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From chanting flames to the big bang in combustors

Abstract:

Chanting flames sounds charming. However, in gas turbines combustors and rocket engines it may lead high-pressure amplitudes and heat release oscillations that can cause severe structural damage to combustor or engine limit the operational envelope of modern gas turbines and may lead to higher pollutant emissions. The simulation of combustion dynamics requires multi-scale methods to couple the combustion simulation with the combustor acoustics. This can be used for the investigation of multi-burner systems as well as their control. Other approaches use low-dimensional network models and measured flame transfer functions, a black box representation of the complex interaction between flow, heat release and acoustics. Better understanding of the hydrodynamic instability mode / flame interaction is obtained by using linear stability theory. The analysis shows clearly why the precessing vortex core occurs and how it may be suppressed depending on the initial conditions.

While in conventional combustors the pressure pulsations are detrimental, the violent pressure increase during a detonation or an explosion can be used to raise the efficiency of a gas turbine dramatically and thus helps to reduce CO_2 emissions. To understand and to control this process requires close cooperation of numerical simulations and experiments. A completely new concept was developed, and its feasibility demonstrated.