

TIME TABLE

TIME	Monday September 21	Tuesday September 22	Wednesday September 23	Thursday September 24	Friday September 25
9.00 - 9.45	Registration	Grimshaw	Klein	Ruban	Workshop
9.45 - 10.30	Steinrück	Grimshaw	Klein	Ruban	Workshop
11.00 - 11.45	Steinrück	Klein	Grimshaw	Klein	Workshop
11.45 - 12.30	Lagrée	Klein	Grimshaw	Klein	Workshop
14.30 - 15.15	Lagrée	Lagrée	Ruban	Ward	
15.15 - 16.00	Grimshaw	Lagrée	Ruban	Ward	
16.30 - 17.15	Grimshaw	Ruban	Ward	Steinrück	
17.15 - 18.00		Ruban	Ward	Steinrück	

ADMISSION AND ACCOMMODATION

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through our web site: <http://www.cism.it> or by post.

A message of confirmation will be sent to accepted participants. If you need assistance for registration please contact our secretariat.

The registration fee is 600,00 Euro.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered board and/or lodging in a reasonably priced hotel. Requests should be sent to CISM Secretariat by **July 21, 2009** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

The Deutscher Akademischer Austausch Dienst (DAAD) and the Deutsche Forschungsgemeinschaft (DFG) offer support to German students. Please contact:

DAAD, Kennedyallee 50, 53175 Bonn
tel. +49 (228) 882-0
e-mail: postmaster@daad.de
web site: <http://www.daad.de/de/kontakt.html>

DFG, Kennedyallee 40, 53175 Bonn
tel. +49 (228) 885 2655
e-mail: ing4@dfg.de
web site: <http://www.dfg.de>

Information about travel and accommodation is available on our web site, or can be mailed upon request.

Please note that the centre will be closed for summer vacation the first three weeks in August.

For further information please contact:

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33100 Udine (Italy)
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fax +39 0432 248550
e-mail: cism@cism.it

Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences



ACADEMIC YEAR 2009
The Sobrero Session

ASYMPTOTIC METHODS IN FLUID MECHANICS: SURVEY AND RECENT ADVANCES

*Advanced School
coordinated by*

Herbert Steinrück
Technical University of Vienna
Austria

Udine, September 21 - 25, 2009

ASYMPTOTIC METHODS IN FLUID MECHANICS: SURVEY AND RECENT ADVANCES

Rational asymptotic methods developed in the fifties and sixties have played an important role in theoretical physics, mechanics and in particular in fluid mechanics. Among the most powerful methods used in fluid mechanics are the method of matched asymptotic expansions and multiple scales methods.

Matched asymptotic expansions are based on the idea of Prandtl's boundary layer theory. In case of high Reynolds number flows the flow field can be approximated by an inviscid flow with the exception of a thin boundary layer along the wall where the viscosity has to be taken into account. Both approximations have to match in an intermediate region.

In some cases the inviscid flow and the viscous flow in a sub-layer have to be determined simultaneously. Thus one speaks of "Interacting boundary layers". An introduction to triple deck problems and recent applications to internal flows, external sub- or super sonic flows, thermal flows and free surface flows will be presented.

Another fruitful application is the theory of separated laminar incompressible flows. Various examples of fluid flows involving separation will be considered, including self-induced separation of the boundary layer in supersonic gas flows, and incompressible flow separation at the leading edge of an aerofoil.

A characteristic feature of multiple scales problem is that the solution exhibits almost

periodic structures whose properties vary on a large scale. Recently multiple scales methods have been applied to problem in meteorology. Thus well established ad hoc approximations have been verified by applying the method of multiple scales to the basic equations of fluid flow in the atmosphere. It will be demonstrated how a large collection of well-established models of theoretical meteorology can be recovered systematically, how new insight into scale interaction processes is gained, and how the asymptotic analyses provide hints for the construction of accurate and efficient numerical methods. The known limitations of the approach will be also discussed.

Many problems in fluid mechanics involve asymptotic expansions in the form of power series. Such expansions necessarily fail to find terms which are exponentially smaller than all terms in the series. Although small, these missing terms are often of physical importance. How to find such exponentially small terms, using as the main tool matched asymptotic expansions in the complex plane and Borel summation will be discussed.

The techniques will be developed in the context of model problems related to the theory of weakly nonlocal solitary waves which arise in the study of gravity-capillary waves and also for internal waves.

INVITED LECTURERS

Roger Grimshaw - Loughborough University, UK
6 lectures on: "Exponential Asymptotics with respect to generalized solitons and embedded solitary waves". These lectures will describe how to find exponentially small terms often hidden in conventional asymptotic expansions, using as the main tool complex variable methods and Borel summation. The techniques will be developed in the context of weakly nonlocal solitary waves.

Rupert Klein - Freie Universitaet, Berlin, Germany
6 lectures on: "Multiple Scales Methods in Meteorology". This lecture series will provide a detailed introduction to a unified framework for meteorological modeling based on multiple scales asymptotics.

Pierre-Yves Lagrée - CNRS, Université Paris 6, France
4 lectures on: "Interacting Boundary Layers". The objective of this course is to present the Interactive Boundary Layers Theory and its link with Triple Deck. Examples of retroaction of the boundary layer on the ideal fluid will be presented in various flow regimes.

Anatoly Ruban - Imperial College, London, UK
6 lectures on: "Theory of Separated Flows". In this part of the course main properties and "paradoxes" of the flow separation will be discussed first. Then the asymptotic theory of separated flows will be presented.

Herbert Steinrück - Vienna University of Technology, Austria
4 lectures on: "Introduction to Asymptotic Methods". An introduction to the method of matched asymptotic expansion will be given and applied to turbulence asymptotics.

Michael Ward - University of British Columbia, Canada
4 lectures on: "Hybrid Asymptotic-Numerical Methods for the Solution of Singular Perturbation Problems in Perforated Domains". In this lecture hybrid numerical-asymptotic methods which have been developed for a large class of reaction diffusion equations will be presented and applied to the Stokes flow around a cylinder.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from CISM web site, instructions will be sent to accepted participants.

PRELIMINARY SUGGESTED READINGS

M. Van Dyke, "Perturbation Methods in Fluid Mechanics", The Parabolic Press, 1975.

V. Sychev, A. Ruban, Vic. Sychev, G. Korolev, "Asymptotic Theory of Separated Flows", Cambridge University Press, 1998.

R. Klein, "An Applied Mathematical View of Meteorological Modelling", in: J. Hill and R. Moore (editors), Applied Mathematics Entering the 21st Century, Proceedings in Applied Mathematics 116, SIAM 2004.

H. Schlichting, K. Gersten, Boundary layer theory, 8. ed, Springer, 2003.

J. P. Boyd, "Weakly nonlocal solitary waves and beyond-all-orders asymptotics" by J. Kluwer, 1998, ISBN 0-7923-5072-3.

R. Grimshaw (ed.), "Solitary waves in fluids", WIT press, 2007, ISBN-13: 978-1-845641-57-3.

J. Cousteix, J. Mauss, "Asymptotic Analysis and Boundary Layers", Scientific Computation, Springer 2007.

T. Cebeci, J. Cousteix, "Modeling and computation of boundary layer flows". 2nd revised and extended edition, Horizons Publishing, Springer, 2005.

**ASYMPTOTIC METHODS IN FLUID MECHANICS:
SURVEY AND RECENT ADVANCES**

Udine, September 21 - 25, 2009

Application Form

(Please print or type)

Surname _____

Name _____

Affiliation _____

Address _____

E-mail _____

Phone _____ Fax _____

Method of payment upon receipt of confirmation (Please check the box)

The fee of Euro 600,00 includes IVA/VAT tax and excludes bank charges

I shall send a check of Euro _____

Payment will be made to CISM - Bank Account N° 094570210900,
VENETO BANCA - Udine (CAB 12300 - ABI 05418 - SWIFT AMBPIT2M -
IBAN CODE IT83Z 05418 12300 09457 0210900).
Copy of the receipt should be sent to the secretariat

I shall pay at the registration counter with check, cash or VISA
Credit Card (Mastercard/Eurocard, Visa, CartaSi)

IMPORTANT: CISM is obliged to present an invoice for the above sum. Please indicate to whom the invoice should be addressed.

Name _____

Address _____

C.F.* _____

VAT/IVA* No _____

(* Only for EU residents or foreigners with a permanent business activity in Italy.

Only for Italian Public Companies

I ask for IVA exemption (ex law n. 537/1993 - art. 14 comma 10).

Privacy policy: I understand that data received via this form will be used only to provide information about CISM and its activities, within the limits set by the Italian legislative decree no. 196/2003 and subsequent amendments.

Complete information on CISM's privacy policy is available at www.cism.it.

I have read the "Admission and Accommodation" terms and conditions and agree.

Date _____ Signature _____