



**LEHRSTUHL FÜR STRÖMUNGSMECHANIK  
INSTITUTE OF FLUID MECHANICS**

DFG and KONWIHR-WORKSHOP

## **Lattice Boltzmann Methods**

Theory and  
Applications in Fluid Mechanics

March, 26th – 28th, 2001

Friedrich-Alexander-Universität  
Erlangen-Nürnberg



**TECHNISCHE  
FAKULTÄT**



## **Workshop at the**

Institute of Fluid Mechanics  
Friedrich-Alexander-University  
Erlangen-Nuremberg  
Germany

### **Contributors:**

Institute of Fluid Mechanics  
University of Erlangen-Nuremberg, Germany

Lehrstuhl für Bauinformatik  
Technische Universität München, Germany

Institute of Combustion and Gas Dynamics  
University of Duisburg, Germany

Numerical Analysis and  
Scientific Computing Group  
University of Darmstadt, Germany

Department of Computer Sciences  
University of Geneva, Switzerland

Institute of Computer Applications  
University of Rome, Italy

Laboratoire de Physique Statistique  
Ecole Normale Supérieure, Paris, France

Institute for Computer Applications for  
Science and Engineering (ICASE)  
NASA Langley, USA

C & C Research Laboratories, NEC Europe Ltd.  
Sankt Augustin, Germany

### **Supported by:**

D F G  
Deutsche Forschungsgemeinschaft

K O N W I H R  
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## Introduction

The development of novel numerical methods for applications in computational fluid dynamics (CFD) and related fields has made rapid progress in recent years. These new techniques include the lattice gas (LG) and lattice Boltzmann (LB) methods. Traditional CFD methods solve the Navier-Stokes equations, i.e. a set of second order partial differential equations, using approximations such as finite differences or finite elements and appropriate numerical solvers. In lattice Boltzmann methods on the other hand, the hydrodynamic quantities are evaluated as phase space averages of the approximated single-particle distribution functions. It has been proven that this approach is a promising alternative to classical CFD methods which circumvents many deficiencies that are inherent in the existing methods. Potential fields of application include, for example, aerodynamics, turbulence research, chemical engineering and combustion.

The goal of the workshop is two-fold: The basic ideas of these methods as well as their possibilities will be presented to a broader audience. We focus on potential users of the technique as well as students with interest in CFD. Scientists and engineers with more substantial experience in CFD in general and LB methods in particular will have the possibility to improve their knowledge and to acquire detailed information from leading experts in this field. Applications and aspects of high performance computing will be presented.

All lectures are presented by experienced research staff. The course language is English.

The course will be accompanied by an exhibition of commercial products and services related to this field.

# Programme

## Monday, March 26th, 2001

- 8.00 Registration
- 8.45 - 9.00 General Information  
*Prof. F. Durst, Erlangen*
- 9.00 - 9.45 Necessity for Modern Numerical  
Methods in Fluid Mechanics  
*Prof. F. Durst, Erlangen*
- 9.45 - 10.30 Introduction to Lattice Gas and Lattice  
Boltzmann Methods  
*Dipl.-Phys. J. Bernsdorf, St. Augustin*
- 10.30 - 11.00 **Coffee Break**
- 11.00 – 11.45 The Kinetic Theory of Gases and the  
Relation to the Boltzmann Equation  
*Prof. A. Klar, Darmstadt*
- 11.45 - 12.30 From Lattice-Boltzmann to the Navier-  
Stokes Equations  
*Dr. L.-S. Luo, Hampton, USA*
- 12.50 - 14.00 **Lunch**
- 14.00 -14.45 Historical Development of Lattice Gas  
and Lattice Boltzmann Methods  
*Prof.S. Succi, Rome, Italy*
- 14.45 - 15.15 Introduction to the Tutorials  
*Dr. M. Krafczyk, Munich*
- 15.15 - 15.30 **Break**
- 15.30 - 17.30 Tutorials

The lectures during the first day are intended to present a general introduction to the mathematical and physical background of LB methods. Starting from the statistical description of the method, the kinetic theory of gases and its relation to the lattice Boltzmann as well as Navier-Stokes equations will be explained. "Hands on" exercises conclude the first day and will ensure that the participants have assimilated the knowledge required to follow the lectures and tutorials of the second and third day.

## Tuesday, March 27th, 2001

- 9.00 - 9.45      Advanced Theoretical Considerations:  
Beyond BGK  
*Prof. D. d'Humières, Paris, France*
- 9.45 - 10.30    Boundary Conditions for LB Methods  
*Prof. D. d'Humières, Paris, France*
- 10.30 - 11.00    **Coffee Break**
- 11.00 - 11.45    Advanced Modelling I: Diffusion and  
Chemical Reactions  
*Dipl.-Ing. T. Zeiser, Erlangen*
- 11.45 - 12.30    Advanced Modelling II: Heat Transport  
*Prof. D. Hänel, Duisburg*
- 12.30 - 14.00    **Lunch**
- 14.00 - 14.45    Practical Realisation of LB Methods for  
Parallel Computers  
*Dipl.-Phys. J. Bernsdorf, St. Augustin*
- 14.45 - 15.15    Introduction to the Tutorials  
*Dipl.-Phys. P. Lammers, Erlangen*
- 15.15 - 15.30    **Break**
- 15.30 - 18.00    Tutorials
- 19.30            **Workshop Dinner**

The second day begins with the presentation of advanced considerations related to the numerical formulation and physical models of the LB technique.

During the afternoon, practical aspects of the implementation of lattice Boltzmann methods on high performance computers are presented. The following exercises will allow the participants to obtain some practical insight into LB methods. Under the supervision of the lecturers, a sample LB code will be developed and implemented on the workstation pool.

A workshop dinner is arranged as part of the workshop. It is intended as a social event but should provide also the opportunity for informal discussions on the topics of the course.

## Wednesday, March 28th, 2001

- 9.00 - 9.45      *Advanced Modelling III: Turbulent Flows*  
*Prof. S. Succi, Rome, Italy*
- 9.45 - 10.30    *Advanced Modelling IV: Multiphase*  
*Flows*  
*Prof. B. Chopard, Geneva, Switzerland*
- 10.30 - 11.00    **Coffee Break**
- 11.00 - 11.30    *Stability Aspects of Lattice Boltzmann*  
*Methods*  
*Dr. L.-S. Luo, Hampton, USA*
- 11.30 - 12.30    *Mesh Refinement and Acceleration*  
*Techniques*  
*Dr. M. Krafczyk, Munich*
- 12.30 - 14.00    **Lunch**
- 14.00 - 14.45    *Accuracy Comparison of Lattice*  
*Boltzmann and Navier-Stokes Methods*  
*Dr. G. Brenner, Erlangen*
- 14.45 - 15.30    *Realtime Demonstration of a Lattice*  
*Boltzmann Solver*  
*Dipl.-Ing. T. Zeiser, Erlangen*
- 15.30 - 16.00    **Final Discussion**
- 16.00            End of workshop with beer and  
pretzels

The morning of the third day is dedicated to advanced models and numerical techniques with respect to important topics in CFD such as turbulence, multiphase flows and acceleration techniques. The lectures will close with an online presentation of a high performance LB code.

The final discussion will provide an excellent opportunity for all the participants to bring forward their particular problems and to discuss possibilities of their solution by lattice Boltzmann methods.

## Fees and Course Material

	Students	University	Others
Before 01.03.2001	€ 50,-	€ 75,-	€ 150,-
After 01.03.2001	€ 60,-	€ 95,-	€ 180,-

Confirmation of registration and a request for payment will be sent out after receipt of the registration. In case of cancellation a substitute participant can be nominated. For cancellation before 1.3.2001 a handling fee of € 50,- plus VAT will be charged. In case of cancellation after 1.3.2001 without nominating a substitute participant the full seminar fees will be charged.

The course fees include refreshments during coffee breaks and a workshop dinner. Every participant will receive a copy of the course material.

## Venue of the course

The course will take place on the Röthelheim Campus of the University of Erlangen-Nuremberg, Paul-Gordan-Straße 3.

## Questions ?

For further questions, please contact:

<b>Workshop Office</b> Ms G. Rothardt Tel: ++49-9131 85-23000	<b>Workshop Supervision</b> Dr. G. Brenner Tel: ++49-9131 85-23005
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Lehrstuhl für Strömungsmechanik  
Universität Erlangen-Nürnberg  
Paul-Gordan-Straße 3  
D-91052 Erlangen

Fax: ++49-9131 85-23002  
E-Mail: [lhm2001@lstm.uni-erlangen.de](mailto:lhm2001@lstm.uni-erlangen.de)  
Web: [www.lstm.uni-erlangen.de/lhm2001/](http://www.lstm.uni-erlangen.de/lhm2001/)

## Overnight Accommodation

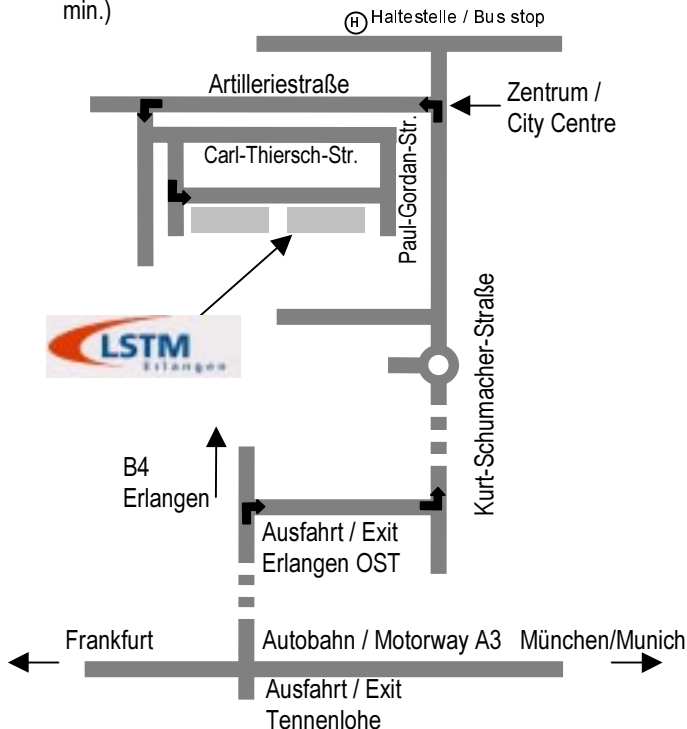
You will receive a list of hotels in the city of Erlangen together with your confirmation of registration. Please book your hotel directly or through the Fremdenverkehrsverein Erlangen e.V., Rathausplatz 1, D-91052 Erlangen, Phone ++49-9131-895112, Fax ++49-9131-895151, e-mail: [tourist@stadt.erlangen.de](mailto:tourist@stadt.erlangen.de).

## Travel

By train: From Erlangen station: Taxi to "Röthelheim Campus" (10 min.) or bus route 284 or 294 (direction "Siegliethof") to bus stop "Berufsschulzentrum"

By car: Leave motorway A 3 at junction Erlangen-Tennenlohe. Proceed along highway B 4 in direction Erlangen and follow the signs for "Erlangen-Ost". After the roundabout, take the second street, Artilleriestraße, on your left. Turn left at vonder-Tann-Straße and immediately left again into Carl-Thiersch-Straße.

By plane: From Nuremberg airport: Taxi to "Röthelheim Campus" (20 min.)





## Lecturers

**Dipl.-Phys. J. Bernsdorf** is a scientist at C&C Research Laboratories Sankt Augustin, NEC Europe Ltd.. The focus of his work is high performance computing and development of lattice Boltzmann methods.

**Dr. G. Brenner** is head of the division of computational fluid mechanics at the Institute of Fluid Mechanics at the University of Erlangen-Nuremberg. The focus of his work is the development and application of numerical methods for the investigation of complex transport phenomena.

**Prof. B. Chopard** is professor at the Department of Computer Sciences, University of Geneva, Switzerland. His research interests concern the modelling and simulation of complex systems on parallel computers, using the cellular automata approach and related techniques. He is co-author of the textbook "Cellular Automata Modeling of Physical Systems" (Cambridge University Press, 1998).

**Prof. D. d'Humières** is professor at the Laboratoire de Physique Statistique de l'École Normale Supérieure, Paris, France. He is one of the leading scientists in this field and has made major contributions to lattice gas and lattice Boltzmann methods.

**Prof. Dr. Dr. h.c. F. Durst** is head of the Institute of Fluid Mechanics at the University of Erlangen-Nuremberg (LSTM-Erlangen). His research work embraces experimental and numerical studies of fluid flows using modern techniques. Special emphasis is given to turbulence research.

**Prof. D. Hänel** is the head of the Institute of Combustion and Gas Dynamics at the University of Duisburg. His research interests concern the development and application of numerical methods in different fields of fluid mechanics, aerodynamics, gas dynamics and combustion.

**Prof. A. Klar** is professor of mathematics at the Technical University of Darmstadt and head of the Numerical Analysis and Scientific Computing Group. He is also manager of the DFG-project "Lattice Boltzmann Methods: Analysis, Numerics and Applications for Complex Physics" in which the German research activities in this field are co-ordinated.

**Dr. M. Krafczyk** is group leader at the Lehrstuhl für Bauinformatik at the Technische Universität München. The focus of his work is the development and application of lattice Boltzmann and other numerical methods in civil engineering and porous media flow.

**Dipl.- Phys. P. Lammers** is a scientist at the Institute of Fluid Mechanics at the University of Erlangen-Nuremberg. The focus of his work is the development of lattice Boltzmann methods for aerodynamic applications and high performance computing.

**Dr. L.-S. Luo** is a Senior Staff Scientist at the Institute for Computer Applications for Science and Engineering (ICASE) at Nasa Langley Research Center, Hampton, Virginia, USA. His research concentrates on lattice Boltzmann methods and the application to complex fluids and other systems.

**Prof. S. Succi** is the head of the Fluid and Complex Systems Dynamics Group at the Istituto Applicazioni Calcolo of the University of Rome, Italy. His main interests are fluid dynamics, turbulence research and the theory and application of lattice Boltzmann methods.

**Dipl.- Ing. T. Zeiser** is a scientist at the Institute of Fluid Mechanics at the University of Erlangen-Nuremberg. The focus of his work is the development and application of lattice Boltzmann methods in chemical engineering and high performance computing.

**Registration:**

Position/Title: \_\_\_\_\_

Name: \_\_\_\_\_

Address: \_\_\_\_\_

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\_\_\_\_\_

Tel.-No.: \_\_\_\_\_

Fax-No.: \_\_\_\_\_

E-Mail: \_\_\_\_\_

Date: \_\_\_\_\_ Signature: \_\_\_\_\_

**WORKSHOP**

**Lattice Boltzmann Methods**

Theory and Applications in Fluid Mechanics

26th – 28th March 2001

Course fees see text.

Online registration:

[www.lstm.uni-erlangen.de/lbm2001/](http://www.lstm.uni-erlangen.de/lbm2001/)

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Universität Erlangen-Nürnberg  
- Workshop LBM 2001 -  
Paul-Gordan- Str. 3

D-91052 Erlangen