AEROSPACE ENGINEERING RESEARCH AT FCEFYN–UNC

Collaborations and Graduate Programs

OVERVIEW OF FCEFYN-UNC

- Faculty of Exact, Physical and Natural Sciences (FCEFyN).
- National University of Córdoba (UNC), Argentina.
- One of the oldest and most prestigious engineering schools in Latin America.
- Strong focus on aerospace research, education, and national technological development: driving industrial innovation through academic partnerships and technology transfer.

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AEROSPACE ENGINEERING DEPARTMENT

- Undergraduate degree in Aeronautical/Aerospace Engineering.
- Emphasis on aerodynamics, propulsion, structures, flight mechanics, space systems.
- Active involvement of students in research and development projects throughout their studies, particularly from the third year onward. The degree lasts approximately five years and is semester-based. It includes an introductory leveling cycle and a shared first year with other engineering programs.

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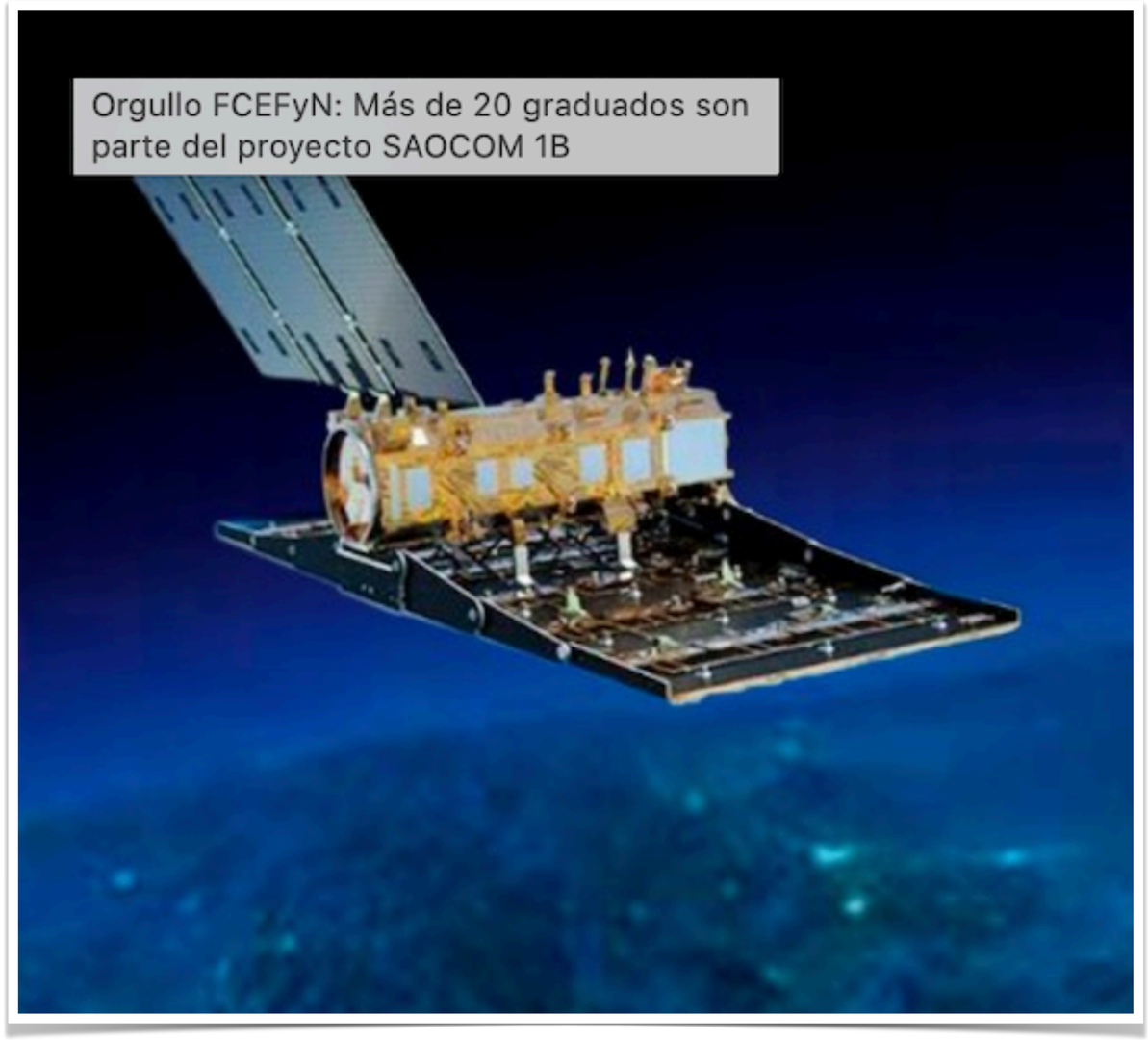

MAIN RESEARCH AREAS

- Space propulsion (electric and chemical).
- Computation Fluid Dynamics (CFD).
- Space mission analysis and orbital dynamics.
- Aerospace structures and advanced materials.
- Sustainability and space debris analysis.
- Nonlinear dynamics and chaos.

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NATIONAL AND INSTITUTIONAL COLLABORATIONS

- CONAE (Argentine Space Agency): joint projects in satellite missions and training.
- VENG S.A.: support in mission design, testing, and internships.
- INVAP: joint development and testing of aerospace systems.
- FADEA: collaboration in aircraft technology and testing.
- CIA (Centro de Investigaciones Aeroespaciales): co-supervised research and test facilities.

CONAE

VENG

INVAP

FAdeA

Fábrica Argentina de Aviones "Brig. San Martín" S. A.

CIA

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GRADUATE PROGRAMS

- **Master's in Aerospace Engineering:**
  - Focus: CFD, advanced aeronautical systems, flight mechanics, design, and propulsion.
- Master's in Space Systems:
  - Focus: systems engineering for space missions, nanosatellites, GNC, operations.
- PhD in Engineering Sciences:
  - Open to aerospace topics, often co-supervised with national space actors.

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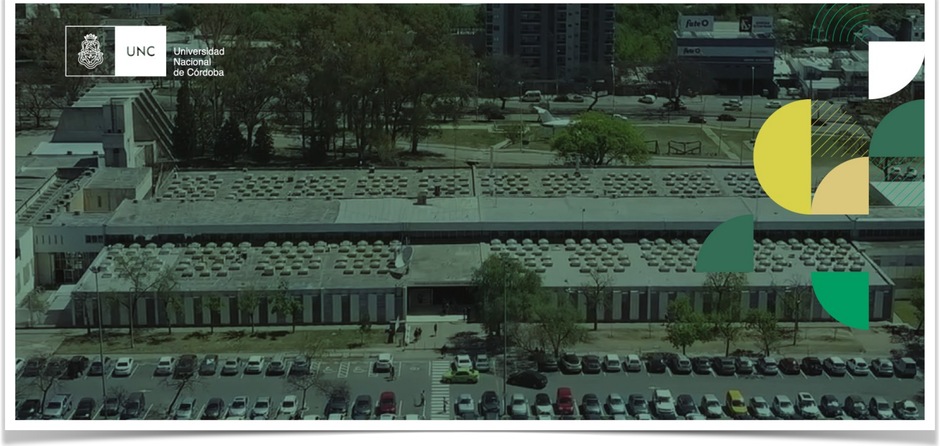
MASTER'S IN SPACE SYSTEMS

- The program is delivered at the Instituto Gulich, located within the Teófilo Tabanera Space Center (CETT) of CONAE, in Falda del Cañete, Córdoba Province, Argentina.
- Curriculum Highlights:
  - Integration of academic training with ongoing CONAE projects.
  - Courses delivered by experts from academia, CONAE, and international agencies.
  - Special emphasis on applications in Earth observation, communications, and in-orbit technology validation.
- Student Engagement:
  - Participation in active CONAE missions.
  - Access to high-level infrastructure for testing and simulation.
  - Opportunities for internships and thesis work on real-world problems.



Facultad de Ciencias Exactas, Físicas y Naturales (FCEFyN-UNC)

Instituto de Altos Estudios Espaciales Mario Gulich (CONAE-UNC)

GRADUATE PROGRAMS

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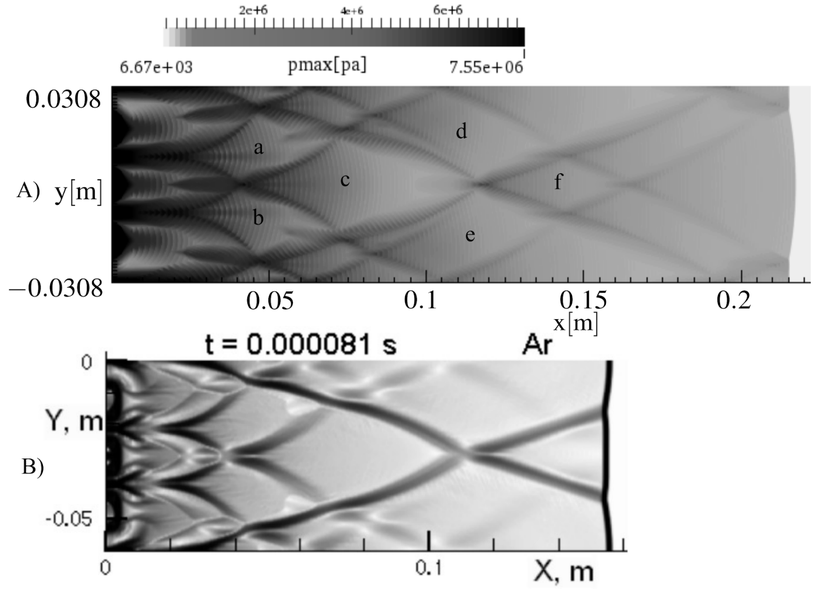
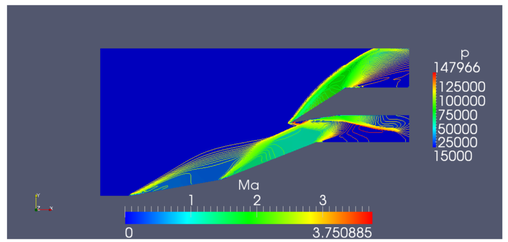
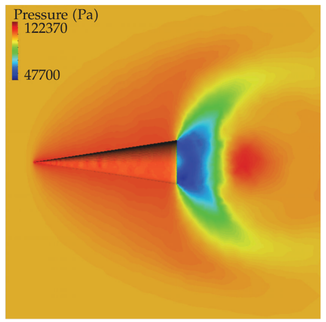
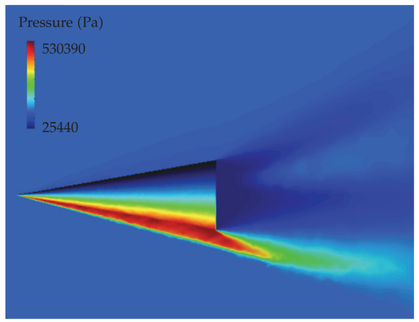
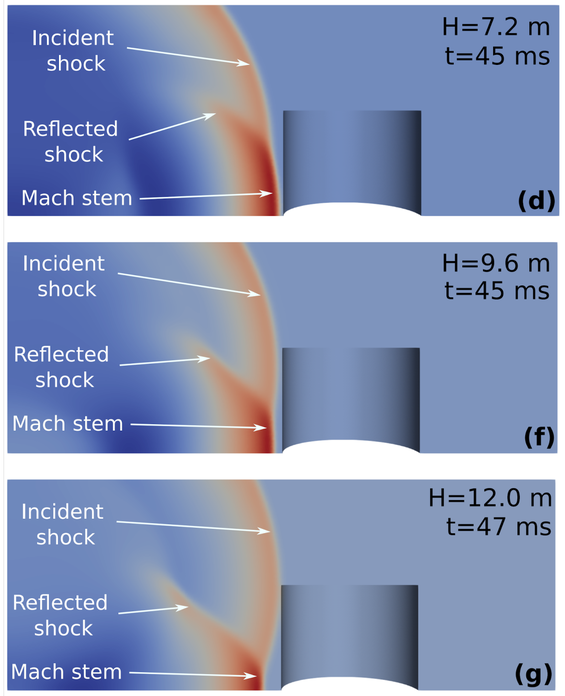
CFD OF COMPRESSIBLE FLOWS. HIGH ENTHALPY FLOWS. DETONATIONS











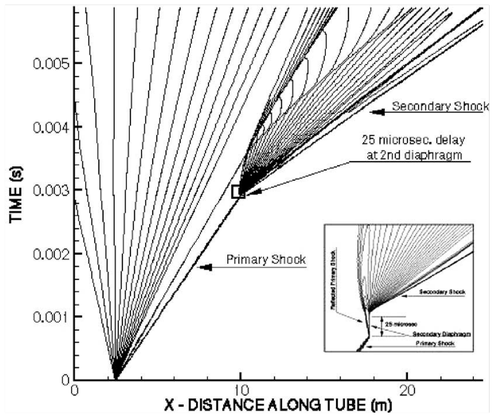


Fig. 2. Computed X–T diagram of logarithm of density contours. Mach 17 HYPULSE test condition.

- High enthalpy, chemically active gas flows: work has been/is ongoing along several lines:
- 1) Improvement of numerical schemes for simulating supersonic gas flow.
- 2) Numerical simulation of detonations and flows with chemical effects.
- 3) Simulation of strong explosions and the rebound and interaction of shock waves with solid surfaces. This numerical investigation examines blast wave interactions with atmospheric storage tanks, focusing on the critical effects of explosion height.
- National projects: Ministry of Science, Technology and Innovation, CONICET-PUE-IDIT, FONCyT-PICT-2017, and National University of Córdoba.
- Contact: Dr. Sergio Elaskar: selaskar@unc.edu.ar

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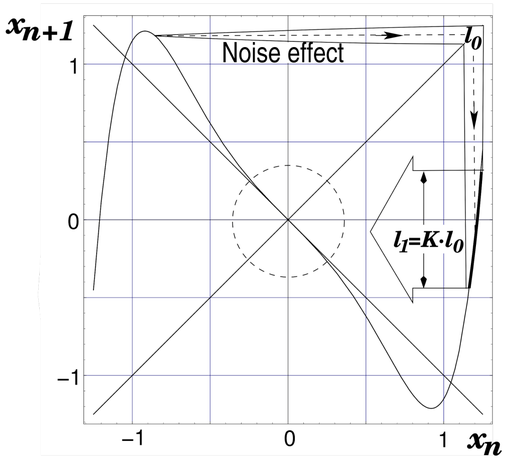
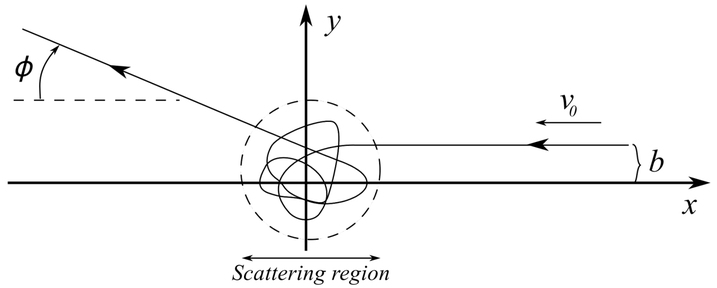
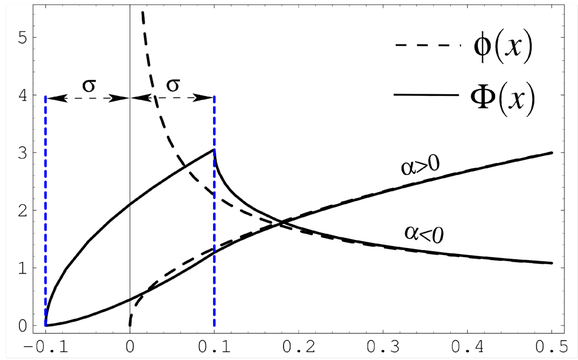
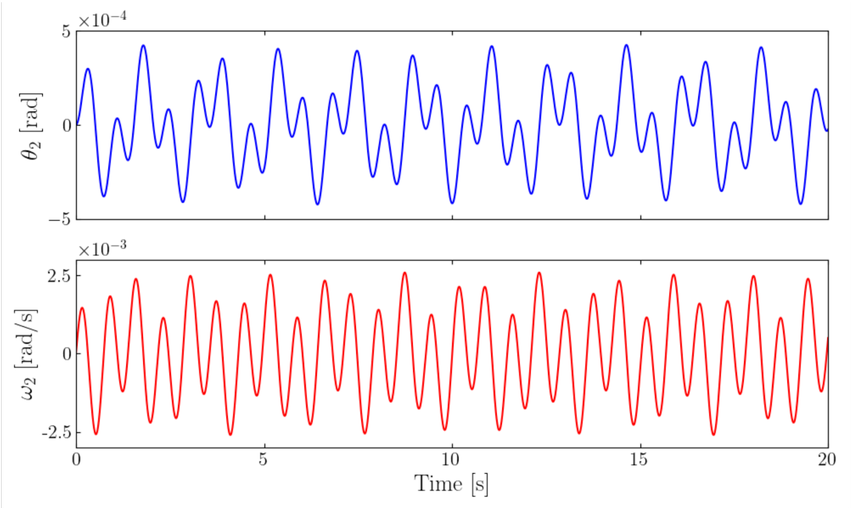
NONLINEAR DYNAMICS AND CHAOS









- 1) A new theory of chaotic intermittency was developed, which includes, as a special case, the theory previously developed. The mathematical form of the reinjection probability distribution function was described, and its foundations and derivation were theoretically explained. Other parameters, such as the probability distribution of laminar lengths and characteristic relationships, were evaluated.
- 2) Energy and time synchronization of escaping particles in perturbed chaotic scattering.
- 3) Analysis of the swinging sticks pendulum. It is an intriguing physical system that exemplifies the intersection of Lagrangian mechanics and chaos theory. Unlike a simple pendulum, this system exhibits complex and chaotic behavior due to the interplay between its degrees of freedom.
- Items (1) and (2) are an international cooperation with Spain through the Polytechnic University of Madrid and Rey Juan Carlos University.
- Item (3) is an international cooperation with China through the Guangdong Technion - Israel Institute of Technology.
- Contact: Dr. Sergio Elaskar: selaskar@unc.edu.ar

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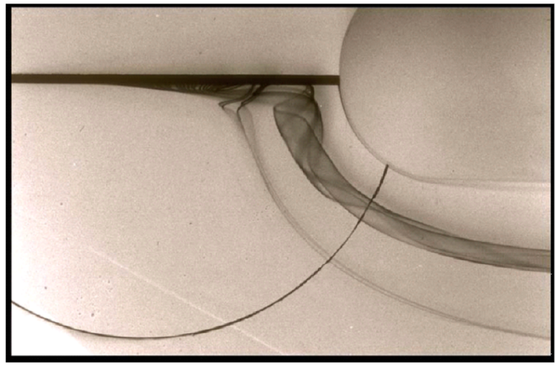
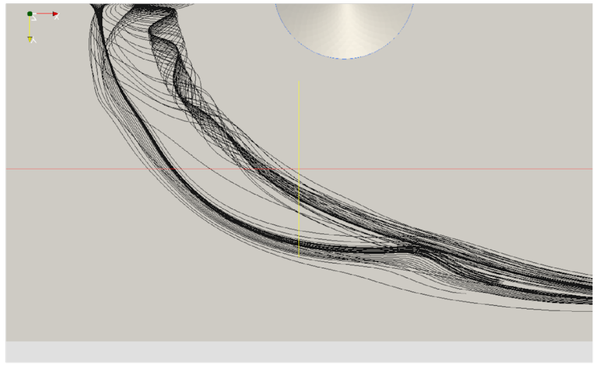
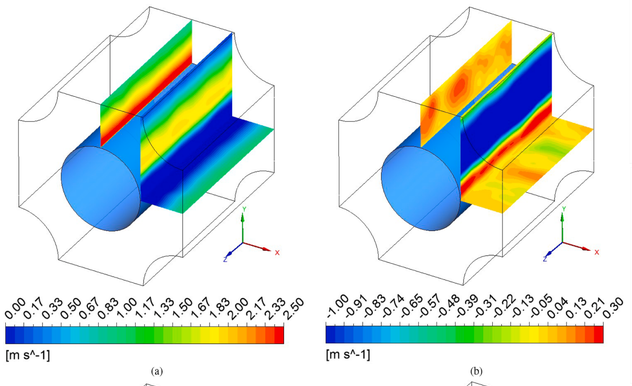
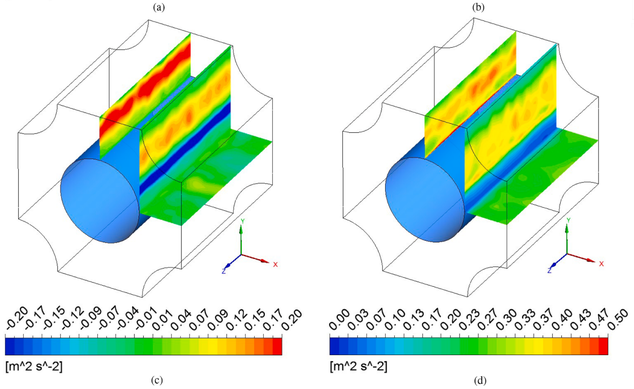
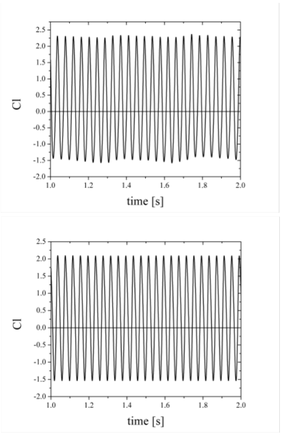
CFD OF INCOMPRESSIBLE TURBULENT AND EXTERNAL FLOWS

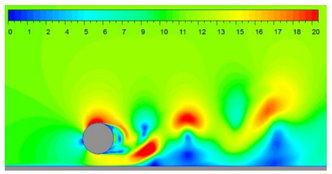


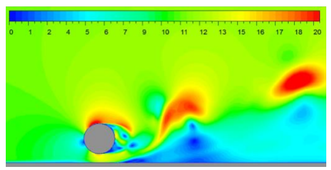


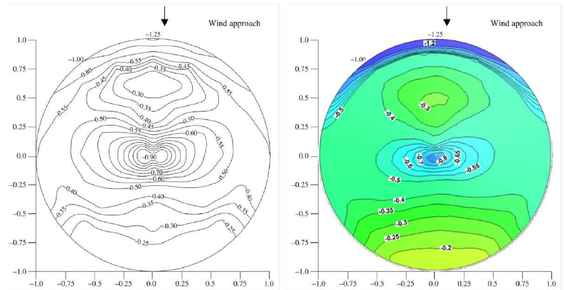












- Work is underway to simulate turbulent flows around vertical tanks, horizontal cylinders, and networks of small tubes or wires. Various models have been implemented to simulate turbulence, with the most promising being the second-order closure model, which involves solving the Reynolds stress tensor transport (RSM), and the SST-SAS approach, which is considered an intermediate model in terms of accuracy and computational requirements.
- International cooperation with France through ECOS Sud-MinCyT, CNRS and University Pau & Pays Adour.
- National projects: Ministry of Science, Technology and Innovation on the Argentine side, CONICET-PUE-IDIT, FONCyT-PICT-2017, and National University of Córdoba.
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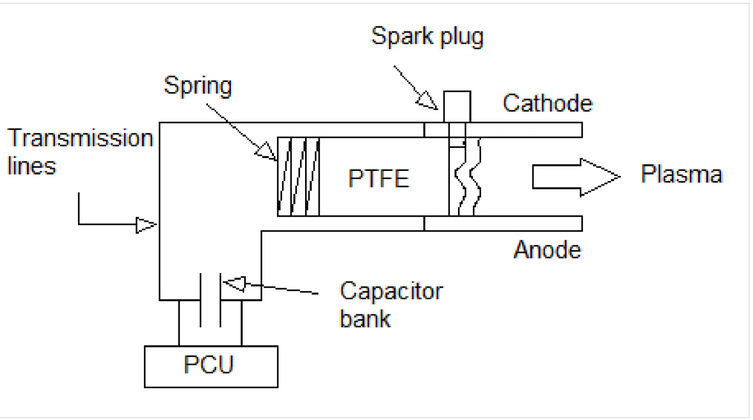

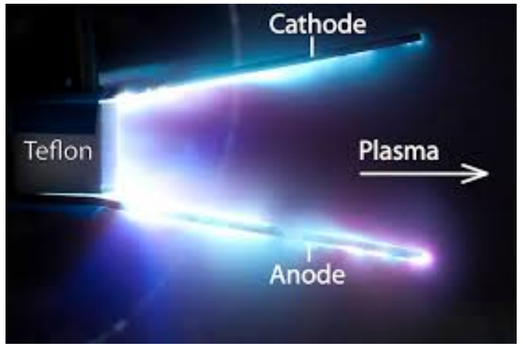

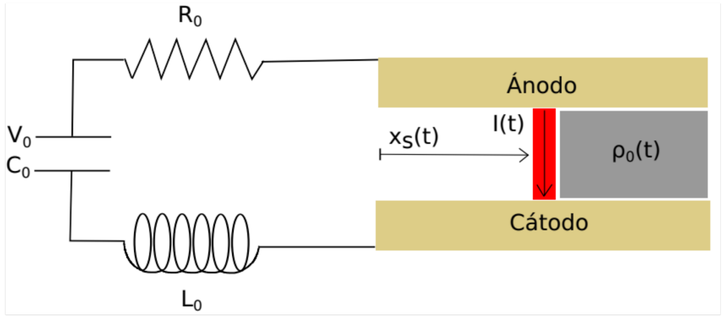

Figure 3. Snowplow model of a parallel electrode PPT.

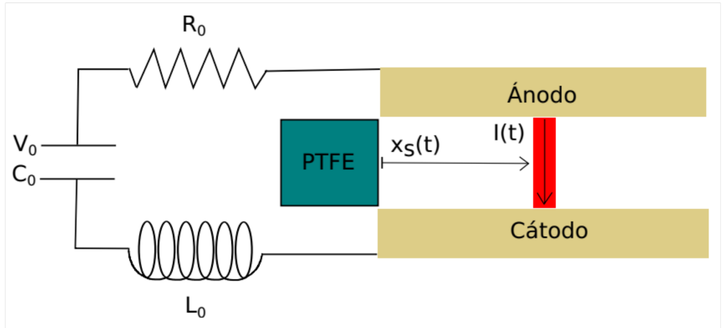

Figure 4. Slug model of a parallel electrode PPT.

SPACE PROPULSION

- In plasma propulsion, we collaborated on the development of a Teflon ablative pulsed plasma thruster (APPT).
- New non-stationary electromechanical for prelimiray design models were developed that allow estimating parameters such as ablated mass, pulse bit, specific impulse, and propulsive efficiency.
- Work is underway to couple these models with genetic optimization algorithms.
- International cooperation with Italy through the University of Pisa.

- Contact: Dr. Sergio Elaskar: selaskar@unc.edu.ar

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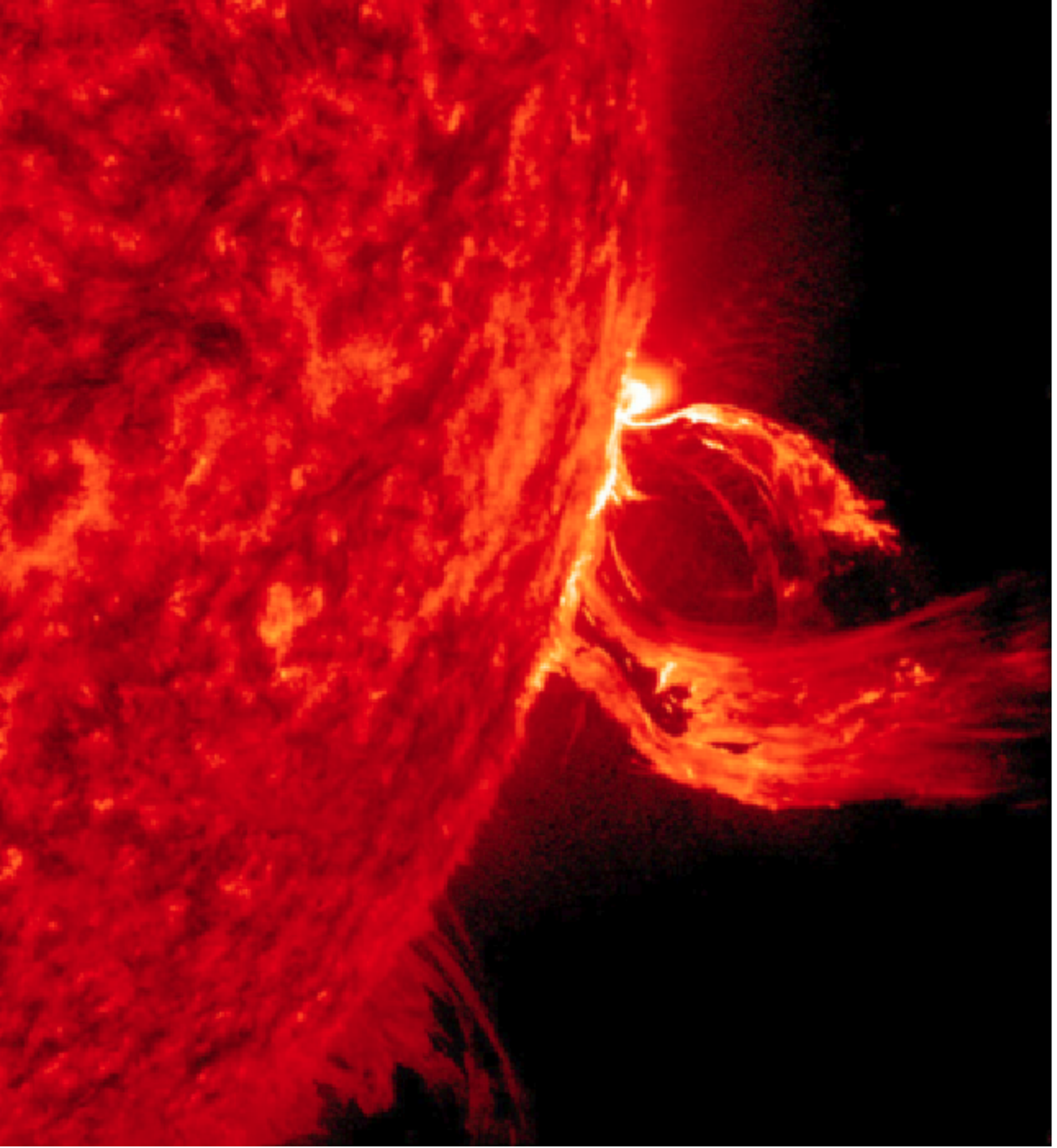

NUMERICAL ANALYSIS OF LARGE-SCALE EVENTS OF THE SOLAR ATMOSPHERE

- We work together with the Institute of Theoretical and Experimental Astronomy (IATE) of the Mathematics, Astronomy and Physics Faculty (FAMAF).
- We focus on events like coronal mass ejections (CME), large-scale blast waves, Moreton waves, quiescent filaments, etc.
- Our aims are to validate theoretical models and to predict the evolution of large-scale solar events.
- The physical model is based on the magnethydrodynamics equations of a compressible full-ionized plasma.

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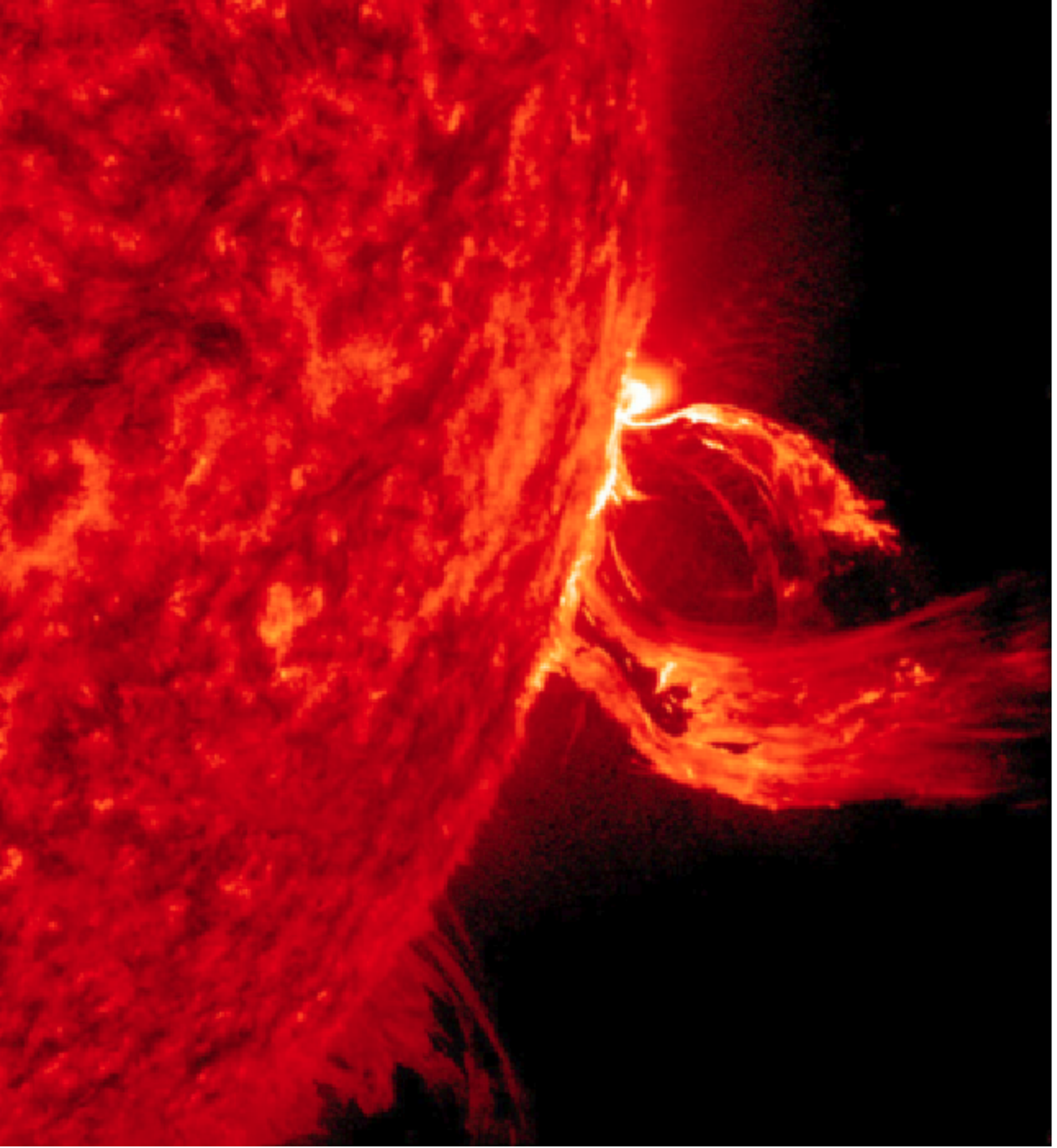

NUMERICAL ANALYSIS OF LARGE-SCALE EVENTS OF THE SOLAR ATMOSPHERE

- The numerical model is based on the finite volumes method with an unsplit formulation and a constrained-transport method to enforce the divergence-free condition of the magnetic field.
- We use the FLASH Code, a 20-year existence computational code developed by the Flash Research Center and the University of Chicago.
- The FLASH Code is an open-source massively parallel high-order finite volume code with adaptive mesh refinement (AMR) capabilities.
- We adapted the FLASH Code to model special conditions of our problems, like strongly stratified atmospheres, line-tied boundary conditions, anisotropic heat conduction, etc.

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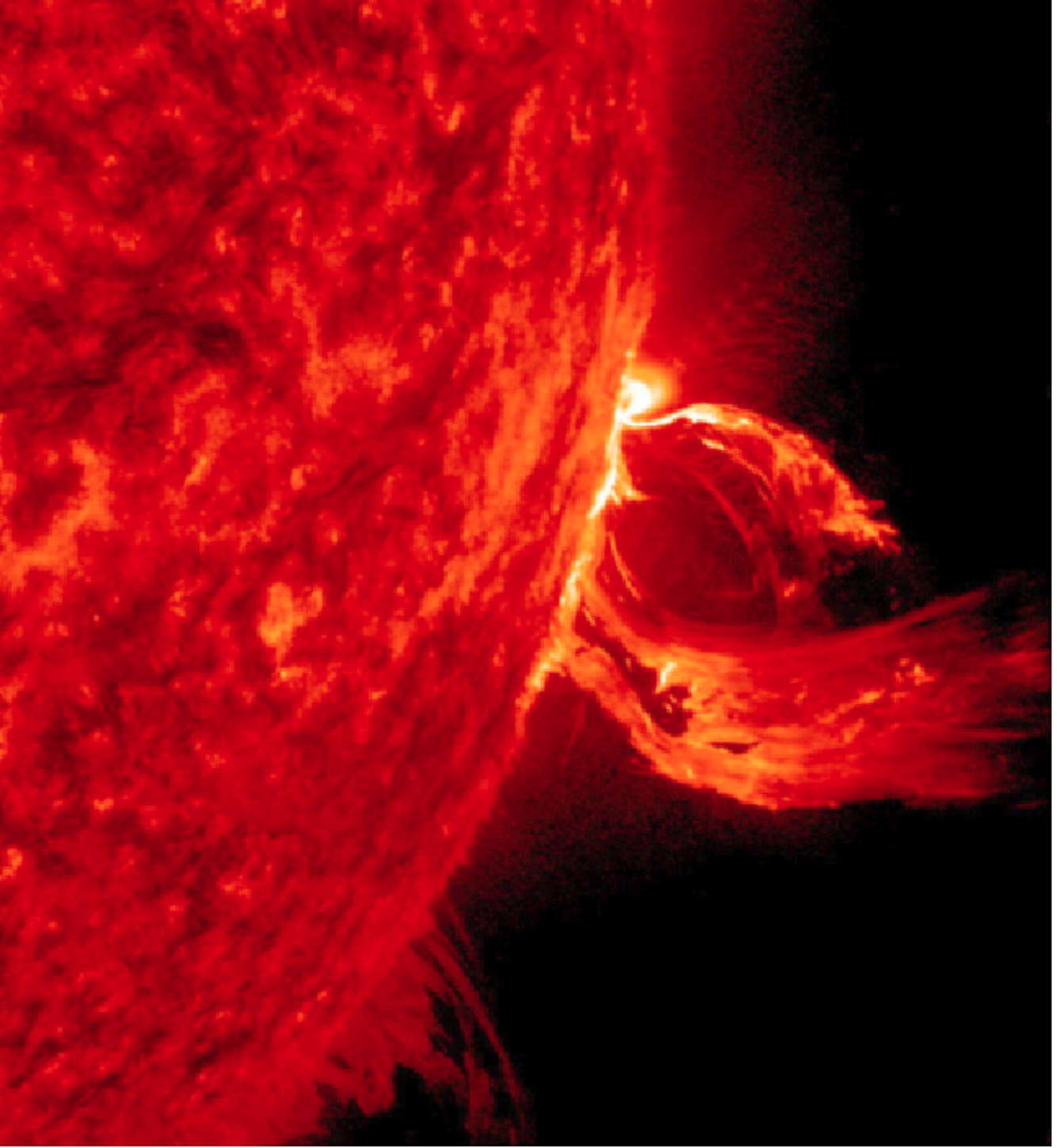

NUMERICAL ANALYSIS OF LARGE-SCALE EVENTS OF THE SOLAR ATMOSPHERE

- Among other results, our research shows that:
  - Both blast waves and coronal mass ejections can produce large-scale Moreton waves.
  - Coronal holes have a crucial relevance in the trajectory of coronal mass ejections.
  - Both blast waves and coronal mass ejections can produce large amplitude oscillations in solar filaments.
  - Pseudostreamer configurations of the magnetic field play a crucial role in the evolution of flux-ropes.
- Contact: Dr. Gustavo Krause: gustavo.krause@unc.edu.ar

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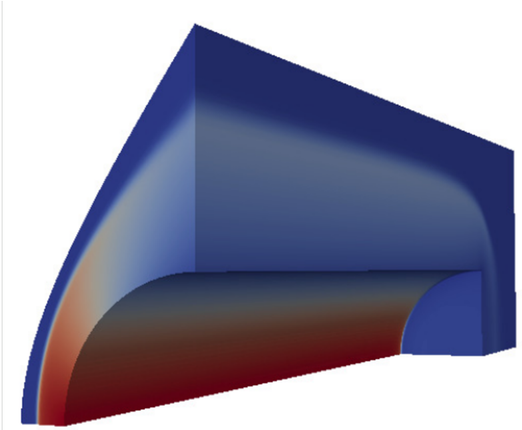

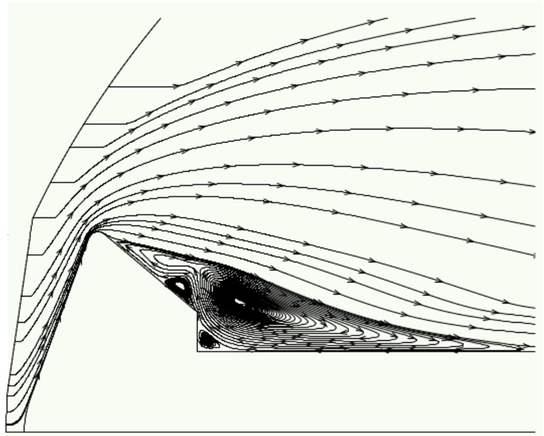

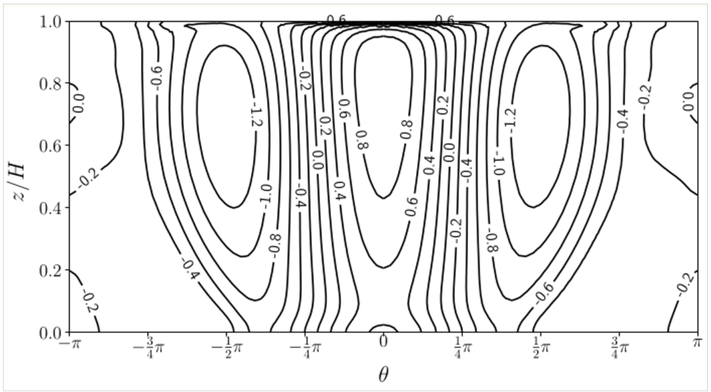

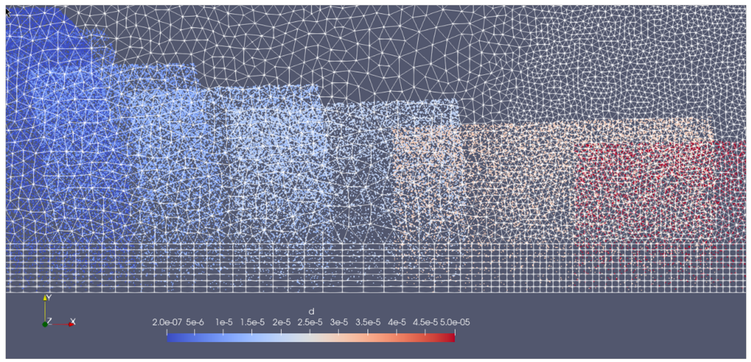

COMPUTATIONAL FLUID DYNAMICS

- Development of parallel/adaptive computational fluid dynamics codes. Main focus: atmospheric reentry, compressible reacting flows, magnetohydrodynamics flows.
- Computational Wind Engineering: Numerical simulation of the atmospheric boundary layer, wind loads, unsteady RANS models.
- Particle dispersion in turbulent flows: Development and application of an unmanned aircraft system to measure aerosol particles.

- Contact: Dr. Juan Pablo Saldía: jsaldia@unc.edu.ar

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STUDENT PROJECTS AND INNOVATION

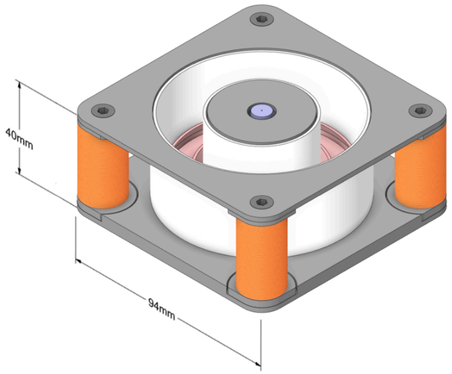

Figura 18: Dimensiones de configuración final (esquema) de la primera versión del P70/30.

- Nano 70/30: student-led CubeSat project integrating propulsion, structures, orbital analysis, various subsystems.
- Hands-on experience through thesis and final projects.
- Close interaction with industry and research institutions.

- Contact: wschulz@unc.edu.ar

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OPPORTUNITIES FOR COLLABORATION

- Joint research and co-supervision of graduate theses.
- Exchange programs and mobility for students and faculty.
- Shared access to test infrastructure (wind tunnels, propulsion labs).
- Participation in international calls for aerospace innovation.

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CONTACT AND ACKNOWLEDGEMENTS

Thank you for your interest!

For more information:
Dr. Sergio Elaskar: selaskar@unc.edu.ar
Dr. Gustavo Krause: gustavo.krause@unc.edu.ar
Dr. Juan Pablo Saldía: jsaldia@unc.edu.ar
Dr. Walkiria Schulz: wschulz@unc.edu.ar

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