I.J.A.T. Sept. 2001

A Tribute to Elias Gyftopoulos on his 75th Birthday

Within the midst of the thermodynamics research community associated with the *International Center for Applied Thermodynamics* and the *International Journal of Applied Thermodynamics*, there is without a doubt the foremost thermodynamicist in the world today, Prof. Elias Gyftopoulos. This outstanding individual, researcher, and educator has been a member of the engineering faculty at the Massachusetts Institute of Technology (MIT) since 1958 and was the Ford Professor of Mechanical Engineering and Nuclear Engineering from 1970 to 1996. He has published 4 books and over 140 journal articles and, since becoming Professor Emeritus in 1996, has continued to be very active in his scholarly endeavors.

In addition to his academic work, Prof. Gyftopoulos has served or is serving as a member of the Board of Directors of the American Nuclear Society, the International Institute of Energy Conservation, and six U.S. private corporations. He is also currently a member of the Governing Board of the Constantine G. Karamanlis Institute of Democracy and is a member of the Scientific Committee of the Foundations of the Hellenic World. Prof. Gyftopoulos has also served as a trustee for a number of institutions of higher learning including Anatolia College, the American Farm School, and Hellenic College and is currently vice chairman of the Board of Trustees for Anatolia College. He is a fellow of the American Academy of Arts and Sciences, the American Nuclear Society, and the American Society of Mechanical Engineers (ASME) and is a member of the National Academy of Engineering and a corresponding member of the Academy of Athens. He has received a number of honorary doctorates as well as the prestigious ASME James Harry Potter Gold Medal Award and has been appointed Commander of the Order of Merit by the President of the Republic of Greece. He will be receiving the very prestigious ASME Edward F. Obert Award this November in New York.

One might say at this point that the credentials outlined above are pretty impressive but how does that make him the foremost thermodynamicist of our times? In fact, it does not. What does is his thirst for knowledge, his willingness to question established norms, and most importantly his very, very original contributions to the domains of physics and thermodynamics, the genesis of which began almost 50 years ago after he was admitted to graduate school at MIT. As he tells it, this genesis was probably the least expected direction in which he envisioned going, particularly since his Ph.D. was in electrical engineering. In fact, his background in thermodyamics only began after he attended a survey course on nuclear reactors during his second year of studies at MIT which in turn led to his developing and teaching a full-term course on nuclear reactor safety and control. After joining the faculty at MIT in 1958, this course prompted a request by his older colleague, Prof. George Hatsopoulos, to investigate whether or not thermionic converters could be coupled with nuclear reactors to convert nuclear energy directly into electricity. Shortly thereafter (in the mid-1960s), he and his friend Prof. Hatsopoulos decided to write a two-volume treatise on thermionic conversion, the first volume to cover processes and devices and the second, theory, technology, and applications. The first two chapters of the second volume were intended to summarize the aspects of quantum mechanics and thermodynamics relevant to thermionic converters. However, after reading a few good textbooks and providing the summary, Elias was troubled. He went with his concerns to his colleague, explaining that he believed that there were any number of ill definitions,

inconsistencies, contradictions, circularities and discrepancies, not to mention, of course, the well-known paradoxes which pervaded the literature. None of these were either recognized generally or had been dealt with successfully. In other words, there were, he believed, a number of very serious problems with the existing paradigm of physics and thermodynamics. To his surprise, his colleague agreed and indicated that he had come to the same conclusion some time before. Two courses of action were now open to them: to proceed with their book ignoring their concerns or to dig deeper in order to see if these concerns could, in fact, be addressed. Fortunately, for us, they took the latter course and, thus, began a 30 years odyssey which has resulted in a new paradigm of physics and thermodynamics which unifies these disciplines and completely, simply, and elegantly deals with the concerns which Elias initially raised so very many years ago.

After having studied this new paradigm for a number of years, it is evident that Elias Gyftopoulos' contributions to the disciplines of thermodynamics and physics, to science in general, and to how we view nature cannot be over emphasized. In his unified quantum theory of mechanics and thermodynamics, he and his colleagues have developed a simple and elegant theory, which bases the foundations of thermodynamics on a non-statistical view of nature. Furthermore, to my knowledge, this is the first complete and totally unambiguous presentation of thermodynamics. Unlike all other formulations which present thermodynamics as a statistical theory that applies to macroscopic systems in states of thermodynamic equilibrium only, this novel exposition by Elias Gyftopoulos and his colleagues shows in very sharp contrast that thermodynamics is indeed non-statistical in nature and applies to both macroscopic and microscopic systems (including one particle systems) either in a state of thermodynamic equilibrium or not in a state of thermodynamic equilibrium. These foundations are not simply a rehash of all the expositions on "equilibrium" or "classical" thermodynamics, which have proliferated and inundated the scientific and engineering community particularly over the last 40 years. In fact, "classical" thermodynamics or "thermostatics" is simply a special case of the thermodynamic foundations developed by Elias Gyftopoulos and his colleagues, foundations which also provide the basis for the *first complete* resolution of a number of paradoxes, which have plagued the scientific community since the 19th century. These include, for example, the paradox of Maxwell's Demon, which is resolved by proving that individual molecules have private entropies just as they have private inertial masses and private energies. This contrasts with the over four hundred published attempts at resolving this paradox, none of which address the original problem posed by Maxwell. Another paradox, the paradox between macroscopic irreversibility and microscopic reversibility, is resolved simply, elegantly, and completely by proving that spontaneous entropy generation (irreversibility) is independent of the size of the system, i.e. it applies at the microscopic level just as much as at the macroscopic level. In addition, these new foundations include the first complete equation of motion, which describes all known classes of processes, both reversible and irreversible. This contrasts with the well-known Schrödinger equation of motion, which is limited to a special class of reversible processes only.

Finally, Elias Gyftopoulos' work represents a landmark contribution to thermodynamics and physics comparable to that of the greats of the 19th century such as Boltzmann and Maxwell. There is, therefore, no doubt that Elias Gyftopoulos is the foremost thermodynamicist of our times and is deserving of our admiration and accolades but more importantly of our interest so that we may be sufficiently challenged to delve into this new paradigm of physics and thermodynamics, gaining in the process a sufficient understanding to legitimately either accept or reject it on the basis of knowledge and deep reflection. In fact, it is hoped that a number of you will take up the challenge to delve further because as Thomas Kuhn in his well-known book *The Structure of Scientific Revolutions* writes:

> "...a new theory, however special its range of application, is seldom or never just an increment to what is already known. Its assimilation requires the reconstruction of prior theory and the re-evaluation of prior fact, an intrinsically revolutionary process that is seldom completed by a single man and never overnight."

M. R. von Spakovsky

Professor Virginia Polytechnic Inst.