PRINCETON
Mechanical & Aerospace Engineering

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Maeder Hall, ACEE
3:30 PM

Combustion Dynamics: Advancing Knowledge and Coping with Applications

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A considerable research effort has concerned combustion dynamics issues. This work initially motivated by problems encountered during the early development of rocket propulsion has been focused during the last period on issues raised by gas turbines. To reduce NOx emissions these machines now operate in a lean premixed combustion mode. In the new combustor architectures, the flames are more compact, the power density is higher, and the damping rate is reduced a combination of factors that promotes instabilities. Under certain conditions this leads to unacceptable levels of pressure oscillations in the system and this has become an essential issue in the design of these systems. Much of the early understanding of combustion dynamics phenomena has its origin in research carried out by Luigi Crocco, his students and colleagues during his years at Princeton. This group understood that instabilities in rocket engines were caused by the delay between injection and combustion and derived the sensitive time lag theory which accounted in a clever but somewhat empirical way for the fact that the delay was sensitive to operating parameters. Much progress has been accomplished since that time in the physical understanding and identification of the fundamental processes giving rise to combustion dynamics phenomena and self sustained oscillations. This has been based on well-controlled experiments, novel theoretical ideas and high performance computing. This lecture proposes a review of issues, progress and current research in this broad field. It will cover the following topics: (1) Historical background and combustion dynamics fundamentals (introductory material intended for a general audience), (2) Perturbed flame dynamics experiments and theory, (3) Flame describing function unified framework for the nonlinear analysis of self-sustained oscillations, determination of limit cycle amplitudes, mode switching and triggering, (4) Dynamics of swirling flames, (5) Annular combustor dynamics and azimuthal modal coupling (see Fig.1). The last topic will be emphasized because the annular geometry is used in many practical systems of importance like jet engines and gas turbines. In general, these combustors are equipped with multiple injectors. This situation is investigated by making use of novel experimental configurations, new low order models and comprehensive large eddy simulations.

Sébastien Candel is a University professor emeritus at CentraleSupélec, University Paris-Saclay (EM2C laboratory CNRS) and a honorary professor at Institut Universitaire de France. His research in the domains of combustion and aeroacoustics has applications in energy and aeronautical and space propulsion. Among many distinctions, Sébastien Candel has been the recipient of the Marcel Dassault Grand Prize of the French Academy of sciences, the *Pendray Aerospace Literature award* of the *American Institute of Aeronautics and Astronautics,* the Distinguished Alumni Award of the California Institute of Technology, the Silver and Zeldovich Gold medals both from the *Combustion Institute*. Sébastien Candel is a member of the French Academy of sciences and the Vice-President of this academy in 2015 and 2016 and a foreign member of the *National Academy of Engineering* of the United States.

Social Period outside of Maeder Hall, following the seminar

ALL VISITORS ARE WELCOME