TIME TABLE

TIME	Monday September 2	Tuesday September 3	Wednesday September 4	Thursday September 5	Friday September 6
9.00 - 9.45	Registration	Furmanski	Furmanski	Amberg	Amberg
9,45 - 10,30	Sarler	Furmanski	Furmanski	Amberg	Amberg
11,00 - 11,45	Gobin	Amberg	Sarler	Stella	Stella
11,45 - 12,30	Gobin	Amberg	Sarler	Gobin	Sarler
14,30 - 15,15	Stella	Gobin	Stella	Sarler	
15,15 - 16,00	Stella	Gobin	Stella	Sarler	
16,30 - 17,15	Kowalewski	Kowalewski	Gobin	Furmanski	
17,15 - 18,00	Kowalewski	Kowalewski	Kowalewski	Furmanski	

ADMISSION AND ACCOMMODATION

The registration fee amounts to 620,00 € or 430,00 € for participants on regular staff of Universities and Academies of Sciences.

Applicants should send their application form at the latest one month before the beginning of the course. Registration can be made by post, or on-line through our web site: http://www.cism.it.

A limited number of participants from Universities and Academies who are not supported by their own Institutions can be offered board and/or lodging at the University Residence (or a middle class hotel). **For this they should apply to the Secretariat of CISM by July 2, 2002** and enclose a curriculum and a letter of recommendation by the Dean confirming that the Institute has no funds for financing their participation. Preference will be given to applicants coming from countries which have adhered to CISM and contribute to its operating resources.

A list of hotels in Udine is available at http://www.cism.it or sent by post upon request. A limited number of single rooms are usually available at the University Residence at the price of approx. 18,00 € per person per night. Those interested should apply promptly through CISM.

Please, note that the Centre will be closed for summer vacations during the first three weeks of August.

For further information please contact:
CISM
Palazzo del Torso - Piazza Garibaldi 18
33100 Udine (Italy)
tel. +39 0432 248511 (6 lines)
fax +39 0432 248550
E-mail: cism@cism.it
http://www.cism.it

ACADEMIC YEAR 2002
The Lighthill Session

PHASE CHANGE WITH CONVECTION
MODELLING AND VALIDATION

Advanced School
Coordinated by

T. Kowalewski, IPPT PAN, Warsaw, Poland
D. Gobin, CNRS & Université Paris-Sud, France

Udine, September 2 - 6, 2002

International Centre for Mechanical Sciences
Centre International des Sciences Mécaniques

PHASE CHANGE WITH CONVECTION:

Solid-liquid phase-change phenomena are present in a large number of industrial applications (materials processing, crystal growth, casting of metal - matrix composites, heat storage, food conservation, cryosurgery) and natural processes (iceberg evolution, magma chambers, crust formation). It is generally recognized that the dynamics of such phase change processes are to a large extent influenced by natural convection. Numerical modelling of such strongly non-linear, moving boundary, thermal and fluid flow problems is not a trivial task. Complex flow structures may appear and their sensitivity to small variations of the parameters or boundary and initial conditions imply the use of appropriate physical models and performing numerical methods.

In the case of solidification, the planar interface is generally unstable, creating different structures, such as cells or dendrites. The subsequent growth of dendrites may be analysed by considering the kinetics of solidification and the local heat and mass transfer away from the dendrite tip. A particular issue of recent interest is the effect of convection in the melt on the growth rate and morphology of an isolated dendrite structure. These local mechanisms have drastic consequences at a larger scale and convective motion in the interdendritic melt is a primary cause for a macrosegregation, that is the variation in composition of a solidified alloy for instance. In the microgravity environment, despite the absence of natural convection, problems arising from the effects of Marangoni convection or g-jitter effects seriously damped initial enthusiasm on using space labs for crystal growth.

For these reasons, computer simulation has a major relevance as a tool of analysis of the experimental studies or for the design of engineering hardware. It is first necessary to establish appropriate physical models and then to develop numerical procedures for solving the resulting set of equations. In order to assess a satisfactory level of confidence of the simulation tools, both the model and the procedure have to be tested through properly designed validation experiments, reproducing the basic features of the simulated phenomena. Therefore, besides well-established numerical benchmarks for code verification, experimental benchmarks for code validation have gained a special attention in the recent years, including recent achievements in measurement techniques (optical and electro-optical methods like thermography, tomography or particle image velocimetry).

The aim of the course is to present a review of modelling phase change problems and of recent methods of numerical and experimental analysis used, with a particular focus on solidification coupled to convective flow. Special attention is given to the validation and verification of numerical codes and to the applications to practical problems. Theoretical background and practical examples of tailoring numerical codes will provide framework to develop skills in using them in various branches of physical or engineering problems.

This course is addressed to advanced students and scientists from engineering and applied sciences, as well as to physicists and mathematicians interested in the fundamentals of the field. It will give researchers and engineerings knowledge and critical assessment of numerical approaches, physical models and validation methods (used in the field).

PRELIMINARY SUGGESTED READINGS

M. C. FLEMINGS, Solidification Processing, McGraw Hill, New York, 1974.

W. KURZ and D.J. FISCHER, Fundamentals of solidification, Trans Tech Publications, Aedermansdorf, Switzerland 1989.

B. CAROLI, C. CAROLI and B. ROULET, Instabilities of planar solidification fronts, in Solids far from Equilibrium (Chap. 2, 155 - 296). Cambridge University Press, 1992.

J. CRANK Free and Moving Boundary Problems, Clarendon Press, 1984.

P. PRESCOTT and F. INCROPERA, Convection heat and mass transfer in alloy solidification in Advances in Heat Transfer, vol. 28, 231 - 338. Wiley Interscience, 1996.

W. SHYY, H.S. UDAYKUMAR, M.M. RAO and R.W.SMITH, Computational Fluid Dynamics with Moving Boundaries Taylor & Francis, 1995.

V. R. VOLLER, An overview of numerical methods for solving phase-change problems, in Advances in Numerical Heat Transfer - Volume 1, chap. 9, 341 - 380, Taylor & Francis, 1997.

M. RAPPAZ, M. BELLET, M. DEVILLE, Modélisation Numérique en Science et Génie des Matériaux, Presses Polytechniques Universitaires Romandes), 1998.

M. RAPPAZ, Modelling of Microstructure Formation in Solidification Processes, Int Mater Rev, Vol.34, 93-123, 1989.

M. RAFFEL, C. WILLERT, J. KOMPENHANS, Particle Image Velocimetry, Springer, Berlin 1998.

R.J. GOLDSTEIN, Fluid Mechanics Measurements, Taylor & Francis, Washington DC 1996.

INVITED LECTURERS

G. AMBERG - KTH, Stockholm, Sweden
6 lectures on: Mullins-Sekerka instabilities, microsegregation, mushy zones, chimneys and dendrites - fundamentals and practical approach; convective effects, phase field model, basics of models for macro-segregation in ingots.

P. FURMANSKI - PW ITC, Warsaw, Poland
6 lectures on: Microscopic-macroscopic modelling of transport phenomena during solidification in heterogeneous systems; mushy zone of binary alloys, in manufacture; averaging procedures; thermodynamic and topological relations.

D. GOBIN - CNRS & Université Paris-Sud, France
6 lectures on: Coupling between natural convection and phase change for pure substances or binary mixtures; basic ideas on natural convection (fundamentals, equations, scaling laws and correlations): thermal convection, double diffusive convection; validation problems for phase change with convection; challenging issues for the simulation of solidification processes.

T. KOWALEWSKI - IPPT PAN, Warsaw, Poland
5 lectures on: Experimental methods and benchmarks for numerical simulation of phase change problems; initial, boundary conditions and sensitivity analysis; full field measurements, advanced optical measuring techniques, PIV, interferometry, thermography, tomographic methods.

B. SARLER - Nova Gorica Polytechnic,
Laboratory for Multiphase Processes, Slovenia
6 lectures on: Solid-liquid phase change research: history, numerical methods and casting applications; boundary element and meshless methods for phase change problems, simulation and optimisation of continuous casting of steel.

F. STELLA - Università di Roma, La Sapienza, Italy
6 lectures on: Numerical methods for phase change problems in praxis; requirements of numerical solvers; comparison of different numerical approaches; directional solidification; micro-gravity conditions; commercial codes in solidification problems.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from CISM web site after registration.

PHASE CHANGE WITH CONVECTION
MODELLING AND VALIDATION
Udine, September 2 - 6, 2002
Registration Form
(Please print or type)

Surname _____

Name _____

Affiliation _____

Address _____

_____

E-mail _____

Phone _____ Fax _____

Method of Payment - (Please check boxes)

❑ I enclose a check of Euro 620,00 / 430,00 (IVA, VAT included and excluded bank charges)

❑ Payment has been made on CISM - Bank Account N° 210900, Banco di Sicilia - Udine (CAB 12300-ABI 01020-SWIFT BSICITRRUDN) Copy of the receipt should be sent to the secretariat

❑ I shall pay at the registration counter with a VISA Credit Card *(Mastercard/Eurocard, Visa, CartaSì)*

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

Name _____

Address _____

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C.F.* _____

IVA or VAT* _____

(*) Only for EC or Italian residents or foreigners with permanent business activity in Italy.

According to the Italian law 675/96 in defense of privacy, your personal data will be used exclusively for conducting the course unless upon your explicit authorization.

Date _____ Signature _____

Please return to: CISM
Piazza Garibaldi, 18
33100 UDINE (Italy)