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PREFACE

Professor Hiroshi Matano was born in Kyoto, Japan, on July 28th, 1952. He studied at Kyoto University, where he prepared his doctoral thesis under the supervision of Professor Masaya Yamaguti. He obtained his first academic position as a research associate at the University of Tokyo. He then moved to Hiroshima University in 1982 and came back to Tokyo in 1988. He is a Professor at the Graduate School of Mathematical Sciences at the University of Tokyo since 1991.

He has also been a visiting Professor at universities all over the world, including the University of Arizona, the University of Wisconsin, the University of Minnesota, the University of Tours, the Universities of Paris, Orsay and Cergy-Pontoise, the University of Rome, the University of Heidelberg, Johns Hopkins University, the University of Chicago, as well as a number of various other institutions.

His main field of research is the qualitative theory of nonlinear diffusion equations and nonlinear elliptic equations. He is particularly interested in how the geometry of the spatial domain influences the properties of solutions such as stability. He is also interested in studying the global dynamical structure of various nonlinear diffusion equations by using the theory of infinite-dimensional dynamical systems.

Among other things, he studied nonlinear diffusion equations in several space dimensions and discovered that nonconstant stable stationary states can exist even in a spatially uniform diffusive media provided that the domain is dumbell-shaped (1979).

His other work includes: the introduction of the lap-number argument (or zero-number argument) in the qualitative study of one-dimensional parabolic equations; the development of the theory of order-preserving dynamical systems and its applications to various partial differential equation; the study of blow-up phenomena and other singularities in nonlinear heat equations and elliptic equations; geometrical and dynamical properties of the Stefan problem and other free boundary problems. More recently he has also been interested in some singular perturbation problems and in travelling waves in heterogeneous media.

In addition to his fundamental contributions in mathematics, Hiroshi Matano's profound work has had and continues to have considerable impact in applications reaching beyond the field of partial differential equations. His lectures are extremely clear and elegant and he brings an enormous inspiration to his colleagues and students; he is and has been an invited lecturer at most prestigious institutions and conferences. In particular he was an invited speaker at the International Congress of Mathematics ICM 94 in Zürich and a laureate of the Spring Prize of the Mathematical Society of Japan in 1990. He is on the editorial board of a number of international journals including the Proceedings of Royal Society of Edinburgh, the journal of Dynamics and Differential Equations, Discrete and Continuous Dynamical Systems, and others.

Hiroshi Matano promotes collaboration between Japanese, European and American scientists, and organizes many international conferences, among which the

SNP Worshops, Singularities Arising in Nonlinear Problems, where he invites scientists from all over the world. Let us add that he is a coordinator of ReaDiLab (Reaction-Diffusion Laboratory), which is an international laboratory (LIA) of the French CNRS. Today Hiroshi is 60, and his lectures are as beautiful and inspiring as ever. We wish him good health and hope that he will continue to produce deep mathematical articles for very many years.

The aim of this special issue of the Journal Network and Heterogeneous Media is to present a collection of papers which represent recent progress in the field of nonlinear partial differential equations, as well in the theoretical aspects as in their applications to complex systems. The idea of this issue grew while organizing the International Conference entitled : "Nonlinear Partial Differential Equations: Theory and Applications to Complex Systems, An International Conference in honor of Hiroshi Matano", which was held at IHES, Bures-sur-Yvette, France in June 2012. This conference, whose themes were centered around reaction-diffusion systems, was organized by the five editors of the present special issue.

This volume covers a large area in the field of elliptic and parabolic equations, including mathematical modeling in biology, various topics around reaction-diffusion systems such as travelling waves, pulses, as well as more intricated patterns, phase transition problems and numerical methods.

In the field of mathematical modelling, an article deals with growth regulation and the insuline signaling pathway; mathematically it comes to solve a large system of reaction-diffusion equations coupled to ODE's through boundary values. Other articles involve topics from epidemiology, such as interactions between compartments of hosts in the Ross-Macdonald Malaria transmission system, and the analysis of a spatially structured SI epidemic model with vertical transmission, a logistic effect on vital dynamics and a density dependent incidence, where the authors prove the existence of an infinite number of travelling wave solutions. Another study concerns the spread of viral infection of immobilized bacteria, which are modeled by a reaction-diffusion system with a distributed time delay; it turns out that there exist traveling wave solutions with a unique spreading speed for virus infection. A model involving the stochastic control of traffic patterns is also presented; in particular it appears that a stochastic modulation of the safety distance can reduce traffic jams.

The existence of segregated travelling wave solutions is proved for a system of partial differential equations describing the effect of contact inhibition in growth processes of normal and abnormal cells. Also the existence of travelling wave solutions is proved for a bistable equation on a strip with a nonlinear boundary condition. An essential problem is to understand spreading and invasion in heterogeneous media, which motivates the proof of existence of travelling fronts for heterogeneous monostable and bistable reaction-diffusion equations on $\mathbf{R^N}$. The existence of travelling fronts of pyramidal shape of a competition-diffusion system in $\mathbf{R^N}$ is also established. A result due to Bramson about the logarithmic delay of the position of the solution of the Fisher-KPP reaction-diffusion equation with respect to the travelling front of minimal speed is now proved by PDE methods. Moreover, a study is performed for the wavespeed selection in the heterogeneous Fisher equation in the case of slowly varying inhomogeneities. The effect of several type of boundary conditions, Dirichlet, Neumann and Robin, on the dynamics of pulse solutions of reaction-diffusion systems on a half line is also studied.

While reaction-diffusion systems possess rather simple patterns such as travelling waves and single pulse solutions, their solutions can also exhibit more complex patterns. In this context, we should mention the proof of the existence and uniqueness of the unstable eigenvalue for the linearized equation around a stripe pattern for the Gierer-Meinhardt equation. The analysis of minimal conditions for the formation of diffusion-driven instabilities in the sense of Turing is performed for a class of kinetic equations with mass conservation. The study of patterns is an essential tool for understanding vision which motivates the study of a spatialized model of textures perception using structure tensor formalism.

Finally let us mention results in the field of phase transition problems, with in particular a homogenized description of multiple Ginzburg-Landau vertices pinned by small holes, where the mathematical proofs are based upon a Γ-convergence approach. In the context of mean curvature flow, formal asymptotic expansions are given for ancient convex and compact solutions of curve shortening. Moreover, numerical schemes for the evolution of motion by volume preserving mean curvature flow show how non-convex closed plane curves become convex very fast under this flow. A numerical comparison is performed between the solutions of the degenerate and non-degenerate deep-quench obstacle problems, which appear as limits of the Cahn-Hilliard equation, and new upper bounds for coarsening are given.

We would like to thank all the authors for their efforts to make this special issue a reality. Special thanks are due to Benedetto Piccoli and Corrado Lattanzio for giving us this editorial opportunity and to the many referees of this issue. It is our great pleasure to be able to join the authors in dedicating this volume to Professor Hiroshi Matano.

Guest Editors:

Henri Berestycki, Danielle Hilhorst, Frank Merle,
Masayasu Mimura and Khashayar Pakdaman