EXPLORING THE DEFLAGRATION-AUTOIGNITION-DETONATION TRANSITION IN THE CONTEXT OF PESSURE GAIN COMBUSTION

(WORK IN PROGRESS)

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INTRODUCTION

01 PROJECT MOTIVATION

Autoignition of hot spots can develop into a detonation under certain conditions. Detonations must be suppressed in Constant Volume Combustion and promoted in Rotating Detonation Combustion. Controlling the transition between combustion regimes is key to developing pressure gain combustion.

02 PROJECT OBJECTIVES

STAGE 1

Enhance understanding of autoignition propagation modes using conventional 1D-modelling

STAGE 3

Enhance the 1D model to better match the experiment and explore strategies for promoting and suppressing detonations

STAGE 2

Experimentally investigate the Deflagration-Autoignition-Detonation-Transition (DADT)

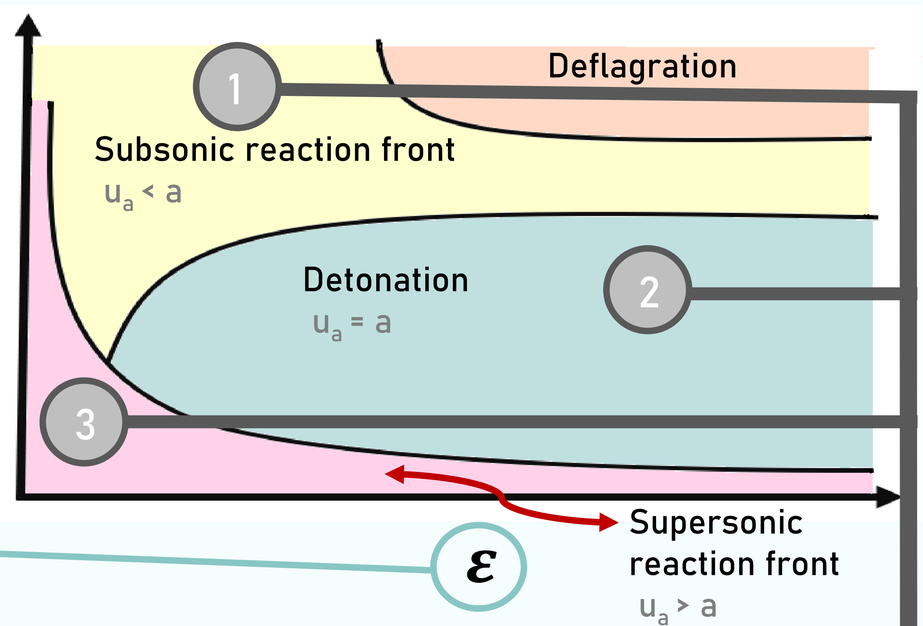
03 REGIME DIAGRAM

The propagation modes of hot spots under different conditions can be represented by a regime diagram. The different hotspot conditions are represented by 2 dimensionless parameters.

$$\xi = a/\left(\frac{dr}{dT} * \frac{dT}{dt_{ig}}\right)$$

$$\varepsilon = (r_0/a)/t_e$$

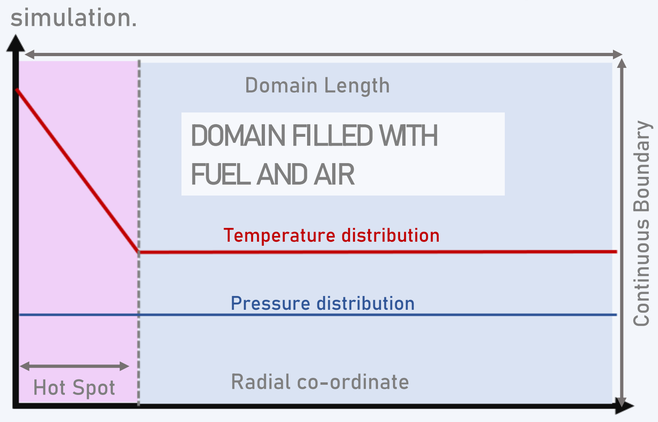
a = the local speed of sound
r = radius
r_0 = hotspot radius
t_e = excitation time
t_{ig} = ignition delay time
u_a = autoignition wave speed
T = temperature



METHODOLOGY

04 STAGE 1 METHODOLOGY

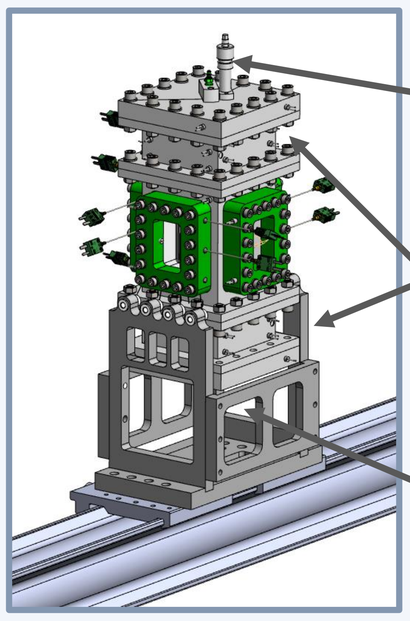
The INSFLA code provided by the Karlsruhe Institute of Technology is capable of providing time and space solutions for 1-D compressible reacting flows for both planar and spherical configurations. The diagram below shows the Initial conditions and set-up for a 1-D spherical hotspot simulation.



Conditions Explored	Pressure, Temperature, Oxidizer Composition, Temperature Gradient

05 STAGE 2 METHODOLOGY

The DADT transition will be investigated experimentally using the MDAID set-up shown in the diagram below



- Modular square inner section 110/172/234 x 40 x 40 mm^3
- Spark plug with Transistorized Coil Igniter (E_{el}~30 mJ)
- Cartridge heaters with 1 to 3 zones PID regulation
- Heat flux sensor (bottom)
- Four UV quartz windows: high speed chemiluminescence, schlieren, fluorescence...

STAGE 1 RESULTS

Figures 1, 2 and 3 are some of the results obtained from stage 1 using the INSFLA code. The results are for a stochiometric hydrogen and air mixture. The INSFLA code is still being adapted, therefore the results are only preliminary.

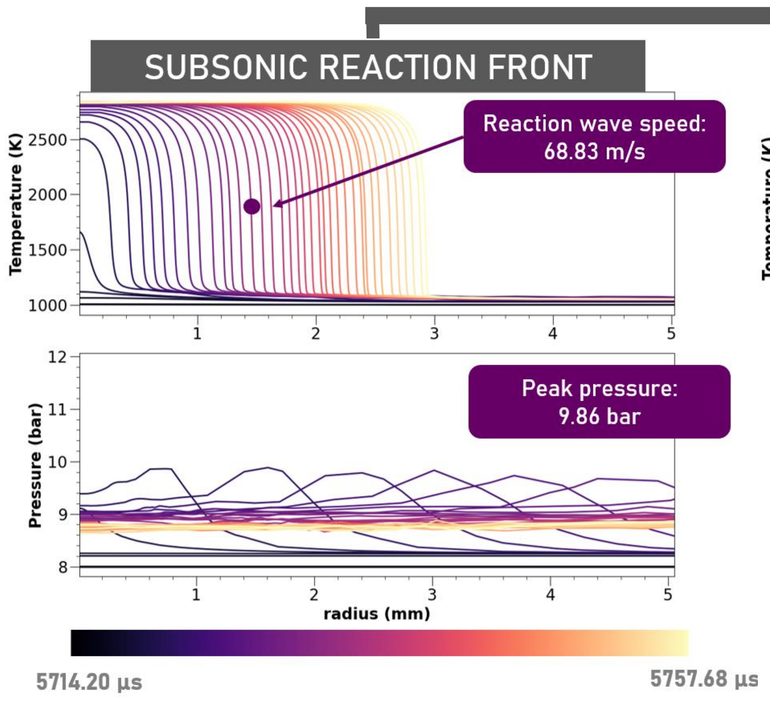


Figure 1: Stochiometric hydrogen in air,1000 K, 8 bar, 4 cm domain length, 2.5 mm hotspot radius, temperature gradient of 2000 K/m, planar configuration.

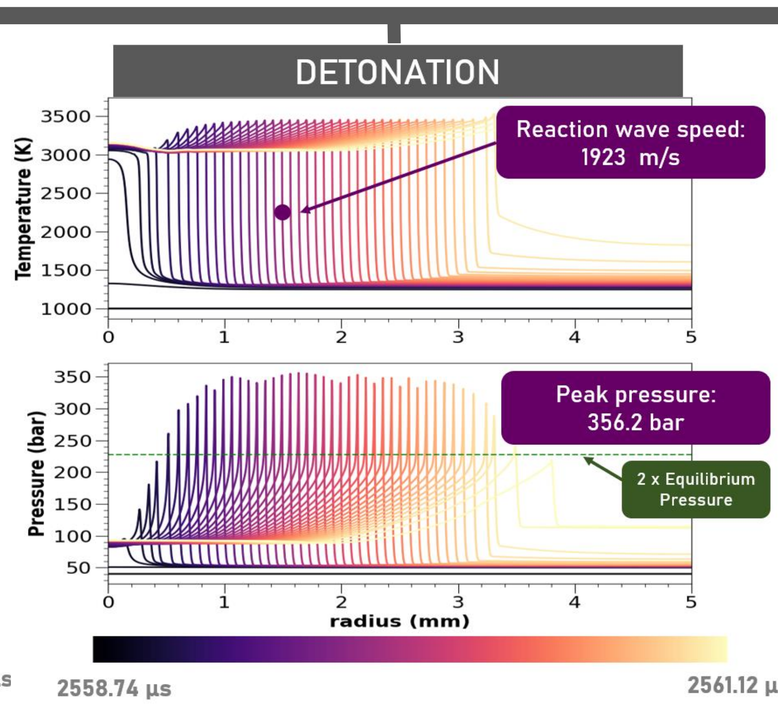


Figure 2: Stochiometric hydrogen in air, 1000 K, 40.53 bar, 5 cm domain length, 1 mm hotspot radius, temperature gradient of 150 K/m, planar configuration.

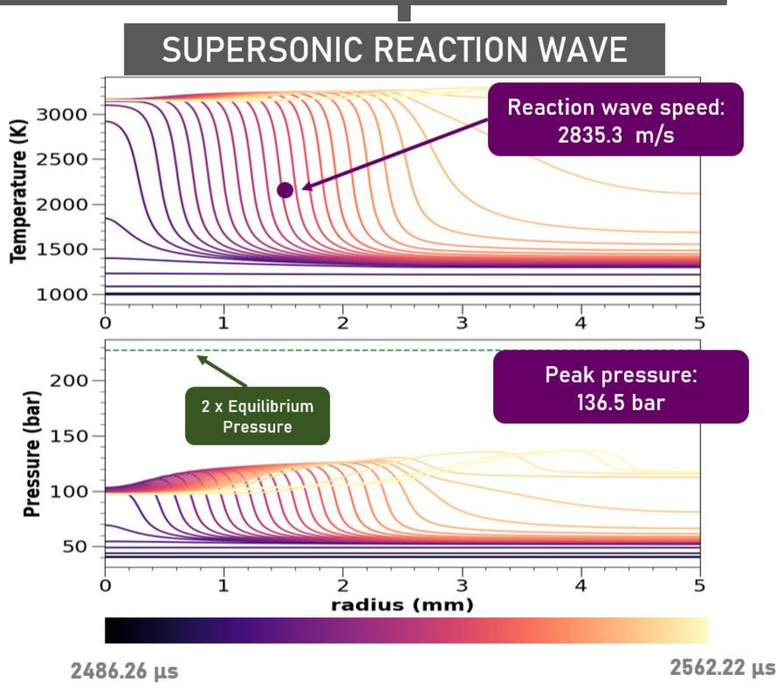


Figure 3: Stochiometric hydrogen in air, 1000 K, 40.53 bar, 5 cm domain length, 2.5 mm hotspot radius, temperature gradient of 25 K/m, planar configuration.

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