Reasearch group on *Structural Analysis in Fluid Mechanics*

IMAR Participants: R. Stavre.
International Cooperations:
France: Universite “Jean Monnet” de Saint Etienne
Workpackages involved: A1, C7.
Doctoral research: D. Dupuy de l'Universite “Jean Monnet” de Saint Etienne has finished his PhD thesis working in the frame of this research group.

Scientific Objectives:

1. asymptotic methods for micropolar fluids,
2. optimal control problems for fluids with special properties.

Main Scientific Results:

1. R. Stavre, The control of the pressure for a micropolar fluid, Z. angew. Math. Phys. (ZAMP), 53, no. 6, 912-922, 2002.
2. R. Stavre, Optimization and numerical approximation for micropolar fluids, Num. Funct. Anal. Optimiz., 24, no. 3-4, 223-241, 2003.
3. R. Stavre, Optimal control of nonstationary, three dimensional micropolar flows, Analysis and optimization of differential systems, V. Barbu, I. Lasiecka, D. Tiba, C. Varsan editors, Kluwer Academic Publishers, Boston/ Dordrecht/London, 399-409, 2003.
4. D. Dupuy, G. P. Panasenko, R. Stavre, Asymptotic analysis for micropolar fluids, Compte Rendus Acad. Sci. Paris (accepted).
5. D. Dupuy, G. P. Panasenko, R. Stavre, Asymptotic methods for micropolar flows in a tube structure, Math. Mod. Meth. Appl. Sci., 6, 14, 2004.
6. D. Dupuy, G. P. Panasenko, R. Stavre, Multiscale modelling for micropolar flows in a structure with one bundle of tubes (submitted).
7. R. Stavre, Boundary control of a nonstationary magnetohydrodynamic flow, Preprint IMAR, No. 10, 2003.

D. Dupuy, Modelisation mathematique de l'extrusion bivis, Ph. D. Thesis, january 2004.

Research Activity:
The mathematical model of micropolar fluids, introduced in 1966, has a large domain of practical interest: animal blood, liquid cristals, certain polymeric fluids, etc may be represented by this model.

- In order to study the blood motion we performed an asymptotic analysis of a micropolar flow in a thin, periodically constricted tube ([4], [5]). The unknowns of the nonlinear, coupled system which describes this motion are approximated by asymptotic expansions. The macroscopic solution is introduced. By using the technique of boundary layer terms, we establish some error estimates between the microscopic solution and the macroscopic one. The method of partial asymptotic decomposition of domain is applied in order to simplify the solution on the part of the flow domain where it has a regular behaviour.
- In [6] we give a more realistic description, by considering a structure with some branches, representing a simplified model for the bloodstream. This approach is a generalization of the previous two papers. The boundary layer approach is more complicated than in [4], [5] because of the necessity of considering a further boundary layer problem, formulated in a neighbourhood of the junction of the tubes.
- For the same model of micropolar fluids we studied some optimal control problems in [1], [2], [3]. A problem of physical interest is to control the blood pressure. Modifying the exterior action on the micropolar fluid, we want to obtain a desired field of the pressure. For studying the adjoint system, which, in this case has not a classical form, we proposed a method based on the construction of several functions.

- In the theory of micropolar fluids, a special case appears when the microrotation is equal to the vorticity of the fluid. The aim of [2] is to determine an external field which realises this case. For solving the optimality system, an iterative algorithm is proposed and its convergence is obtained.
- In [3] we study an optimal control problem associated with the three dimensional flow of a micropolar fluid. This case is more complicated than the previous ones, since we cannot prove the existence of a strong solution. To overcome this difficulty, we consider a suitable formulation of the control problem which allows us to prove the existence of an optimal control and to derive the necessary conditions of optimality.
- Magnetohydrodynamics is concerned with the interactions of magnetic fields with fluid matter (liquids and gases). It finds practical use in many areas of engineering and pure science. The last paper, [7], is concerned with an optimal control problem associated with a nonstationary magnetohydrodynamic viscous flow. This motion describes, for instance, the liquid-lithium flow inside a Tokamak cooling system. The fluid motion across the magnetic fields drives an electric current in the liquid metal, and the electric current produces the electromagnetic body force opposing the motion. Thus, stagnant regions or even recirculation regions may appear. When we formulate an optimal control problem, finding a cost functional which is relevant to the physics of the flow is a very important step. Since we are interested in obtaining flows without recirculation regions, we introduce a suitable optimal control problem associated with the considered magnetohydrodynamic motion. We look for an exterior magnetic field which realises a magnetohydrodynamic flow without recirculation.

Communications:

1. R. Stavre, Optimization and numerical approximation for micropolar fluids, Seminar of applied mathematics of the University Jean Monnet, Saint-Etienne, France, september, 2001.
2. D. Dupuy, Asymptotic analysis for micropolar fluids, CANUM, Anglet, France, may 2002.
3. R. Stavre, Optimal control of nonstationary, three dimensional micropolar flows, The international conference on "Analysis and optimization of differential systems", Constanta, Romania, september, 2002.
4. G. Panasenko, Method of asymptotic partial decomposition of domain and partial homogenization, Seminar of The Institute of Mathematics "Simion Stoilow", Romanian Academy, december 2002.
5. G. Panasenko, Two-phase flow homogenization, Seminar of The Institute of Mathematics "Simion Stoilow", Romanian Academy, january 2003.
6. R. Stavre, Optimal control of nonstationary, three dimensional micropolar flows, The 5th Congress of Romanian Mathematicians, Pitesti, Romania, june 2003.
7. D. Dupuy, Asymptotic decomposition of the domain for a flow in a tube structure, CANUM, La Grande Motte, France, june 2003.
8. G. Panasenko, Asymptotic decomposition of a domain in continuum mechanics, The international confernce on "New trends in continuum mechanics", Constanta, Romania, september 2003.
9. R. Stavre, Boundary control of a nonstationary magnetohydrodynamic flow, The international confernce on "New trends in continuum mechanics", Constanta, Romania, september 2003.
10. R. Stavre, Optimal control problems for some special classes of viscous fluids, Seminar of applied mathematics of the University Jean Monnet, Saint-Etienne, France, september, 2003.
11. D. Dupuy, The asymptotic study of a flow in a wavy structure, Seminar of the Laboratory Jacques-Louis Lions, University Paris VI, november, 2003.