Robin W. Tucker, he edited the collection of contributed papers "Geometry, Continua and Microstructure 2008, *Il Nuovo Cimento C* of the *Società Italiana di Fisica* (Italian Physical Society)", published in 2009 (www.sif.it/riviste/ncc/econtents/2009/032/01).

From 2009, Prof. Giaquinta was corresponding member of the *Accademia Peloritana dei Pericolanti* of Messina, Italy, (ww2.unime.it/accademiapeloritana/) and, in the last years of his life, he continued his commitment to promote science, art and culture in general as Chair of the scientific committee of the Floresta Longo Foundation (http://en.fondazioneflorestalongo.it) (Catania, Italy).

What made a great man out of Prof. Giaquinta was his need to transmit his huge culture to the younger generations. In fact, he "professed" Physics, and he did it for his students. The most important recipients of his cultural message were in fact the young people that were around him in his lectures or in the corridors of the Faculty of Engineering. To them he devoted his life, while talking about the beauties of Physics and the challenge of discovering its fundamental laws in a poem or a painting.

Among the last disciples of Prof. Giaquinta, we are so far the only ones who have pursued an academic career. We therefore felt that it was our duty to pay this tribute to our *maestro*, who has so deeply influenced our way to conceive science and life.

In this special issue, we have five contributions. Cuomo [13] proposes to describe scale effects in plasticity by means of a second-gradient material model, which employs different evolution laws at the microscopic and macroscopic scales; the model is aimed at the study of metamaterials. Epstein and de León [14] provide an introduction to the use of the differential geometrical concepts of Lie groupoids and Lie algebroids in Continuum Mechanics for the description of material properties and material defects, respectively. Mićunović and Kudrjavceva [15] use the effective field approach to retrieve the fourth-order elasticity tensor and to study the damage evolution of a composite with a void phase and a short fibre phase, with an application to the damage-elasto-viscoplastic strain of an industrial steel. Lo Giudice et al. [16] present a mathematical model aimed at reproducing the kinematic evolution of the surface of sand piles and dunes and at predicting stationary configurations; the study is corroborated by a comparison with experimental results. Wittum et al. [17] study a model of the barrier function of the skin tissue, by treating the extracellular space with full spatial resolution, considering the cells being of both hexagonal prismatic shape and tetrakaidekadehedral shape, and considering vertical cell stacking.

We would like to close this Preface with a quote from Prof. Giaquinta, which may help the Readers understand the man he was (this quote can be found in the website www.tonynicotra.it, of the Italian painter Tony Nicotra):

> *"Art and Quantum Dynamics, complementary fields that reflect the reality of universal symmetry."*

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[2] The information contained in this Preface is extracted from Prof. Giaquinta's *Curriculum Vitae et Studiorum*, available on line at `http://fondazioneflorestalongo.it/team/gaetano-giaquinta/`, and from our personal knowledge of Prof. Giaquinta.

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