A TRIBUTE TO PROFESSOR PHILIPPE G. CIARLET ON HIS 70TH BIRTHDAY

HERVÉ LE DRET

Laboratoire Jacques-Louis Lions, Université Pierre et Marie Curie, B.C. 187, 75252 Paris, France

VICENŢIU D. RĂDULESCU

Institute of Mathematics "Simion Stoilow" of the Romanian Academy,
P.O. Box 1-764, 014700 Bucharest, Romania
Department of Mathematics, University of Craiova, 200585 Craiova, Romania

RODERICK S. C. WONG

Department of Mathematics, City University of Hong Kong, Kowloon, Hong Kong

Professor Philippe G. Ciarlet was born on October 14, 1938, in Paris. He obtained his undergraduate degree in 1961 from the celebrated École Polytechnique in Paris, followed by graduate studies (1962-1964) at the École Nationale des Ponts et Chaussées in Paris. Professor Ciarlet received in 1966 his Ph.D. at the Case Institute of Technology, Cleveland, U.S.A., under the guidance of Professor Richard S. Varga. The title of his Ph.D. thesis is *Variational Methods for Non-Linear Boundary-Value Problems.* He continued with a Doctorat d'État (*Fonctions de Green Discrètes et Principe du Maximum Discret*) at the University of Paris in 1971 and his advisor was Professor Jacques-Louis Lions.

Philippe G. Ciarlet was Professor at the Université Pierre et Marie Curie in Paris between 1974 and 2002. He was also a senior member of the Institut Universitaire de France from 1996 to 2006. Since 2002 Professor Philippe G. Ciarlet is Chair Professor at the City University of Hong Kong. Other distinguished positions include:

– Head of the Department of Mathematics, Laboratoire Central des Ponts et Chaussées, Paris (1966-1973);

– Maître de Conférences at École Polytechnique in Paris (1967-1985);

– Scientific consultant at I.N.R.I.A. (1974-1994);

– Professor at the École Normale Supérieure in Paris (1978-1987);

– Head of the Laboratoire d'Analyse Numérique, Université Pierre et Marie Curie (1981-1992).

Professor Ciarlet was elected a Member of seven academies: Academia Europaea (1989), French Academy of Sciences (1991), Romanian Academy (1996), French Academy of Technologies (2000), National Academy of Sciences of India (2001), European Academy of Sciences (2003), and TWAS: Academy of Sciences for the Developing World (2007). He also holds seven Honorary Doctorates, from Chinese and Romanian universities.

Professor Philippe G. Ciarlet has held visiting positions at several places, including University of Pavia, Tata Institute of Fundamental Research in Bangalore, University of Göteborg, Imperial College in London, University of Louvain, University of Kyoto, University of Tokyo, Cornell University, University of California at

Berkeley, University of Maryland, École Polytechnique Fédérale in Lausanne, Beijing University, Fudan University, University of Wisconsin at Madison, University of Texas at Austin, University of Stuttgart, University of Santiago de Compostela, University of Houston, Brown University, Stanford University, Courant Institute, Istituto Mauro Picone in Rome, E.T.H. Zürich, University of Heidelberg, University of Bucharest, Tel Aviv University, Institute of Mathematics of the Romanian Academy, Kyushu University, Oxford University, Tsinghua University of Beijing, etc.

During his long and very prestigious career, Professor Philippe G. Ciarlet has been coordinator of several important research projects and organizer of high-level scientific meetings. A partial list of such activities include the following:

– Local Project leader, European Scientific Cooperation Project on "Mathematical Problems in Nonlinear Mechanics", 1987-1990;

– Project leader and coordinator, "Junctions in Elastic Multi-Structures", European Cooperation "S.C.I.E.N.C.E." Program, 1991-1993;

– Organizer (with K. Kirchgässner) of the Conference "Lower-Dimensional Theories and Domain Decomposition Methods in Mechanics", Oberwolfach, 20-24 July 1992;

– Project leader and coordinator, "Shells : Mathematical Modeling and Analysis, Scientific Computing", European Cooperation "Human Capital and Mobility" Program, 1995-1997;

– Chair, Academic Advisory Committee, École Polytechnique, Palaiseau (1997-2002);

– Co-Director (with Li Ta-tsien) of the Chinese-French Institute of Applied Mathematics, Paris and Shanghai (1999-2001);

– Organizer (with D. Arnold, I. Babuška, F. Brezzi and J. Pitkäranta) of the Workshop "Shells: Modeling, Analysis and Numerics", Mathematical Sciences Research Institute, Berkeley, 17-28 April 2000;

– Organizer (with Li Ta-tsien and A. Piriou) of the ISFMA Symposium - CIMPA School "Plates and Shells", Fudan University, Shanghai, 20-31 August 2001;

– Organizer (with Roderick Wong) of the "International Conference on Nonlinear Partial Differential Equations - Theory and Approximation", City University of Hong Kong, 29 August - 02 September 2002;

– Organizer (with Felipe Cucker) of the "Department of Mathematics Colloquium", City University of Hong Kong, since September 2002;

– Deputy Director of the Liu Bie-Ju Centre for Mathematical Sciences, since October 2002;

– Member, Council of the Légion d'Honneur Club-Hong Kong Chapter, since November 2002;

– Organizer of the "France-Hong Kong Distinguished Lecture Series", a series of high-profile lectures under the auspices of the French Academy of Sciences, organized jointly by the Consulate General of France in Hong Kong, the French Academy of Sciences, and City University of Hong Kong, since January 2005;

– Organizer of the session "Applied Differential Geometry" at the "Third Pacific Rim Conference on Mathematics", Fudan University, Shanghai, 17-21 August 2005;

– Organizer (with Li Ta-tsien) of the ISFMA Symposium - CIMPA School "Differential Geometry: Theory and Applications", Fudan University, Shanghai, 07-18 August 2006;

– Head of the Division of Mathematics and Computer Science of the European Academy of Sciences, Brussels, since March 2007.

Professor Philippe G. Ciarlet is a scientist of remarkable prescience and immense energy. His vision has extended to the development of entire areas of mathematical science. He has understood that mathematics can make a great contribution to science. The mathematical work of Professor Philippe G. Ciarlet is at the same time very diverse and well unified. His main research contributions are in applied and computational mathematics. The main themes of works developed by Professor Philippe G. Ciarlet are the following:

Numerical analysis of finite difference methods and general variational approximation methods: Discrete Green's functions; discrete maximum principle and convergence; nonlinear problems of monotone type.

Numerical analysis of the finite element method in general: Lagrange and Hermite interpolation theory in $\mathbb{R}^n$; discrete maximum principle and uniform convergence; curved finite elements; numerical integration.

Numerical analysis of the finite element method applied to problems in elasticity and fluid mechanics: Non-conforming finite elements and macro-elements for plate problems; mixed method for the biharmonic equation in fluid mechanics; finite element methods for shell problems.

Modeling and mathematical analysis in three-dimensional linearized and nonlinear elasticity: Existence of solutions; incremental methods; modeling of constitutive equations; modeling of contact and non-interpenetration; weak form of Saint-Venant compatibility equations.

Mathematical analysis of the von Kármán and generalized von Kármán equations: Existence, multiplicity, and bifurcation of solutions, equivalence with a "displacement" problem.

Modeling of plates by the techniques of asymptotic analysis and singular perturbations: Convergence to a two-dimensional model in the linear case; justification of two-dimensional model, including the von Kármán equations, in the nonlinear case by formal asymptotic expansions; extension to "shallow shells"; "generalized" von Kármán and Marguerre-von Kármán equations.

Modeling, mathematical analysis, and numerical simulation of "elastic multi-structures" that comprise junctions: Convergence to a "pluri-dimensional" model in the linear case; justification of the boundary conditions of clamping for a plate; vibrations of a multi-structure.

Modeling and mathematical analysis of general shells: Existence theorems for two-dimensional linear shell models (W.T. Koiter, P.M. Naghdi, "flexural", "membrane"); justification of two-dimensional linear shell models ("membrane" and "flexural" equations; W.T. Koiter's equations) by the techniques of asymptotic analysis; existence theory for nonlinear shell equations; definition of a new nonlinear shell model "of Koiter's type"; intrinsic shell equations.

Differential geometry: Inequalities of Korn's type on a surface; rigidity theorems and manifold theory; recovery and continuity of a manifold, with or without boundary, as a function of its metric tensor; nonlinear Korn inequality in an open set of $\mathbb{R}^n$; recovery of a surface, with or without boundary, with prescribed first and second fundamental forms; continuity of a surface, with or without boundary, considered as a function of its two fundamental forms; nonlinear Korn inequality on a surface.

The mathematical output of Professor Philippe G. Ciarlet is immense. He has written 15 books; most have become classics, often being translated into several foreign languages. It is fair to say that his books *The Finite Element Method for Elliptic Problems*, North-Holland, Amsterdam (1978), *Les Équations de von Kármán*, Springer-Verlag, Berlin (1980), *Introduction à l'Analyse Numérique Matricielle et à l'Optimisation*, Masson, Paris (1982), *Mathematical Elasticity, Vol. I: Three-Dimensional Elasticity*, North-Holland, Amsterdam (1988), *Mathematical Elasticity, Vol. II: Theory of Plates*, North-Holland, Amsterdam (1997), *Mathematical Elasticity, Vol. III: Theory of Shells*, North-Holland, Amsterdam (2000), *An Introduction to Differential Geometry, with Applications to Elasticity*, Springer-Verlag, Heidelberg (2005), did very much to stimulate research interest in analytic approaches to nonlinear problems in the physical sciences. Professor Philippe G. Ciarlet has also written more than 170 papers. The different themes of his work have been briefly described in this survey, in an order that approximately follows their chronology.

Professor Philippe G. Ciarlet produced dozens of master's and more than 50 Ph.D. students. Currently, most of them enjoy very high positions in industries or at academic institutions.

Professor Philippe G. Ciarlet has served as an editor or a member of the editorial boards of several prestigious journals, including Applicable Analysis, Asymptotic Analysis, Chinese Annals of Mathematics, Comptes Rendus de l'Académie des Sciences, Computers and Mathematics with Applications, ESAIM: Control, Optimisation and Calculus of Variations, Foundations of Computational Mathematics, Journal de Mathématiques Pures et Appliquées, Journal of Computational Mathematics, Journal of Elasticity, Mathematical Models & Methods in Applied Sciences, Mathematics and Mechanics of Solids, Modélisation Mathématique et Analyse Numérique, Numerical Algorithms, Numerical Linear Algebra with Applications, Numerical Methods for Partial Differential Equations, Numerische Mathematik. Currently, he is a Co-Editor-in-Chief of Analysis and Applications.

Professor Philippe G. Ciarlet is a fine gentleman and an exceptional person in many respects. He is a charismatic man, generous, very open and accessible, with an ability to mitigate conflicts and contentious situations. One of the most striking aspects of his personality is his long-term vision. He has many good ideas, and he has had the mathematical talent, the physical strength, and the understanding of people needed to implement them.

The above summary gives an impression (not a full one) of the wide scope and broad interests of Professor Ciarlet's research and outstanding career. His work has been influential both among mathematicians and among mechanicians, which makes him a true representative of the field of applied mathematics. He has a deep intuition as well as an impressive technical mastery. He enjoys scientific interactions, whether in the form of collaborations or enlightening discussions. Throughout his long and prestigious career, Professor Philippe G. Ciarlet has always been a wonderful enthusiast and generous in his encouragement for all matters pertaining to the nonlinear sciences. We wish him many enjoyable years to come.

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E-mail address: herve.le_dret@upmc.fr
E-mail address: vicentiu.radulescu@imar.ro
E-mail address: rscwong@cityu.edu.hk