Notes on the research biography of Professor Alemdar Hasanov Hasanoğlu[*)]

Prof. Alemdar Hasanov Hasanoğlu is a distinguished scholar in the inverse problems community and well-known expert in the field of inverse problems and mathematical modeling.

He was born in 1954 in Agstafa, Azerbaijan, in the former USSR. The city borders Armenia on the south-western frontier and Georgia on the northern frontier. His mother, Vezire, was a teacher, and his father, Ibrahim, was director of the school, and then Head of the Education Department of the Qazahk Region, Azerbaijan. Alemdar graduated from high school with honors in June 1971. He won prizes at the Azerbaijan National Mathematical Olympiad two times (1969, 1971). He enrolled in the Mathematics and Mechanics Faculty of Baku State University (BSU), Azerbaijan, in 1971. At that time, BSU was one of the top research universities in the USSR, especially in the areas of functional analysis and differential equations. In 1974, Alemdar was a winner of the Republican round of the University Olympiad, and was invited to participate in the First Soviet Student Olympiad, organized by one of the twentieth century's greatest mathematicians, Andrey Nikolaevich Kolmogorov, at Moscow State University. He graduated from this university with honors in June 1976, and earned his Master of Science degree in Mathematics.

Alemdar Hasanov began his scientific career as a researcher (1977–1979) at the Institute of Applied Mathematics of the USSR Academy of Sciences, now named after Mstislav Keldysh, in Department No. 3, chaired by Aleksander A. Samarskii, a member of the Russian Academy of Sciences. Aleksander A. Samarskii was not only an outstanding Russian mathematician but also considered a supreme authority in computational mathematics and mathematical modeling in the USSR. In 1979, Alemdar became a PhD student at the Faculty of Computational Mathematics and Cybernetics of Lomonosov Moscow State University, founded in 1970 by Andrey Tikhonov, a Soviet and Russian mathematician and geophysicist known for important contributions to topology, functional analysis, mathematical physics, and ill-posed problems.

Working on his doctoral dissertation, under the scientific supervision of professors Aleksander A. Samarskii and Vladimir B. Andreev, in the department of Mathematical Physics, chaired by Andrey Tikhonov, Alemdar focused on a challenging and important problem, formulated by Jacques-Louis Lions in his famous book Quelques méthodes de résolution des problèmes aux limites non linéaires (Paris, Dunod, 1969), for elliptic variational inequalities (EVI). It is known that the main distinguishing feature of the EVI corresponding to the elliptic operator $A(u,v) := a(u,v)$, $u, v \in \overset{\circ}{H}{}_1(\Omega)$ is that the part $\Gamma_c := \{x \in \partial\Omega : u(x) = 0\}$ of the boundary $\partial\Omega$ of the domain Ω, is also unknown, and needs to be defined. If Γ_c could be found by any way, then the EVI could be transformed into the integral identity $a(u,v) := b(v)$, for all $v \in \overset{\circ}{H}{}_1(\Omega)$. Analyzing the unilateral boundary conditions $u(x) \geq 0$, $\partial u / \partial n_A \geq 0$, $(\partial u / \partial n_A) \cdot u = 0$ Lions pointed out that the most important problem here is the study of the behavior of the solution of EVI on perturbed boundaries $\widetilde{\Gamma}_c \subset \Gamma_c \subset \partial\Omega$ and $\widetilde{\Gamma}_c \supset \Gamma_c$, $meas\ \Gamma_c > 0$. In these basic directions Alemdar has obtained fundamental results [1-3]. Namely, He proved that if $\widetilde{\Gamma}_c \subset \Gamma_c$ and $meas\ (\Gamma_c - \widetilde{\Gamma}_c) \neq 0$, then $\exists\, x_0 \in (\Gamma_c - \widetilde{\Gamma}_c)$ such that the inequality $u(x) \geq 0$ changes sign at this point: $u(x_0) < 0$. In the opposite case, i.e. if $\Gamma_c \subset \widetilde{\Gamma}_c$ and $meas\ (\widetilde{\Gamma}_c - \Gamma_c) \neq 0$, then $\exists\, x_0 \in (\widetilde{\Gamma}_c - \Gamma_c)$ such that the inequality $\partial u / \partial n_A \geq 0$ changes its sign at this point: $(\partial u / \partial n_A)(x_0) < 0$. These theoretical results have not only the precise physical meaning applied to Signorini type problems, i.e. boundary value problems with unilateral constraints, but also permit one to construct locally adaptable mesh algorithm for these problems. The first series of these results have been published in the journal Differential Equations [1-2]. Further results including an approximation of variational inequalities in an infinite-

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dimensional space, has been then published in Doklady Mathematics [3]. Alemdar Hasanov received his Ph.D. in Computational Mathematics from Moscow State University in September 1982.

In October 1982, he accepted the position of Assistant Professor in the Department of Computational Mathematics at Baku State University, where he worked until 1986. From 1986 to 1988, Alemdar joined again the Faculty of Computational Mathematics and Cybernetics, Moscow State University, to complete a dissertation leading to Doctor of Science degree in Physics and Mathematics. In addition to his professional work at the university, during this period, he was the chair of various scientific-technological projects related to mathematical modeling, computational methods, and nonlinear equations. These projects were supported by such well-recognized leading organizations as the All Union Physico-Technical and Radio-Technical Measurement Institute (Solnechnogorsk, Moscow Region), the Institute of Machine Science named after A.A. Blagonravov of the USSR Academy of Sciences (Moscow), and the Scientific-Technological Union "Technology" (Obninsk, Moscow Region). These institutions were leading scientific organizations that focused on high priority military technology. One of the main scientific and technological problems in these projects was related to the identification of unknown elasto-plastic properties of materials based on experimental data obtained during spherical indentation testing. Note that spherical indentation testing was, and still is, one of the most extensively used experimental methods to measure the hardness of metal and polymer materials. The objective here is usually to analyze the indentation curve as dependent on the size of the sample (indent) and indenter relative to the material length parameters, strain hardening, and yield stress to modulus ratio. From the perspective of an engineer, one of the most significant and important problems in material science and technology was determining real elastoplastic properties based on the measured indentation curve obtained experimentally during the uniaxial quasi-static indentation process. In engineering terms of that period, this problem has been defined as the nondestructive diagnostics of an elastoplastic medium. On the other hand, it is known that within the framework of the J_2-deformation theory of plasticity, these properties can be described by the following stress-strain relationship $\sigma_i = 3G\left[1 - g(e_i)\right]$. It inspired Alemdar to create a mathematical model of the nondestructive diagnostics problem. The first pioneering results related to the nondestructive diagnostics problem for an elastoplastic medium were obtained in 1986 [4]. Alemdar formulated this problem as a coefficient identification problem for 3D nonlinear Lame equations, with an integral overdetermination. Then he used the quasi-solution approach with Tikhonov regularization to prove the existence of a solution to the inverse problem.

These results have been discussed in the seminar of the well-known expert in inverse problems, Professor Vladimir A. Morozov, the author of the concept "Morozov's discrepancy principle", at the Research Computing Center of Lomonosov Moscow State University in May 1987. With helpful suggestions of Professor Morozov, some results were then presented by Academician A.A. Samarskii to the journal Doklady Mathematics [5]. At that time, Alemdar did not know much about coefficient inverse problems (CIPs), in particular about the pioneering works of J. Cannon and P. DuChateau on parabolic CIPs, due to the difficulties of accessing foreign scientific journals in the former USSR. Later, Alemdar and Paul DuChateau developed a simple and effective algorithm for the coefficient inverse problem with limited boundary data [11]. After relocating to Turkey in 1992, he was truly surprised to find out that his result in [5] was actually a first attempt to solve a CIP for a nonlinear equation when measured data is given in integral form, now defined as non-local measured output. Only thirty years later, mathematicians and engineers began to discuss the ill-posedness of this problem (see, for example, [L. Liu, N. Ogasawara, N. Chiba, X. Chen, Can indentation test measure unique elastoplastic properties, *Journal of Materials Research,* 24 (2009) 784-800]).

In February 1988, Alemdar completed his dissertation, and in October 1988, the Special Scientific Committee chaired by Academician Andrey N. Tikhonov at the Moscow State University conferred upon him the highest scientific degree, Doctor of Science in Physics and Mathematics, on "Mathematical Modeling, Methods, and Computational Technologies in Science". He was the youngest person to receive this degree in this area in all of the Soviet Union. A year later, he was awarded the Medal of the USSR Academy of Sciences at the Exhibition of Achievements of USSR National Economy, on "*Fundamental Sciences in Technology*" (Cert. No. 480-N, 02.08.89), for the series of scientific works "*Computational Express-Nondestructive Diagnostics of Engineering Materials".* Five years later, this work has been published in the SIAM Journal of Applied Mathematics [6]. This is one of the first papers on coefficient inverse problems for nonlinear PDE systems. In 1989, he became a full professor at the Baku State University, Azerbaijan.

In 1992, the Scientific and Technological Research Council of Turkey invited Alemdar Hasanov to the Marmara Research Center. A year later, he was invited to Kocaeli University to organize a new Applied Mathematical Sciences Research Center. In October 1996, he was invited by the Department of Mathematics at the

University of Nebraska to become a visiting research professor for the spring semester of 1997. During this period, Alemdar worked with Steve Cohn on identification problems for nonlinear parabolic equations arising in electrochemistry, with Jennifer Mueller on backward parabolic problems, and with Paul DuChateau on coefficient inverse problems.

He kept his position as director of the Applied Mathematical Sciences Research Center at Kocaeli University until 2009, when he got an invitation from the newly organized Izmir University. He invited the best mathematicians from the former Soviet Union and organized one of the best research centers that had scientific contacts with the world's leading centers. Alemdar extended here his research of direct and inverse problems in nonlinear mechanics to inverse problems for a nonlinear bending plate [7] and inverse coefficient problems for elliptic variational inequalities with a nonlinear monotone operator [8-11]. In addition to the above mentioned problems, Alemdar became interested in inverse source problems for evolution equations. He made essential contributions by developing the systematic use of functional analysis and a weak solution approach for solving these problems, both theoretically and numerically. Some of these results are given in [12-14]. Developing these results proposed a unique integral representation formula for a unique regularized solution of the inverse source, as well as backward problems with final overdetermination for evolution equations [15-16]. Then he proved that, in the constant coefficient linear parabolic and hyperbolic equations cases, this representation formula is an integral analogue of well-known Picard's Singular Value ecomposition for compact (i.e. input-output) operators.

During the years of work as the Head of the research Center, he have organized new programs for graduates and doctoral students. Due to these programs, he has many excellent PhD and post-doctoral students from Turkey and outside. Thanks to his productive work, he was able to not only conduct extensive scientific research, but also complete his well-recognized books *Variational Problems and Finite Element Method*, Literatur, Istanbul (2001); *Partial Differential Equations*, Literatur, Istanbul (2010). Contributions of this Research Center to the development of applied mathematics in Turkey are reported in various official documents, in particular, in the Scientific Report on the 75th Anniversary of the Republic of Turkey, published as a book by the Turkish Academy of Sciences [*Science in the 75th Year of the Turkish Republic 1923-1998*, Turkish Academy of Sciences (TUBA), Ankara, 1999, page 74-75].

The results of many years of work on inverse problems, as well as actively working with Vladimir G. Romanov since 2012, are reflected in the book *Introduction to Inverse Problems for Differential Equations,* published by Springer in 2017, which is defined by Springer as the "First systematic and comprehensive introductory book on inverse problems for differential equations" (https://link.springer.com/book/10.1007/978-3-030-79427-9). In this period, Romanov and Professor Hasanov developed also a new mathematical theory of inverse coefficient problems for damped wave equations with Dirichlet-to-Neumann as well as the Neumann-to-Dirichlet operators. This theory opens up a completely new page on the role of the characteristics of the wave equation in solving the inverse problems. Remark that although these problems have been studied since the 60th year of the last century, the role of the damping parameter was investigated in any of these studies. Specifically, the damping factor leads to a number of characteristic features in the propagation of waves through the conductor and in reflection from conducting surfaces. The first consequence of these is the formation of various domains, called 'subdomains defined by characteristics', by the reflected wave from the boundary. It is precisely in these areas that all analyzes related to direct, adjoint, and inverse problems should be carried out. This phenomenon has first been examined in [20-22], and is then systematically presented in the second edition [24] of the above-mentioned book. In particular, a detailed microlocal analysis of regularity of the direct problem solution in the subdomains defined by the characteristics as well as along these characteristics is provided. Based on this analysis, necessary regularity results and energy estimates for the direct problem, and existence, uniqueness and stability results for the inverse problems are derived.

In recent years, Professor Hasanov has developed new inverse problems of vibration governed by dynamic damped Euler-Bernoulli, and the Kirchhoff-Love plate equations. These problems arise from real engineering and technological problems [17-19, 23, 25-27].

It is impossible to identify all works and contributions of Dr. Hasanov to applied mathematics, in particular, to inverse problems. Nevertheless, we need to underline two essential points. First, the spectrum of his contributions is very wide from applied mathematics, engineering sciences and medicine to computational methods. Second, almost all models and methods proposed by Dr. Hasanov are original and contain new ideas. As a result, he has published more than 120 articles in various mathematical, engineering and medical journals. His research projects has been supported by U.S.S.R Academy of Sciences institutions (1982-1989), Kocaeli Governorship, Arcelik A. S., Istanbul Municipality, Scientific and Technological Research Council of Turkey (TÜBİTAK) (1994-2018), Office of Naval Research, USA (2002), INTAS, Brussels (2007-2009), Science for Peace and Security

Section, NATO, Brussels (2008-2010), Japan Society for the Promotion of Science (JSPS) (2018). He has supervised 16 PhD students in Turkey and outside the country. Most of these students became his research collaborators. Dr. Hasanov had been also an invited speaker at many important international conferences.

He has such an active and colorful life that we may only outline some aspects of it in the form of highlights. First of all, having a deep love to literature and arts, Dr. Hasanov is known as a person who has produced unique ideas both in philosophy and social sciences. It has been in solidarity with young researchers studying in different countries of the world in all areas of life, including financial support. It is amazing to realize how many engineers, mathematicians, also different distinguished people with different profe ssions from various countries, have been, and are still, collaborating with Alemdar. These people, as well as the related research subjects, are too numerous to be listed here.

Alemdar Hasanov, Albert Tarantola and Alex Tolstoy were first initiators and organizers of the First International Conference "Inverse Problems: Modeling and Simulation" (IPMS 2002, Fethiye, Turkey)

This photo shows the most famous representatives of the inverse problems community: IPMS 2014, Fethiye, Turkey

Professor Hasanov is the founder and co-organizer of one of the best international conference series on inverse problems,"Inverse Problems: Modeling and Simulation" (IPMS) (https://www.ipms-conference.org/ipms2022 This conference series brings together scientists working on various topics of inverse problems every two years since 2002, making a very important contribution to the inverse problems community.

All the IPMS meetings have become symbols for the inverse problems community and young scientists are bestowed with IPMS awards at these meeting for their excellent achievements. The series of special issues related to IPMS conferences are remarkable.

In 2012, together with colleagues Bernd Hofmann, Sergey Kabanikhin, Gen Nakamura, Andreas Neubauer, Roman Novikov, and Vladimir Romanov, he organized the founding congress of the Eurasian Association on Inverse Problems (EAIP), which was officially registered in the same year. Thie association coordinates and supports international research activities of scientists in the Eurasian Plate and elsewhere (https://www.eurasianip.org/).

The EAIP Young Scientist Award Ceremony at the Ninth International Conference IPMS 2018, Malta
Awardeers: Giovanni S. Alberti, University of Genoa, Italy, Andrei Shurup, Lomonosov Moscow State University, Russia

The EAIP Award Ceremony at the Ninth International Conference IPMS 2018, Malta
Awardeer: Prof. Dr. Otmar Scherzer (University of Vienna)

The EAIP Award and EAIP Young Scientist Award of The Eurasian Association on Inverse Problems association are currently one of the most distinguished international awards of this branch of science.

Alemdar with his wife Şhafak and sons Aziz and Rahman

On behalf of his colleagues, students, and friends from all over the world, we would like to wish Alemdar every success in his scientific work and much happiness with his wife Şafak and his sons Aziz and Rahman, and also grandson Ayaz. For Alemdar, retirement is just a formality. In fact, he is more active now, both in science and in organizational matters. He is not an outstanding organizer of various international conferences, playing a leading role in the inverse problems community, but also a very nice and friendly.

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