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Last stages of the Transition from Laminar to Turbulent Flows

Born 1927 in Titu, Romania. Ph. D. in mechanical engineering from the Fluid Mechanics Institute of the Romanian Academy in 1956. 1955 — 85 Associate Professor at the Polytechnic Institute of Bucharest (major fields: Aerodynamics and Experimental Fluid Mechanics). Visiting research scientist at the *Max-Planck-Institut fur Strömungsforschung* in Göttingen, 1969, 1971, and 1986; at the Albert-Ludwigs-Universität in Freiburg, 1971-72; and at the *Hermann-Föttinger-Institut der Technischen Universität Berlin,* 1988. Present Position: Dean of the Department of Engineering at the Universitatea Ecologica Bucuresti. Publications: *Transition from Laminar to Turbulent Flow* (Bucharest 1968); (together with A. Georgescu, H. Dumitrescu, and M. Bucur) *Mathematical Investigations into the Modern Theory of the Boundary Layer* (Bucharest 1981). — Address: Bd. I. B. Tito 38, Bl. A-11, Bucuresti III, Romania.

This brief informal report aims to point out the essential aspects of my scientific activity at the Wissenschaftskolleg during the ten months of my fellowship, i.e. October 1990 — July 1991.

—The subject `Transition from laminar to turbulent flows', to which I have devoted thirty years of scientific activity, is a very complex one and involves a lot of theoretical, experimental, and numerical work; I only studied the last stages of the transition process — let us call them 'Incipient turbulence in incompressible developing layers' — from the standpoint of the physical mechanisms, responsible for the qualitative change of the flow motion. In this respect I continued to develop my previous concept of special critical points in perturbed shear layers.

—Being handicapped by the isolation of my country, which became more and more severe during the last twenty years, I spent a long time reading, interpreting, comparing, and using recent achievements (especially the computing facilities) for studies of transition, which tremendously increased in quantity and quality.

—I eventually tried to conceptualize the physical process of transition in order to apply it to other transition processes in social and biological

sciences. I was especially interested in the transition from dictatorship to democracy, a subject currently discussed by the social, philosophical, and political scientific communities. I greatly enjoyed the wonderful conditions at the Wissenschaftskolleg, attending every panel discussion, meeting, or lecture about this subject.

Summing up, I will present the achievements, the hopes and the disappointments, the difficulties and the future works in the perspective of my connection to the activity at the Wissenschaftskolleg.

The positive points are the following:

—The improvement of my model of chaotic dynamics around critical points in perturbed shear layers by the study of a logistic map with time-dependent parameters. The paper "The Importance of Transversal Velocity Fluctuations in the Perturbed Shear Flows" (in cooperation with U. Görn and H. Fiedler from the *Technische Universität* Berlin) was written during my stay at the Wissenschaftskolleg. It will be submitted to a fluid mechanics publication.

—The extension of this model to swirling flows. By using a model device of aerodynamic spinning I explained the phenomenon of fiber entangledness as chaotic dynamics generated by the small oscillations of a concentrated vortex ring around its stable position. This basic solution resulted from a two-dimensional potential flow model along the axis of the vortex ring. This special analysis of the swirling flow was realized here at the Wissenschaftskolleg and resulted in a report to the University of Cambridge under the title "Examples of Chaotic Dynamics around Special Critical Points in Perturbed Flows" (Cambridge — DAMTP — June 1991). The scientific importance of this example of a swirling flow with toroidal concentrated vorticity is twofold: (i) It represents the first attempt to control the chaotic dynamics generated by a real vortex ring and (ii) it provides the possibility to study the resulting thread as a direct material result of the process of topological complexity at the incipient turbulence with the help of experiments and microscopic examinations. What is also worth mentioning is the pedagogical value of this special vortex tube device and its practical importance in the fields of applied research such as combustion, ecology, and biology.

—The deduction of the logistic map from the probability of the realization of two independent events *A* and *B*. The well-known relation $P(A \cup B) = P(A) + P(B) - P(A) \cdot P(B)$ turns into: $P_{n+t} = A \ P_n \ (1-P_n)$ which is a typical form of the quadratic map. When the parameter A ranges between 3 and 4, this map displays a chaotic behaviour. Due to its universality, this model can be applied to other fields like the evolution of human mentality which oscillates between comfort *(A)* and discomfort *(B)*. This was part of a lecture I gave at the *Max-Planck-Institut fur Strö-*

mungsforschung in Göttingen in January 1991. Professor Vencov, a guest of the Wissenschaftskolleg, used it under the title "A mathematical model concerning the psychological conflicts in social life" for the extension of the application of higher mathematics to new fields like individual or social psychological groups.

—What is also worth mentioning is the computing activity I undertook here as the realization of some small programs, the implementation of big programs (chaos, phaser trax, flowstar), and the transformation of some mathematical models into a form suited to computing on available machines. This aspect is very important because it allowed the numerical experiments I have never been able to exploit before in an efficient way.

However, there is one disappointing aspect of my achievements here. Due to the limited time (ten months) I have had to stop this computing activity, because the conditions here *(EDV-Beratung,* the colleagues, the atmosphere, and the available machines) are far from becoming available in my country. In my specific case the saying *'partir c'est mourir un peu'* becomes, unfortunately, a sad facet of my scientific work. In this context I have to mention the permanent contact with the fluid dynamics department of the *Technische Universität* Berlin, and the *Deutsche Forschungsanstalt far Luft- and Raumfahrt,* respectively. By taking part in the weekly seminars which involved lectures and discussions and by consulting the specific literature available at this institute, I recognized the importance of being integrated in current scientific research as well as the disastrous effects of a long isolation. Despite the heavenly conditions at the Wissenschaftskolleg, the stay was too short to develop a complete theory of critical points (identification of a proper topological space, applications of the Morse theory, structural stability and discrete-continuum models); however, it was sufficient to understand the current trends of research dealing with the transition problem. The main consequence will be to rebuild my laboratory in Bucharest — it was dismantled under the Communist regime — and to equip it for research on boundary layers and turbulence. And the main problem I have to solve is: How can I stop the `brain drain' of my qualified team? In my opinion, it is a bad solution to generate social instabilities, both for the East and the West. During my stay at the Wissenschaftskolleg I contacted some authorized institutions which will help me to find a better solution. These are the results:

—Material help for laboratory equipment, e.g. the important measuring devices offered by the *Max-Planck-Institut für Strömungsforschung* in Göttingen.

—Moral support for the organization of international conferences on relevant topics (environmental fluid dynamics) in Bucharest, such as the official support of the University of Cambridge (Trinity College).

I did not succeed in establishing contact with any institution which could have prepared the ground for cooperation in specific subjects, for scientific exchange, and for grants and donations.

However, it was a very fruitful stay and I would like to express my eternal gratitude beyond the official end of this period. I hope that this stay is not only a limited period but a starting point for the continuation of my work. This explains why I am so greatly interested in the possibility of continuing to use the programs I implemented here, the library facilities, and the scientific atmosphere created by the staff of the Wissenschaftskolleg.

This moral support is essential during the difficult period of normalization and integration into Europe of a scientific community from the East, which has suffered from political pressure and injustice.

Here, at the Wissenschaftskolleg, I learned that optimism is philosophically justified. And, therefore, I now define myself as an *Alt-Fellow*.