EUROMECH Final Report

EUROPEAN MECHANICS SOCIETY

Please send this report to the Secretary-General of EUROMECH, within one month after the Colloquium.

EUROMECH Colloquium No: 383

Title: CONTINUATION METHODS IN FLUID DYNAMICS

Dates and location: 6-9 September 1998 - AUSSOIS (FRANCE)

Chairman: D. HENRY, H. BEN HADID LMFA (Ecole Centrale de Lyon)

Co-Chairman: H. DIJKSTRA IMARU (University of Utrecht)

Is there need of another Colloquium on the same or a related subject? Which year? It was asked by the participants - Not before three years.

Full registration fee: 2600 F

What other funding was obtained? Ercoftac, CNRS, MENRT, AUM, PRC-GDR1185

What were the participants offered? Inscription, accomodation (double rooms), meals, full printed proceedings by Vieweg (Notes on Numerical Fluids Mechanics)

Number of members of EUROMECH (reduced registration fee): 3

Number of non-members of EUROMECH (full registration fee): 29

Number of participants from each country:

Austria		Germany	2	Romania	
Belgium	4	Great Britain	2	Russia	1
Byelorussia		Greece		Slovakia	
Bosnia		Hungary		Slovenia	
Bulgaria	1	Ireland		Spain	2
Croatia		Italy		Sweden	
Czech Republic		Latvia		Switzerland	1
Denmark		Lithuania		Ukraine	
Estonia		Netherlands	5	Yugoslavia	
Finland		Norway		~~Others~~ USA	2
France	8	Poland		Canada	1
Georgia		Portugal		~~Israel~~	2
				~~Taiwan~~	1
				Total	32

Please turn

Report on ERCOFTAC AND EUROMECH COLLOQUIUM 383

CONTINUATION METHODS in FLUID DYNAMICS

AUSSOIS, FRANCE, 6 – 9 SEPTEMBER 1998

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Introduction

The idea of a meeting on Continuation Methods was first mentioned during a French meeting of a research group on Numerical Fluid Mechanics. We wanted to know the people who were working with such methods and the capabilities of these methods when applied to particular problems with large number of degrees of freedom. After two years, the idea of a French meeting had evolved towards a European colloquium in order to enlarge the viewpoint by increasing the number of potential participants. This first colloquium "Continuation Methods in Fluid Mechanics" was finally held in Aussois (french Alps) at the beginning of September 1998. In the following we will give first the scientific scope as mentioned in the announcement, then an overview of the colloquium, and finally a conclusion.

Scientific scope

Continuation methods are a powerful and efficient tool for investigating nonlinear phenomena in dynamical systems. An important area of application of these numerical techniques is in hydrodynamic stability problems, where bifurcations lead to multiple equilibria and complex temporal behavior.

Continuation methods have found widespread application in problems with a relatively small number of degrees of freedom. However, only recently have advances in computational hardware and software enabled continuation methods to be applied to very large systems, say $\mathcal{O}(10^5)$, resulting from the discretization of partial differential equations governing fluid flows in two and three dimensions. The potential application of continuation methods to large systems depends strongly on the availability of efficient numerical solvers for large nonsymmetric linear systems and eigenvalue problems.

The aim of the colloquium is to define the state of the art of continuation methods as applied to problems in fluid mechanics. This will require classifying the various methods used, determining which capabilities exist for particular types of problems, and reviewing new advances. Towards this end, research groups will present the particular fluid mechanical problems they study, the algorithms and capabilities of the continuation methods they use, and the physical conclusions they draw. Several test problems will be made available before the colloquium on which researchers are encouraged to test and compare their techniques.

Colloquium overview

Thirty-two people attended the colloquium: twenty-six came from nine different European countries, six from countries outside Europe. Among them were five invited speakers, most of them pioneers in the domain of continuation methods. Twenty-four oral presentations were then scheduled during the five half-days of the colloquium. They were organized in four sessions on five topics:

A) General methodology

B) Solvers

C) Hopf bifurcations and limit cycles

D) Shear-driven flows

E) Convection

Concerning topic A) on general methodology, we had first an introductory talk on the basic ideas of continuation, and then presentation of different approaches to build stability and continuation codes. For the solvers topic, we had a talk on the solution of linear systems and eigenvalue computation in the case of large sparse systems. For topic C), some Hopf bifurcation calculations in large problems were presented, but the two presentations on limit cycle continuation techniques concerned applications to small problems. At last, the main applications to fluid mechanics problems concerned shear-driven flows and convection and they were presented in topics D) and E).

The talks were interesting, of a good scientific level, and covered a large range of fluid mechanical situations. The main objective of the colloquium which was to bring together people using continuation methods in different fluid mechanical situations was fulfilled. From post-colloquium reports, it seems that people learned a lot from the talks, but also from numerous informal and inter-personal discussions. This was facilitated by the fact that conference, lodging and meals were organized in the same place, the Centre Paul Langevin, and by the pleasant atmosphere among people. Some comments can be made. It would have been interesting to have more contributions from mathematicians on linear algebra solvers, which constitute a key point for the use of continuation methods for large problems. We got no proposition in this domain (only one invited talk): perhaps the announcement was not sufficiently oriented in this direction. The colloquium could also have benefited people working in Computational Fluid Dynamics, not yet using continuation methods. This time, only very few proved to be interested. At last, the talks on applications showed that not many three-dimensional fluid mechanics problems have been treated by continuation techniques, and even for two-dimensional problems complex behaviours (high-codimension bifurcation points, limit cycles) are still little considered.

Concerning the test problem on the two-dimensional Rayleigh-Bénard situation, although limited to linear aspects, it was treated by only four participants. It was a pity, as test problems are often an invaluable way to assessing methods, and the participants in such exercises often learn a great deal. One difficulty was that the application areas were so diverse that any test problem was easy for some groups and impossible for others.

Detailed information on the colloquium programme, together with the text of abstracts can be found in the colloquium brochure. More detailed scientific information on the colloquium and on the different presentations will be available within a few months in a special issue of

"Notes on Numerical Fluid Mechanics" (Vieweg publications).

Conclusion

Four different points will be addressed in the conclusion.

- Colloquium attendance.
  People attending the colloquium came from different domains of fluid mechanics applications, and most of them did not know each other. This gave very interesting talks based on different experiences. To improve the benefits of the colloquium, more people from linear algebra and computational fluid dynamics could have been involved. How to motivate them? One way would be to write an attractive book of proceedings in Notes on Numerical Fluid Mechanics.
- State of the art.
  Main improvements concern the application of known techniques to specific large problems of fluid mechanics. Much remains to do: adaptations of known techniques, applications to three-dimensional problems, treatment of complex behaviour.
- Interactions.
  Besides the individual presentations, numerous informal discussions and exchanges of ideas occurred during the colloquium. The colloquium will be genuinely fruitful if these interactions prove to be the first step of future collaborations.
- Perspectives.
  Most people have expressed their satisfaction, and all were favourable to a new edition of the colloquium within two or three years. It seemed important for conferences and lodging to be in the same location, as they were at Aussois, in order to facilitate contacts between participants.

For additional information please contact Daniel Henry (henry@mecaflu.ec-lyon.fr).

October 23, 1998

D. Henry