



UNIVERSITÀ DEGLI STUDI DELL'AQUILA
M&MOCS



International Research Center for the
MATHEMATICS AND MECHANICS OF COMPLEX SYSTEMS



Tullio Levi-Civita



TULLIO LEVI CIVITA
INTERNATIONAL PRIZE 2021

LAUDATIO OF PROF.
SEBASTIEN CANDEL

MEMOCS CENTER
DECEMBER 2022

M&MOCS CENTER, JANUARY 2023



Sébastien Candel is currently University Professor Emeritus at CentraleSupélec, University Paris-Saclay. *Officier* of the Legion of Honor, *Commandeur* of the National Order of Merit, *Commandeur* of the Academic Palms, he was elected a member of the French Academy of Sciences in 2011, holding the role of Vice President (2015-2016) and then of President (2017-2018) of this Academy. He is a founding member of the Academy of Technologies (2000), a member of the Air and Space Academy (2013), was elected as a foreign member of the National Academy of Engineering of the

United States of America in 2009 for his significant contributions to solving multidisciplinary problems in the fields of combustion, fluid mechanics, aeroacoustics, and propulsion and became a member of the Chinese Academy of Engineering in 2020.

He has been a member of numerous scientific and technical panels. A member of the Advisory Board of *Office National d'Etudes et de Recherches Aéropatiales* (ONERA) from 1994 to 2002, he was president of the Supersonic Aircraft Research Network (2000-2004), was a member of the Scientific council of the *Centre National de la Recherche Scientifique* (CNRS) from 2010 to 2014, chaired the Scientific council of IFPEN (*Institut Français du Pétrole et des Energies Nouvelles*) from 2010 to 2016 and the Scientific council of Cerfacs (*Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique*). He is chairing the Scientific council of EDF (the French Electrical Utility company) since 2017 and the Launchers Research and Technology Evaluation Committee of CNES (the National Center for Space Research) since 2011 and has been a member of the Scientific advisory board of Safran since 2015.

On the international level, Sébastien Candel was a Vice President of the Combustion Institute from 1996 to 2002, and an Associate Editor of *Combustion and Flame* from 2001 to 2009. He is a Fellow of the American Institute of Aeronautics and Astronautics, of the Combustion Institute and of the Institute of Physics (UK).

Sébastien Candel obtained his engineering diploma from Ecole Centrale Paris and an advanced degree (DEA) in plasma physics both in 1968; he subsequently received his PhD from the California Institute of Technology, prepared under the supervision of the famous aeronautical scientist Frank E. Marble in 1972 and obtained a *Doctorat d'Etat* from University Pierre and Marie Curie in 1977.

His scientific production includes more than 230 peer-reviewed journal articles, 40 book sections, more than 230 scientific conference papers, two published books: *Mécanique des fluides* (Dunod) and *Problèmes de Mécanique des Fluides* (Dunod) and an edited book: *Turbulent mixing and Combustion* (Kluwer).

Initially focused on aeroacoustics, his research was aimed at identifying the noise-generating mechanisms in aero-engines and developing estimation methods for calculating sound radiation

from aircraft and space launchers. He notably led the first model scale experiments of the sound radiated by Ariane 5 at takeoff, essential to improve the acoustic "comfort" of the payload.

From 1978, he embarked on a new field of research on combustion. His research in this field focused on flame structures, combustion dynamics and combustion control, combustion instabilities, modeling and simulation of turbulent flames, combustion of cryogenic propellants at supercritical conditions with applications in the energy sector and in the aeronautical and space propulsion domain. A large-scale research effort was carried out with his team on combustion dynamics to identify the mechanisms driving and coupling instabilities including experimentation on simple flames, more complex turbulent combustors, multiple injector annular systems representing gas turbine combustors and high-pressure configurations fed with cryogenic propellants. Theory and reduced order modeling were developed in parallel exploiting flame describing function (FDF) concepts to represent the nonlinear dynamics of combustion systems. Active control methods were investigated experimentally to suppress instabilities, adaptive control was first demonstrated and simulated. Theory, experimentation, direct numerical simulation (DNS) and large eddy simulation (LES) were carried out to investigate flames with complex kinetics, their response to strain rate, ignition, flashback and extinction conditions, flame /vortex interactions, dynamics of flames formed in swirling flows, turbulent combustion and light-round ignition in annular systems. In the domain of space propulsion, the set of experiments carried out with his team have provided unique information on the physics of cryogenic combustion, on flame stabilization, flame structure and dynamics under extreme pressure conditions. These data have served as a guide for the development that was subsequently conducted with his team of large eddy simulation of transcritical flames and of high frequency instabilities in liquid rocket engine configurations.

His in-depth knowledge, his huge experience in different, crucial, research fields (fluid mechanics, combustion, propulsion, acoustics and aeroacoustics, signal processing, and hypersonics) together with his sense for strategic and sustainable innovation (in this regard his professional service at the French Institut Français du Pétrole et des Energies Nouvelles, Cerfacs, CNES, EDF and Safran) make him a point of reference for more than a generation of young researchers and also a privileged scientific adviser at an industrial and political level.

From 1978 to 2014 more than 1500 young engineers specialized at the Ecole Centrale Paris in the field of study that he was heading, the *Air-Espace* Option, which later became the Mechanics, Aeronautical and Energy Option. Sébastien Candel is also well known for his excellence in teaching Fluid Mechanics at the basic and more advanced level. His common core course was attended over the years by approximately 8000 engineering students at Ecole Centrale Paris. Sébastien Candel has advised and trained more than 60 doctoral students.

For the significant international value of all his activity, for his scientific and strategic vision, for the deep impact, among others, of his work on fluid mechanics, combustion, aeroacoustics and high-speed reactive flow aerodynamics, the Scientific Committee of the Levi-Civita Prize in Mechanical and Mathematical Sciences is honored to propose Sébastien Candel as the Recipient of the 2021 Prize Edition.