# GMF

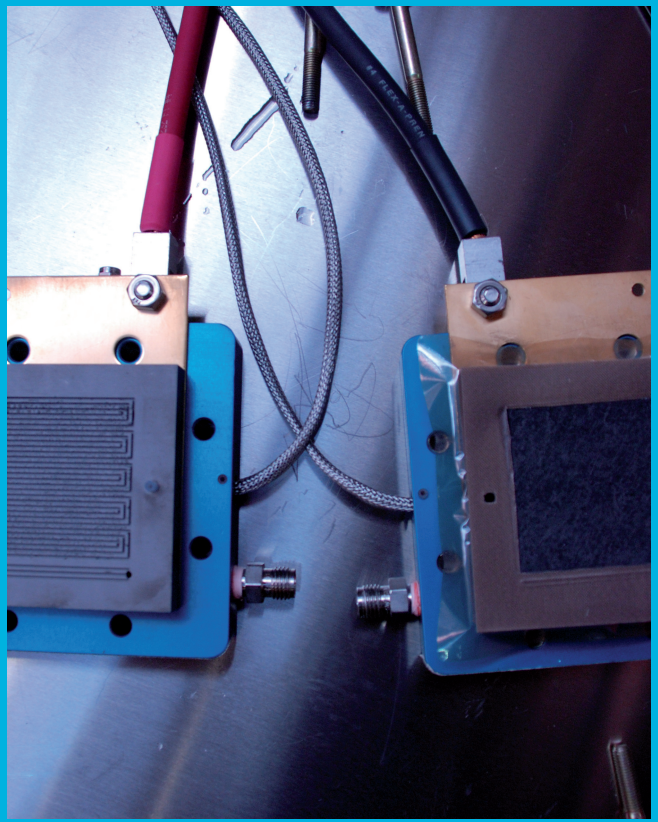
## FLUID MECHANICS GROUP

UC3M

RESEARCH GROUPS

Image: UC3M physics particles

Universidad
Carlos III de Madrid
www.uc3m.es



*Single fuel cell membrane assembly to be tested on the GMF's Test System.*

The **Fluid Mechanics Group (GMF)**, headed by Dr. Antonio Luis Sánchez Pérez, is formed by a multidisciplinary team of 19 researches made up of aeronautical engineers, chemical engineers, industrial engineers and physicists.

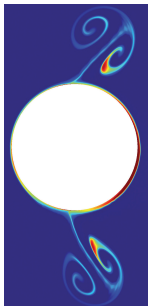
The GMF, as expert in the use of analytical, numerical and experimental techniques, offers solutions for solving challenging thermofluidynamical problems of interest for both the industrial and academic worlds.

All the members of the group have spent long periods of time in internationally renowned research institutions, such as the University of California, San Diego (USA), the University of California, Berkeley (USA), Yale University (USA), the University of East Anglia (UK), the University of Twente (Netherlands), Technische Universiteit Eindhoven (Netherlands) or the Von Karman Institute for Fluid Dynamics (Belgium).

Such a distinguished international background provides the group with a great heterogeneity and allows the GMF to uncover innovative solutions to problems within a wide range of applications.

## •LINES OF RESEARCH•

- Combustion
- Multiphase Flows
- Microfluidics
- Biofluid Dynamics
- Fuel Cells
- Heat and Mass Transfer
- Computational Fluid Mechanics
- Detonations and Supersonic Flows
- Low Density Jet Hydrodynamic Stability
- Steady Streaming in Turbulent Flows
- Dynamics and Stability of Liquid Jets Subjected to the Influence of Gravity



*Velocity field formed by the asymmetric vibration of a sphere in a liquid. Due to the small-amplitude cylinder oscillation, the fluid is ejected from the sphere surface giving rise to the characteristic steady-streaming velocity field observed in the image.*

## •RESEARCH PROJECTS•

The group works in collaborations with aeronautical companies, temperature control system providers and engineering companies. Its recent collaborators and clients include REPSOL, EADS and Acciona Windpower S.A.

Some of the active research projects and funding institutions of the Fluid Mechanics Group are enumerated below:

- "Fundamental Ultra-compact Rotary Engine Combustion Analysis"
  *Funding Entity:*
  *Spanish Ministry of Economy and Competitiveness*
  *Date: 2013-2016*

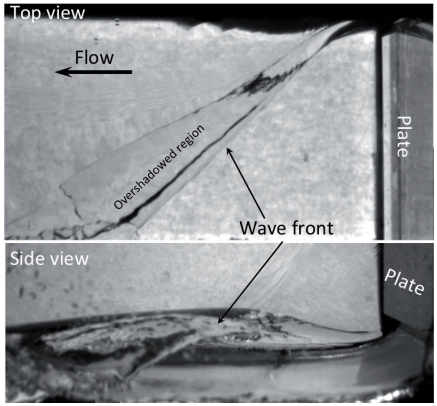
- "Experimental Characterization of Fuel Jet Atomization"
  *Funding entity: REPSOL S.L.*
  *Date: 2012-2013*

- "Sustainable Combustion Research"
  *Funding Entity:*
  *Spanish Ministry of Science and Innovation*
  *Date: 2010-2015*

- "Mechanisms for Generating Micrometric Droplets and Bubbles with Industrial Process, Pharmacology and Medicinal Applications"
  *Funding Entity:*
  *Spanish Ministry of Science and Innovation*
  *Date: 2011-2014*

- "Multiphase Modeling of Relevant Thermal-fluid Problems in Energy Generation and Exchange Systems with Industrial Application"
  *Funding entity:*
  *Spanish Ministry of Science and Innovation*
  *Date: 2011-2014*

- "Development of Predictive tools for Hydrogen Combustion in Gas Turbines"
  *Funding entity: Regional Government of Madrid (Comunidad de Madrid)*
  *Date: 2010-2013*




*A snapshot of the three-dimensional structure of a breaking wave started from the corner of a plate inside the hydrodynamics tunnel.*

## •SCIENTIFIC-TECHNICAL SERVICES•

The GMF offers a portfolio of technical, consultation and training services capable of solving the most challenging problems in the industrial sector with innovative solutions.

Among these services, it is worth highlighting:

· The extensive numerical computation of real-world phenomena, such as droplet combustion, dynamic of tornadoes or liquid atomization. Such activity has been extended to both the industrial and academic worlds, as proved by our collaborations with engineering firms and by the GMF publications in the best scientific journals (Journal of Fluid Mechanics, Physics of Fluids, Combustion and Flame, Journal of Power Sources...)

· The experimental characterization of industrial processes. As an example, we mention here the fuel-jet, droplet characterization performed for the company REPSOL SL.

· The theoretical analysis of relevant industrial problems, covering aspects as diverse as the description of combustion reactions, mathematical modeling of hydrogen / ethanol / methanol / alcohol fuel cells, jet stability, microfluidics and biological flows.

· The training of technical and scientific personnel by means of high-level training programmes, such as:

  - "Advanced CFD and Turbulent Modeling Course". This course was recently given for the members of the design team of Acciona Windpower S.A. Specifically, this 24-hour theoretical-practical course focuses on the general theory of Computational Fluid Mechanics with a special emphasis on turbulence models and their practical implementation using ANSYS FLUENT.

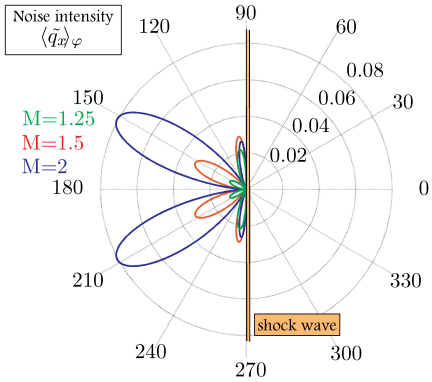
- "Systems Integrations for the Aerospace Industry". A Masters program sponsored by the company EADS España and the subcontractors of the parent company. This international program is especially designed for students and professionals having interest in aeronautics system integration. This master was offered for first time 4 years ago and, since then, more than 300 students have participated in it, showing a great degree of satisfaction after ompleting the 90 credits that form the master.

## •TECHNOLOGICAL EQUIPMENT•

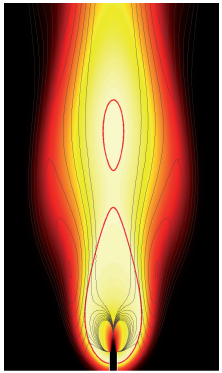
The GMF has a numerical and experimental laboratory equipped with the most innovative equipment necessary for successfully tackling any problem involving fluid dynamics. In addition to the general equipment and premises of the UC3M, the GMF owns the following equipment:

1. Numerical calculation laboratory:
   - Computational cluster with 192 2.27 GHz Intel Xeon cores distributed over 21 nodes, with 600 GB of RAM and a 12 TB Raid system.
   - Massive data storage systems.

2. Aerodynamics and hydrodynamics measurement laboratory
   - Subsonic wind tunnel.
   - Horizontal hydrodynamics channel with a 2.5 $m^3$ capacity. The test section is 0.7 m in length with a 0.25 m x 0.25 m square section.
   - 60 x 60 x 100 cm vertical hydrodynamics channel with a variable diameter injection cylinder.
   - Two-component laser Doppler DANTEC anemometry system.
   - AA hot-wire anemometry system.
   - High-speed camera with a maximum frame capture speed of 1000 frames per second.




*Acoustic energy flux emitted by an oscillating planar shock wave. The sonic flux intensity generally increases with the shock Mach number. This fact is especially remarkable in certain directions along which the acoustic energy is considerably stronger.*

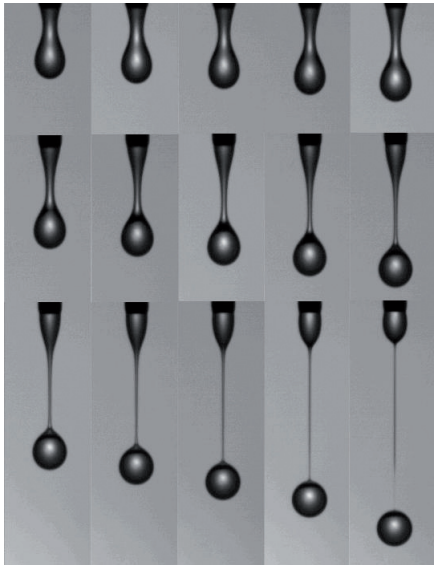


*Numerically obtained temperature field for a methane/air jet diffusion flame. The figure includes the stoichiometric surface where the chemical reaction (red line) takes place and the iso-vorticity surfaces (gray lines) responsible for the flame pich-off.*

- 5 W Argon-Ion laser for illuminating hollow graphene particles for measuring velocity using the PIV technique.
- NAC Memrecam HX-3 camera with 5 Mega Pixel resolution at up to 2,000 fps, Full HD resolution at up to 4,670 fps, 1 Mega Pixel resolution at up to 9,220 fps, and a high speed mode with up to 1300000 fps.
- Microscopic optic for micrometric flow visualization.
- Dual Pulsed laser PIV system with a 2 Mpixels PowerCamera 2MP.

3. Stability laboratory
   - RedLake MotionPro X High-speed cameras which can capture up to 128000 images per second according to the window size.
   - MALVERN droplet particle size analyzer.
   - Active and passive vibration isolation test tables.
   - Harvard apparatus PhdUltra syringe pump for flow rate control.
   - Tensiometer for measuring surface tension with digital and automatic reading.

4. Fuel cell laboratory
   - PEM (polymer exchange membrane) / DAFC (direct alcohol / methanol / ethanol fuel cell) fuel cell.
   - Peristaltic liquid fuel feeding pump.
   - Three-coil, bipolar plate.
   - Light gases distribution and feeding systems.



*Sequence of images depicting the formation of PDMS silicone oil droplets taken with GMF's high-speed camera.*

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IMAGE OF COVER: *Flow*
*David Taborda*