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In Memoriam: Andreas N. Alexandrou (1957–2018)

Andreas N. Alexandrou, 1957–2018. Photo courtesy of Lisa Majaj.

Professor Andreas Alexandrou sadly passed away at the age of 60 on May 31, 2018, after a long battle with cancer. Contributors to this volume and others more generally involved in visco-plasticity and rheology will miss his free academic spirit and the warmth and optimism he conveyed to everyone fortunate enough to know him. Andreas was a well-liked member of the viscoplastic community. In fact, he is one of the few people who participated in all the "Viscoplastic-Fluids (VPF)" conferences, which started in 2005; he also co-organized the third one (VPF2009) in Limassol, Cyprus.

Andreas was born in the village of Episkopi, Cyprus on June 21, 1957. His mother, Electra, and father, Neophytos, also had two daughters, Sofia and Marina. In his high-school years, he was not only an excellent student but also a first-class young athlete, member of the Athletic Club Olympia, Limassol. After attending the Laniteion Gymnasium of Limassol for secondary education (1969–1975) and completing his military service at the National Guard (1975–1977), Andreas continued his studies in Lebanon, at the American University of Beirut (AUB) on a U.S.AID/Fulbright scholarship. He graduated in 1982 with a B.Sc. degree in Mechanical Engineering.

In 1978, Andreas met his future wife, Lisa Majaj, a student of English Literature at AUB. By 1980 they were a couple, and were together thereafter. They married in July 27, 1985 in Limassol, Cyprus. Their daughter Nadia was born in 1997 in Boston and their son Nicolas was born in 2002 in Cyprus.

In 1982, Lisa and Andreas moved to Ann Arbor, Michigan to pursue graduate studies in English Literature and Mechanical Engineering, respectively. After completing his Ph.D. in Mechanical Engineering in 1986, Andreas worked for one year as a post-doctoral fellow with Professor Tasos Papanastasiou in the Chemical Engineering Department. In 1987, he was appointed Assistant Professor, in the Department of Mechanical Engineering of the Worcester Polytechnic Institute (WPI), in 1992 he was promoted to the rank of Associate Professor, and in 1998 to the rank of Full Professor. Andreas excelled not only in research but also in teaching, receiving several teaching awards; in 1992 he became the youngest faculty member to receive the WPI Board of Trustee´s Award for Outstanding Teaching. In 2001, Andreas returned to his home country as the first professor of the newly established School of Engineering of the University of Cyprus. During the development of the School (2001–2004), he held the interim positions first of the Head of the Mechanical and Manufacturing Department and then of the Dean of the School of Engineering. From 2004–2007 he served as the first elected Dean of the School of Engineering.

Andreas's main research interests in rheology concerned yield-stress fluids with emphasis on semisolid metal processing applications. This memoriam reviews briefly his viscoplastic contributions. It should be noted, however, that Andreas's work also included numerical extrusion simulations of non-dilute fiber suspensions and composite materials, modeling of solidification problems by means of inverse finite elements, and numerical simulations of the stick-slip extrusion instability. He has also made significant contributions to other research areas, such as in modeling zeolite crystal growth in solutions and in novel energy systems.

One of Andreas's key contributions in viscoplasticity concerned the determination of yield surfaces in flows of yield-stress fluids. He and his PhD student Gilmer Burgos analyzed the antiplane flow of a Herschel-Bulkley fluid in a wedge between two rigid walls and showed that regularized models, such as the one proposed by Papanastasiou, with a proper choice of the regularizing parameters can be used both to predict the bulk flow and describe correctly the unyielded zones employing the criterion $\tau = \tau_0$ [1]. They also demonstrated that when the value of the regularizing parameter is not sufficient for the direct determination of the yield surface, this can be effectively recovered using an extrapolation procedure based upon an analytical representation of the solution. In subsequent works, Burgos and Alexandrou studied entry flow problems in expansions, obtaining again smooth unyielded regions [2,3].

In WPI Andreas started a lasting collaboration with Professor Diran Apelian, founder and first Director of the Semisolid Metal Processing Center, who introduced him to the important area of semisolid metal

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processing (S2P). Andreas succeeded Apelian as the second Director of the Center (1998–2001). Apelian and Alexandrou combined forces, i.e. experiments and numerical methods, for the accurate characterization of semisolid materials and for more realistic numerical simulations of various processes with these materials. In particular, they developed a well-controlled experimental apparatus to ensure accurate measurements in squeeze flow under both constant shear rate and constant stress conditions and novel numerical techniques involving a "reverse modeling" strategy for simulating the corresponding experiments [4]. The advantage of the proposed technique is that the squeeze flow problem is solved in Lagrangian coordinates and thus the position of the free surface is calculated automatically together with the other unknown fields (i.e., free surface nodes move with the fluid velocity).

Andreas brought new ideas to the S2P community, emphasizing the need of scientific, reliable procedures and analyses in modeling semisolid metal processes and promoting the advantage in using non-dimensional numbers in analysis of die filling behavior. In close collaboration with Professor Vladimir Entov, he studied the steady propagation of bubbles and fingers in a Hele-Shaw cell filled with a power-law or Bingham fluid and showed that unlike its Newtonian counterpart the problem cannot be reduced to that of a steadily transported bubble [5,6]. They also carried out numerical simulations of the Bingham fluid filling of a 2-D cavity [7–9] and obtained a map on the Reynolds/Bingham number plane involving five different flow patterns: mould, disk, shell, bubble, and transition. This map is of great importance for the prediction of appropriate process parameters and the avoidance of defects. The finite-element calculations also showed that the most unstable pattern is that of bubble [8] and that yield stress not only affects the flow pattern during die filling but it is also responsible for flow instabilities in commercial forming operations [9].

Alexandrou realized very soon that thixotropic models are necessary in order to simulate correctly the flows of semi-solid slurries. During processing, these materials are injected at high speed into mold cavities with the process lasting only fractions of a second, and thus the short-term transient material response is thus very important for the understanding of the rheology and the further development of the process. In a joint work with Entov and Burgos, Andreas proposed a structural thixotropic model employing the Herschel-Bulkley model under the assumption that the rheological parameters are functions of the solid-volume fraction and a structural parameter [10]. The breakdown and buildup of structure were selected to be consistent with experimental data. Thus, the structural parameter was assumed to change with processing history following a first-order kinetics. In subsequent works, Andreas developed a novel computational method to test this thixotropic model on rheometric and other flows, such as the circular Couette flow [11,12], the flow past a cylinder [13], and the squeeze flow of semisolid slurries [14–16]. It was Andreas himself who wrote the FORTRAN codes implementing the new method in all cases!

Andreas also promoted the idea of combining computational rheology with rheometry in characterizing semisolid materials, and advocated for the proper interpretation of rheometric data. In addition to the squeeze flow experiment, which is popular in the S2P community, he also studied the circular Couette flow in order to determine the errors introduced by the standard Newtonian and power-law assumptions in the determination of the material properties of yield-stress fluids [17,18]. Andreas emphasized the importance of using "true values" for the rate of strain, since the material properties can be very different from those obtained using "apparent' values for the rate of strain [18]. Lately, Andreas was also involved in the development of Finite Volume Methods for the simulation of steady-state and time-dependent viscoplastic flows [19–21] and developed an interest in wake instabilities and the transition to turbulence of viscoplastic fluids past a confined cylinder [22,23]. Andreas published well over 100 scientific papers, co-authored "Viscous Fluid Flow" [24] and authored "Principles of Fluid Mechanics" [25].

In addition to his administrative duties at WPI and later at the University of Cyprus, Andreas was highly active in community service. In 2004, he organized the 8th International Conference on Semi-Solid Processing of Alloys and Composites in Limassol. A conference that Andreas had never missed was that of the Hellenic Society of Rheology (HSR). Andreas was a founding member of the HSR, served as its vice-President (2004–2006) and President (2006–2008), and in 2017 he co-organized the 8th HSR Conference in Limassol.

Andreas Alexandrou is survived by his wife Lisa, his daughter Nadia and his son Nicolas. Andreas was passionate about his family and loved his homeland. His interests extended to photography, archaeology, politics, and literature. He was a lover of life and an uncompromisingly ethical intellectual with genuine concern for others. He will be greatly missed by his family, friends and colleagues.

I thank Lisa Majaj for her numerous contributions to this obituary and also Alexandros Arsalis, John de Bruyn, Nikos Gatsonis, Ian Frigaard, Stavros Kassinos, George Magos, Michael Modigell, Ahmed Rassili, and Alexandros Syrakos, who were kind enough to provide input and useful information.

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Georgios C. Georgiou
Department of Mathematics and Statistics, University of Cyprus, PO Box 20537, 1678 Nicosia, Cyprus

E-mail address: georgios@ucy.ac.cy