

Spring – Summer 2006 Issue

The Institute of Physics  
COMBUSTION PHYSICS GROUP NEWSLETTER  
No. 53  
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## 1. COMBUSTION PHYSICS GROUP

Web site: <http://groups.iop.org/CB/>

### COMMITTEE 2005/2006:

<b>Chairman:</b>	Professor A.M.K.P. Taylor	Imperial College London
<b>Vice-chairman:</b>	Ms Catherine Goy	E.ON UK
<b>Honorary Secretary:</b>	Mr R. Boyce	Rolls-Royce
<b>Ordinary Members:</b>		
	Mr J. Allen	Scion-Sprays Ltd
	Prof P.J. Bowen	Cardiff University
	Dr. A. Burluka	University of Leeds
	Dr P. Cadman	University of Wales, Aberystwyth
	Dr P. Cumber	Heriot-Watt University
	Dr M. Fairweather	University of Leeds
	Prof. A. R. Jones	Imperial College London
	Prof. K. Luo	University of Southampton
	Dr E. Mastorakos	University of Cambridge
	Dr P. Rubini	Cranfield University
	Dr P. Stephenson	RWE Power International
	Dr K. Syed	Industrial Turbines, Siemens

## 2. EDITOR'S CORNER

In this edition of our Newsletter, we include reports on the past and future activities of our group. We also include various pieces of information related to combustion science that various people have sent to me. I hope you will find them interesting.

Once again I remind you that unsolicited articles, conference reviews etc are very welcome for the Newsletter. Please email them to me. A sum of £50 is available for articles by *bonafide* research students and young researchers (including those working in industry) on topics connected with combustion. Supervisors, please encourage your students to write one! If anyone has any ideas for articles, I would be very pleased to hear from them.

Our Web site is always one of the first places to look for information. The address is:

<http://groups.iop.org/CB/>

Epaminondas Mastorakos, August 2006  
em257@eng.cam.ac.uk

### 3. MEETINGS AND CONFERENCES

#### 3.1 Past

The **final meeting** of the EPSRC-funded Computational Combustion network **COCCFEA** took place in Fitzwilliam College at Cambridge on 19-20 September 2005. There were two international invited experts and UK-based speakers to review the advances and challenges of **computational combustion**. The meeting was concluded by a detailed discussion on the future steps for this consortium, which resulted in a new proposal to the EPSRC. A new grant has been awarded. For details, contact Prof. Kai Luo (K.H.Luo@soton.ac.uk).

The very successful **Young Researchers** meeting took place in Loughborough on the 21<sup>st</sup> of September 2005. The event was co-sponsored by the Combustion Institute. Speakers included PhD students, post-docs, and industrial researchers. About 50 posters were also presented. Copies of the oral presentations can be found in our Web site: <http://groups.iop.org/CB/events/YR2005.htm>

The allocated prizes were:

- The Felix Weinberg Prize to Ben Haberman of the Cambridge University Engineering Department for his talk on “An Introduction to Solid Oxide Fuel Cell Research at CUED”, for the best presentation.
- The Best Poster Prize to Adela Khor I Ling of Chemical Engineering, Sheffield University, for her work in biomass combustion.
- The runner-up prize for best presentation went to Thierry Reveille of Cranfield University and the runner-up prize for the best poster went to A. Charalambides of Imperial College.
- Ben Goh of E.ON won the best presentation from industry award by the British Flame, while Peter Kay from Cardiff was awarded the best poster for industry-relevant research, also by British Flame.



The **Fourth Mediterranean Combustion Symposium** took place in Lisbon in October 6-10 2005. A detailed report can be found in Section 3.3.

A special meeting sponsored by the Combustion Institute and honouring Prof. D. Bradley on the occasion of his 80<sup>th</sup> birthday, took place on 11 April in Oxford. An impressive list of speakers discussed the “**Limits on Combustion**”. Details and copies of the presentations can be found from: <http://www.combustion.org.uk/Oxford06.html>

A Workshop on “**Fires in Enclosures**” was held at the University of Ulster on the 30th and 31st of May 2006. The meeting was organized by Prof. M. Delichatsios. A detailed report is found in this Newsletter.

The **31<sup>st</sup> International Symposium on Combustion** took place in Heidelberg between 6 and 11 of August 2006. Details from <http://combustion2006.org>. A report, available in this issue, has been written with the memories still fresh by a post-doc immediately upon return from Heidelberg.

### **3.2 Future**

Our own **Autumn 2006 Meeting** will be on “**Combustion of Biofuels**” and will take place on 19 September in the E.ON UK Power Technology Centre in Ratcliffe-on-Soar, Nottingham. A list of speakers from academia and industry will discuss the special characteristics of biofuel combustion. The event is organized by Dr. P. Rubini of Cranfield University and Ms. C. Goy of E.ON UK. It is co-sponsored by the British Section of the Combustion Institute and British Flame (International Flame Research Foundation). For more details, please contact the organisers ([p.a.rubini@cranfield.ac.uk](mailto:p.a.rubini@cranfield.ac.uk), [catherine.goy@eon-uk.com](mailto:catherine.goy@eon-uk.com)) or check our Web site: <http://groups.iop.org/CB/events/index.htm>

The **21<sup>st</sup> International Colloquium on the Dynamics of Explosions and Reactive Systems** (ICDERS 2007) will take place in Futuroscope, Poitiers, in 23-27 July 2007. For details, see: <http://www.icders2007-poitiers.org/index.htm>

The **European Combustion Meeting 2007** will take place in Chania, Crete, in 11-13 April 2007. For details, see: <http://www.combustioninstitute.gr>

A more extensive list of national and international conferences can be found at: <http://www.combustioninstitute.org/conferences.htm>  
<http://www.combustion.org.uk>

### **3.3 Detailed reports on meetings**

#### **Mediterranean Combustion Symposium 6-10 October 2005 Lisbon**

The Fourth Mediterranean Combustion Symposium took place in October 6-10 2005 in Lisbon locally organized by Profs. Mario Costa and Pedro Coehlo of Instituto Superior Tecnico. I could not attend the opening reception, which was unfortunate because I heard that the food was excellent – we expected no less from our Portuguese hosts! A rigorous program including virtually all aspects of combustion (laminar and turbulent flames, solid fuels, combustion diagnostics, propulsion, new concepts etc.) was designed. There were seven plenary lectures (Prof. L. Kennedy on combustion synthesis; Prof. A. Masri on bluff-body flames and instabilities; Prof. Gokalp on high-pressure combustion; Prof. Ranzi on kinetics of complicated fuels; Prof. Bockhorn on flame propagation; Prof. W. A. Pitz on tagging velocimetry; and Prof. Coelho on radiation), about 90 contributed papers, and numerous work-in-progress posters. The papers were of a high standard, having already undergone a peer review, and a selection will appear in Special Issues of the journals *Combustion Science and Technology* and *Experimental Thermal and Fluid Science*. The local arrangements were excellent and the social events wonderful, especially the conference banquet. I look forward to the next event organized in Lisbon.

Dr. E. Mastorakos, University of Cambridge

#### **Fires in Enclosures 30-31 May 2006 University of Ulster at Jordanstown**

The fire engineering community is a diverse collection of architects, combustion scientists, structural engineers and technologists from a wide range of fields who all have something to contribute to the challenge of fire safety. On the 30th May a representatively international group met at the University of Ulster for a two day workshop about enclosure fires. About 31 presentations were given.

The goal is to continue to develop the technology and regulation to enhance building performance while maximising safety in the event of a fire. The scope of work is huge, ranging from studying the way individual items burn up to the heating and response of an entire building's structure.

Enclosure fires incorporate a rich variety of physics, however measuring fire phenomena is a daunting prospect, let alone understanding them. Taking readings of basic quantities such as burning rates, heat flows, toxic gas compositions becomes a major engineering achievement given the adverse conditions and large scales presented by realistic fires. A particular highlight of visiting the University of Ulster fire safety engineering facility was a tour of their 20 MW full scale building calorimeter, where suites of rooms can be burned indoors under fully controlled conditions.

The capability to predict fire dynamics and building responses is highly desirable to fire regulators and engineers developing new building concepts, however simulations incorporating all the physical processes present become unwieldy due to the vast range of scales found in practical problems. Nonetheless gradual progress is being made by incorporating state of the art modelling from relevant fields (turbulent combustion, dispersion, heat transfer, structural analysis, chemistry) and through rigorous validation. The need for an effective interface between fire safety design and fire safety regulation was raised in a robust manner by Professor Vincent Brannigan (University of Maryland) through a series of tragic case studies. This served to highlight the need to ensure designers and regulators do not take critical decisions without a comprehensive view of the how different technologies interact. This in turn raises the importance of the interdisciplinary research promoted by this workshop and the European FireNet project through which it was organised.

Mr. Ed Richardson, Engineering, University of Cambridge

**31<sup>st</sup> International Symposium on Combustion  
6-11 August 2006  
University of Heidelberg**

The 31<sup>st</sup> International Symposium on Combustion was organized in the picturesque city of Heidelberg, in Germany. By the Neckar River and under the view of the Castle, the Symposium took place in the heart of the old city centre.

More than one thousand people from the international combustion community assisted to this important event. Almost four hundred papers were presented, as well as around six hundred posters. The traditional Symposium organization was adopted: every day opened with a plenary lecture and then, parallel sessions on the papers were running while the posters were simultaneously exposed. Unfortunately, the building facilities were spread over the old city centre. For this reason, it was quite tight to follow consecutive lectures taking place in different buildings. However, the very helpful local staff helped the participants to find the tracks.

The morning plenary lectures covered various subjects and were also presented by notable experts on the fields. Those general presentations went from the chemistry of combustion and emissions to experimental investigations combined with numerical modelling. The first plenary lecture given by Chung K. Law from Princeton, in which the past, present and future state of the Combustion Science were historically introduced and was particularly interesting. The difficulty and inter-disciplinarity of Combustion was emphasized.

Every day, from Monday the 6th to Friday the 11th August, the papers lectures dealt with different subjects concealing most of the fields in Combustion Science. Theoretical, numerical and experimental investigations were presented on Chemical Kinetics, Soot Chemistry, Laminar and Turbulent Flames, Spray and Droplet Combustion, New Combustion Technologies, Micro-combustion, Gas Turbines, Plasma, Diagnostics, etc, etc. All was running in a strictly measured timing. Nevertheless, questions and further discussions were extended along the break times. Poster sessions allowed detailed discussions with the authors. In a relaxed and convivial atmosphere, one could profit from close explanations on the works presented on the posters, contrasting opinions, investigations and expertise. Without any doubt, those sessions could be the most interactive ones during this meeting.

Many thanks are extended to the organization of this 31st International Symposium on Combustion and to all the participants. As ever, we could enjoy from a great scientific time, meeting old and new members. The event made, once more, possible the interaction between our Community, the exchange of ideas and even the commitment of future and profitable international collaborations.

Dr. Marta de la Cruz Garcia, Engineering, University of Cambridge

*Editor's Note:* We remind the reader that the *Proceedings of the Combustion Institute*, where the Symposium's papers are published, is now officially recognized as a journal and is available from [www.sciencedirect.com](http://www.sciencedirect.com)

#### 4. CONTRIBUTED ARTICLES

##### Silent Burning in a Tiny World

The beginning of the new millennium has seen a rush by the research community worldwide into the tiny world: anything small is beautiful. While many such activities are curiosity-driven, the need for high energy-density mobile power devices is real. Traditional battery and fuel cell technologies have not been able to provide the long-lasting power sources required by a variety of applications ranging from laptops to arctic explorers. The attention inevitably turned to the good old technology: combustion. The fact is: combustion produces much higher energy density than either batteries or fuel cells. The crux of the problem is how to harness the energy in a tiny device. There have been a few research programmes initiated in the USA, notably at MIT, Stanford and University of Southern California, which aim to produce microscale combustors. All of these are experiment-based research and prototypes have been built. Although none has so far produced a workable practical device as promised, it has nevertheless stimulated much interest in a wide range of fields from micro-manufacturing to materials science.

There are special difficulties to burn fuels in micro-combustors. One inherent problem is the high heat loss rate due to the very large surface area to volume ratio. Another difficulty is that the flame dimension is often smaller than its quenching distance. Finally, micro-combustion does not have the benefit of turbulence-assisted mixing and transport that macro-combustion takes for granted. These difficulties call for special measures.

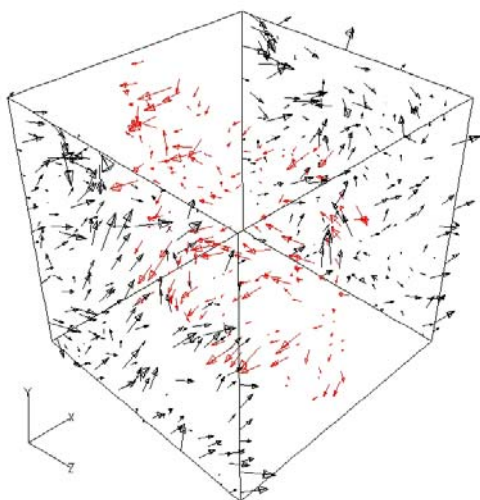


Figure 1. Velocity field in a 10-micron porous cube with a 35% void volume.

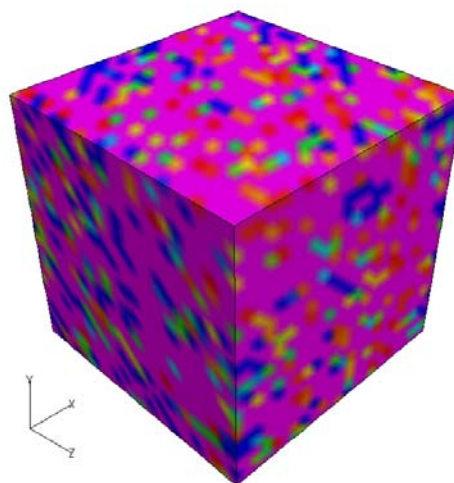


Figure 2. Reaction rate of propane combustion in a micro porous cube.

In the Thermofluids Group at the University of Southampton, we are looking at ways to enhance the heat release rate in a micro-combustor while keeping the heat loss to minimum. Lacking the millions of dollars per annum behind the American teams, we set the more modest goal of providing a numerical simulation tool in parallel to the American experiment programmes. This has proven to be both challenging and exciting. To increase reaction rate in a relatively low temperature environment, catalytic combustion is needed. To keep the heat released by combustion, heat recirculation is desired, which calls for convoluted combustor geometry (the “Swiss roll” being an example). None of these features can be handled easily by macro-simulations based on the Navier-Stokes equations. Instead, we employ a Lattice Boltzmann method (LBM) in an extended DL\_MESO code. LBM is a kinetically based microscopic approach, which is advantageous in dealing with multi-physics phenomena in complex geometries and has high numerical efficiency on massively parallel computers. Figures 1 and 2 show the result of a propane combustion assisted by catalyst. The reactants

enter from the left and exit from the right of the micro cube, with complex flow recirculation. The combustion features surface reaction, which is strongly influenced by the pore structures. The reaction zones are seemingly random, but in fact governed by the Arrhenius law. The pore structures hold the heat released locally, which helps to initiate reaction in nearby regions. Like so many fundamental studies in history, micro-combustors may seem to be impractical today, but could revolutionise our ways of harnessing energy in the long term.

**Raúl Machado and Kai H. Luo**

Thermofluids and Superconductivity Group, School of Engineering Science,  
University of Southampton

## 5. COMBUSTION IN THE NEWS

**“Forget spark plugs, start your car with nanotubes”**, *New Scientist*, 19 November 2005:

The title of the article may be exaggerated, as most popular science articles tend to be, but the content is most interesting. Apparently, carbon nanotubes of some form explode when hit by a flashlight and the US Air Force is interested in this technology as a novel way to initiate combustion.

<http://www.newscientisttech.com/channel/tech/mg18825267.000.html>

**“Nanotechnology”**, *National Geographic*, June 2006:

The various applications of nanotechnology are discussed in this excellent article in a recent issue of *National Geographic*. One of these applications is the production of fire-resistant glass, which contains a layer of silica nanoparticles that help glass panes withstand high temperatures without breaking – and there are photographs to prove this. The magazine’s Web site contains some interesting comments from the photographer:

<http://www7.nationalgeographic.com/ngm/0606/feature4/assignment1.html>

**“Firefighting on the nanoscale”**, *European Commission CORDIS Newsletter*, May 2006:

Continuing on the theme of fires and nanotechnology, the European Commission is currently funding research projects on the use of new polymer materials engineered at the nanoscale that become fire retardant during combustion by creating a protective surface layer. For more information, visit:

[http://cordis.europa.eu.int/nanotechnology/src/pressroom\\_projects.htm](http://cordis.europa.eu.int/nanotechnology/src/pressroom_projects.htm)

**“Second scramjet tested over Australian outback”**, *New Scientist*, 30 March 2006

In an effort to develop air-breathing engines that can be used on supersonic airplanes reaching high Mach numbers, the scramjet (Supersonic-combustion Ram Jet) promises to be an interesting way forward. Scramjets rely on the compression achieved by the forward motion of the aircraft itself to heat the air and then ignite the fuel in the combustor. Scramjets are being tested currently by Japan, Australia, and the USA. The Australian one reached Mach 6.5, which is however still below the record Mach 9.6 held by NASA’s scramjet programme. For more details:

<http://www.newscientisttech.com/article/dn8920.html>

<http://www.nasa.gov/centers/dryden/news/FactSheets/FS-040-DFRC.html>

## **6. GROUP ACTIVITIES**

### **6.1 Prizes**

Professor A. Jones has been in discussions with the Institute of Physics for the past few months with the aim of officially establishing prizes for combustion research. The details concerning the selection process are being finalised by Prof. Jones and the Committee and the final decisions will be described fully on our Web site.

### **6.2 School outreach**

The Committee has enlisted the very experienced Mrs. Kathy Kroon, who used to be a Committee member and is now a Physics schoolteacher, to lead our new initiative to establish contacts with schools and explore possibilities to teach combustion-related phenomena to schoolchildren. We all hope that if combustion, with its many facets good or bad, is taught at a young age, then physics and engineering students entering University will be keener to study our subject.

### **6.3 AGM**

Our Annual General Meeting will take place together with the “Combustion of Biofuels” event in E.ON UK Power Technology, Ratcliffe-on-Soar, on 19 September 2006. Special announcements will be posted to the members.

### **6.4 Travel Grants**

The Institute of Physics Combustion Physics Group (IOP CPG) is offering Travel Grants to students for major combustion conferences. For details, please see our Web site.

### **6.5 Jobs**

For those seeking jobs in a combustion-related field, in industry or academia, the following Web sites can be of assistance:

<http://physicsweb.org/jobs/jobalert/>

<http://jobs.ac.uk/>

<http://www.combustioninstitute.org/>