ΤΕΙ ΚΕΝΤΡΙΚΗΣ ΜΑΚΕΔΟΝΙΑΣ ΣΕΡΡΕΣ

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DEPARTMENT OF MECHANICAL ENGINEERING

Graduate Studies Program: Academic Year 2013 - 14	"Renewable Energy Systems: Design, Development and Optimization"

EXTERNAL SEMINAR

"Vortex Models"

by Georgios Vatistas

Department of Mechanical and Industrial Engineering at Concordia University of Montreal, CANADA

TUESDAY, October 22, 2013

16:00

Classroom 103

Summary of the talk

Vortices appear throughout the spectrum of physics, having sizes ranging from a few angstroms in quantum vortices (of super-fluid helium) to light-years in galactic vortices. Being interwoven into the fabric of fluid mechanics, these appear in the great majority of natural and industrial flows. In technology, eddies are either produced deliberately to accomplish the task

and improve the function of devices, or emerge as a parasitic bi-product of fluid motion. Examples of such applications are the vortex separator, the Ranque-Hilsch tube, steam traps, flow regulating valves, various components of turbo-machinery, heat exchangers, the vortex gyroscope, plasma arcs, tip-vortices produced by both fixed and rotary wings, and many others.

This presentation summarizes the most important classical formulations of the past. Based on order-of-magnitude arguments, the governing equations are shown to reduce into the general form that produced a family of vortices, whereby, depending on the value of parameter n, most of the traditional vortices - ranging from Rankine's ($n \to \infty$) to Scully ($n = 1$) - can be recovered. A good approximation to the popular Burgers and Lamb-Oseen can be achieved with $n = 2$. The new approach shaped a novel methodology in modeling intense, concentrated vortices, and indicated that all vortices become self-similar, if the tangential velocity and the radius are normalized with their instantaneous maximum velocity and core size values respectively. The last implied that, all strong eddies are similar irrespective of their size, strength, decaying or steady, compressible or incompressible. The original formulation was further extended to incorporate the effects of compressibility and turbulence. Moreover, a deeper analysis suggested that there exists an analogy among self-similar vortices. Thus, in addition to the previous types of vortices, the tangential velocity profile will collapse into a single curve even if the flow is turbulent, non-Newtonian, or even electrically charged. The latter was corroborated via correlations, using a diverse assortment of experimental vortex data that range from wing tip and polymer vortices to solar and galactic.

A few words about Georgios Vatistas

Since 1994, Georgios Vatistas is a professor in the Department of Mechanical and Industrial Engineering at Concordia University in Montreal and has served as Associate Dean of the Faculty of Engineering and Computer Science and of the School of Graduate Studies. He is a fellow of the Canadian Society of Mechanical Engineers and of the Engineering Institute of Canada.

Although his interest lies in the general area of fluid mechanics, the central theme of his research is on vortex dynamics. In 1991, he published on a new vortex formulation that gave rise to a family of tangential velocity distributions. The model generalized and set the classical approximations of the past into a firm theoretical ground, removing also some of their physical contradictions. Since 1993 researchers are continuously citing this work in journals, conferences, reports of major national research laboratories, monographs, graduate theses, and patents. The vast majority of the citations are functional, whereby the original contribution is used to advance knowledge in specific areas. The methodology has been used predominately in aerodynamics. However, recently, geophysicists have also discovered the advantages of the *n*-vortex family, and have employed to study the most salient properties of eddies in the ocean and the atmosphere.

In 1990, he discovered a real case of Kelvin's vortex equilibrium patterns; a now abandoned early form of string theory. In 2008 along with his research team physically validated the stability of Kelvin-J.J. Thomson vortex polygons. Due to the highly interdisciplinary nature, this research achievement received international attention and was chosen as one of the top ten discoveries for 2008 by the magazine Québec Science. In the same year he also disclosed the first solitary wave (popularly known as tsunami) in circular motion. Several details of this intriguing wave were recently elaborated.

His research work has been published in journals of high regard and has been cited abundantly. Professor Vatistas holds two patents, while an application on a super efficient vortex heat exchanger is pending. His past graduate students hold either high positions in the local and international industry or are professors in universities around the globe.