



**von KARMAN INSTITUTE
FOR FLUID DYNAMICS**

LIQUID FRAGMENTATION IN HIGH-SPEED FLOW



"Atomization of a Liquid Jet", picture from Prof. Villiermaux from IRPHE, Institut de Recherche sur les Phénomènes Hors Equilibres

March 16-18, 2009

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INTRODUCTION

Liquid injection into compressible crossflow has several interesting applications such as fuel injection in supersonic or hypersonic scramjet engines, thrust vector maneuvering of high speed aerial or space vehicles, and film cooling used in the thermal protection systems of space vehicles that experience atmospheric entry. The field involves many disciplines, and it is a complicated multi-phase flow field especially for compressible crossflow cases, with a unique flow topology including shock-shock and shock-boundary layer interactions. High aerodynamic shear forces, fragmentation, penetration and atomization of the liquid jet are important features that deserve detailed analyses.

The objective of this lecture series is to provide the state-of-the-art information on liquid fragmentation in compressible crossflow. Lectures will include a review of the fundamentals of the phenomena as well as recent advances relevant to the modelling, computation and measurement of the flowfield. Examples of several applications will be presented, by experts of the field from all around the world. The Lecture Series is intended not only to provide suitable training and information to engineers and scientists who wish to enter the field, but also to provide a focal point for technical discussions and an opportunity to exchange views and ideas among engineers and scientists who already work in the field.

The Lecture Series directors are Prof. P. Rambaud and Ir. C. Asma of the von Karman Institute for Fluid Dynamics, Belgium.

TIMETABLE

MONDAY MARCH 16

- 08:45 Registration
- 09:15 Welcome and introduction
- 11:00 Introduction: applications of liquid jet injections I
Prof. E. Villiermaux, IRPHE, France
- 14:00 Introduction: applications of liquid jet injections II
Prof. E. Villiermaux
- 15:45 Liquid injection in high-speed flows
Prof. S.T. Heister, Purdue University, USA
- 17:00 Reception

TUESDAY MARCH 17

- 09:00 Theory of fragmentation and atomization: modelling and numerical approach
Prof. S.T. Heister
- 11:00 Supercritical fluid injection in quiescent flow fields: modelling and mixing enhancement
Prof. G. Lamanna, Universität Stuttgart, Germany

- 14:00 A review of experimental techniques to study liquid fragmentation
Prof. G. Lamanna
- 15:45 Detonations of liquid sprays and drop suspensions: theory
Prof. S. Frolov, N.N. Semenov Institute of Chemical Physics, Russia

WEDNESDAY MARCH 18

- 09:00 Detonations of liquid sprays and drop suspensions: experiment
Prof. S. Frolov
- 10:45 Shock tube experiments at ISL on liquid fragmentation I
Dr. J. Srulijes & Prof. F. Seiler, ISL, France
- 14:00 Shock tube experiments at ISL on liquid fragmentation II
Dr. J. Srulijes & Prof. F. Seiler
- 15:45 Fragmentation of liquid in hypersonic cross flow
Ir. C.O. Asma, von Karman Institute for Fluid Dynamics, Belgium
- 17:00 Concluding remarks and future prospects
- 18:00 Departure of VKI bus

PRACTICAL INFORMATION

Lunch will be taken from 12h30 to 14h00. Coffee breaks are scheduled each morning and afternoon.

Please pass this announcement to someone who may be interested if you are unable to attend the Lecture Series yourself



VON KARMAN INSTITUTE FOR FLUID DYNAMICS



- ☐ INTRODUCTION TO CFD
(12-16 JANUARY 2009)
- ☐ ADVANCES IN LAMINAR-TURBULENT TRANSITION MODELING
(12-15 JANUARY 2009 - AT THE WRIGHT STATE UNIVERSITY, OHIO, USA)
- ☐ RECENT ADVANCES IN PARTICLE IMAGE VELOCIMETRY
(26-30 JANUARY 2009)
- ☐ MODELING AND COMPUTATION OF NANOPARTICLES IN FLUID FLOWS (RTO-AVT-VKI)
(9-12 FEBRUARY 2009)
- ☐ FLOW CONTROL: FUNDAMENTALS, ADVANCES AND APPLICATIONS
(2-6 MARCH 2009)
- ☐ AERODYNAMIC NOISE FROM WALL-BOUNDED FLOWS
(9-13 MARCH 2009)
- ☒ LIQUID FRAGMENTATION IN HIGH-SPEED FLOW
(16-18 MARCH 2009)
- ☐ NUMERICAL INVESTIGATIONS IN TURBOMACHINERY: THE STATE OF THE ART
(20-24 APRIL 2009)
- ☐ HIGH PERFORMANCE COMPUTING OF INDUSTRIAL FLOWS
(5-7 MAY 2009)
- ☐ ADVANCED HIGH TEMPERATURE INSTRUMENTATION FOR GAS TURBINE APPLICATIONS
(11-14 MAY 2009)
- ☐ TURBULENT COMBUSTION
(25-29 MAY 2009)
- ☐ 36TH CFD.ADIGMA COURSE ON VERY HIGH ORDER DISCRETIZATION METHODS
(JUNE 8-12, 2009)

OTHER CONFERENCES:

- ☐ PHYSMOD 2009: INTERNATIONAL WORKSHOP ON PHYSICAL MODELLING OF FLOW AND DISPERSION PHENOMENA
(24-26 AUGUST 2009)
- ☐ 4TH SYMPOSIUM ON INTEGRATION CFD AND EXPERIMENTS IN AERODYNAMICS
(14-16 SEPTEMBER 2009)

COURSE FEE

The fee for the lecture series is 975 euro, applicable to citizens of NATO countries contributing to the financing of the VKI (Belgium, Czech Republic, France, Germany, Hungary, Iceland, Italy, Luxemburg, Norway, Portugal, Spain and Turkey). For citizens of other NATO countries and of NATO partner countries, the fee is 1275 euro. For non-NATO citizens the fee is of 1390 euro. These prices include 21% VAT.

The fee includes printed notes, transport between VKI from and to the recommended hotels in the center of Brussels, lunches, beverages, and administrative costs.

FELLOWSHIPS

To encourage greater participation in our Lecture Series programme by university members, the Institute has established a limited number of VKI Lecture Series fellowships for citizens of NATO countries contributing to the financing of the VKI, as well as for citizens of other NATO countries coming from a university in a VKI financing country. The recipient of such fellowship is entitled to attend the Lecture Series at a reduced fee, which will be of 490 euro (VAT included) for assistants not having a Ph.D. degree and for Ph.D. candidates, or 225 euro (VAT included) for undergraduate students. The request to be considered for an award must accompany the application to attend the Lecture Series, and the applicant must provide a recommendation letter from his or her professor; if not done so, the request will not be taken into consideration. All possible alternative sources of funding should be investigated before aid is requested under this scheme, so that those most in need will benefit.

METHODS OF PAYMENT

Payment 2 weeks prior to the beginning of the course (name and course title clearly indicated) by bank transfer to our account Nr 210-0315330-35 at Fortis Bank, avenue de la Forêt de Soignes 322, 1640 Rhode-Saint-Genèse, Belgium, IBAN BE57 2100 3153 3035 (strongly recommended). SWIFT BIC GEBABEBB.

Late registration can be paid in cash (EURO), or by VISA or Eurocard at the beginning of the course.

PROCEEDINGS

Lectures will be given in English and printed notes will be distributed during registration. Proceedings of other non-RTO lecture series may be purchased at VKI (by e-mail: vanhaelen@vki.ac.be or by fax : 32 2 359 96 00). Information can be found on <http://www.vki.ac.be>.

HOW TO REGISTER

It is highly recommended that the registration/hotel reservation form is sent at the latest 15 days before the beginning of the course. A letter of acceptance and additional information will be sent on receipt of the application form.

ACCOMMODATION & TRANSPORT

Participants are advised to make their reservations as early as possible. VKI secretariat (secretariat@vki.ac.be) can book rooms upon request in the recommended hotels listed below. Daily rates include all charges and continental breakfast. These prices could be subject to changes. **However, participants could occasionally find special offers on hotel websites.**

Hôtel des Colonies
<http://www.hotel-des-colonies.com> Single: 120 € / Double: 140 €

Hôtel Vendôme
<http://www.hotel-vendome.be> see the website

Hôtel Marivaux
<http://www.marivaux.be> see the website

Thon Hotel Brussels City Centre
<http://www.thonhotels.be/> Single: 142 € / Double: 174 €

Hôtel Le Dôme
<http://www.hotel-le-dome.be> Single: 125 € / Double: 145 €

Progress Hôtel
<http://www.progresshotel.be> Single: 200 € / Double: 220 €

A youth hostel, the Sleepwell, is within walking distance of the recommended hotels. We invite you to make your own reservation through their website: <http://www.sleepwell.be>.

The hotels situated in Brussels are all within walking distance from the Place Rogier. A train service links the airport with the Gare du Midi. Complete your journey to the hotel/youth hostel by taxi. Each morning and evening, bus transport will be provided between the Place Rogier and the von Karman Institute, located in Rhode-Saint-Genèse, a suburb south of Brussels.

The following hotels are also recommended, particularly for those who travel by private car.

Auberge de Waterloo****
Chaussée de Waterloo 212 - 1640 Rhode-Saint-Genèse
Tel: +32 (0)2 358 35 80 - Fax : +32 (0)2 358 38 06
<http://www.aubergedewaterloo.be>
(1single room: +/- 106€)

Gravenhof Hotel
Alsebergsesteenweg 616 - B-1653 Dworp
Tel: +32 2 380 44 99 - Fax: +32 2 380 40 60
<http://www.gravenhof.be>
(1 single room: +/- 105 €, breakfast not included)

For more information about the location of the Institute and the hotels, please visit our website on <http://www.vki.ac.be>.

APPLICATION FOR ADMISSION TO VKI LECTURE SERIES

Lecture Series Title: LIQUID FRAGMENTATION IN HIGH-SPEED FLOW

☐ Mr ☐ Mrs

Family name:Firstname:Nationality:

Name & full address of organisation, institution or university:Fax nr:

Phone nr:E-mail:

Position or title:
☐ Asking a reduced fee and joining a recommendation letter as: ☐ undergraduate student ☐ Ph.D. candidate or University assistant

Company / University VAT number:
VAT of the von Karman Institute: BE 0407 185 709

HOTEL RESERVATION (if applicable)

I require accommodation at Hotelforperson(s)
Single:Double:
I shall require transport to and from the InstituteDate of arrival:
I do not require transport to and from the Institute ☐ ☐Date of departure:
Please indicate any special needs (e.g. vegetarian, ...):

Date:Signature:

✂ Please mail under -cover to VKI