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

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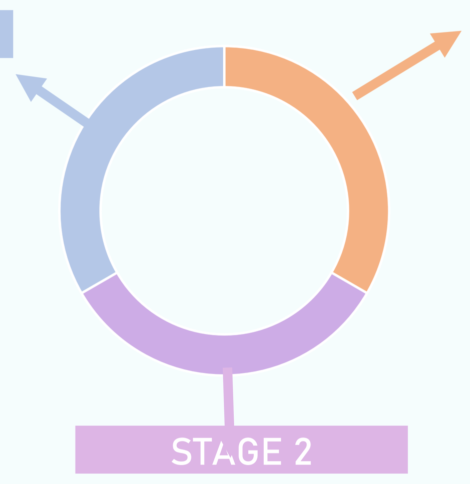
INTRODUCTION

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

STAGE 3: Enhance the 1D model to better match the experiment and explore strategies for promoting and suppressing detonations

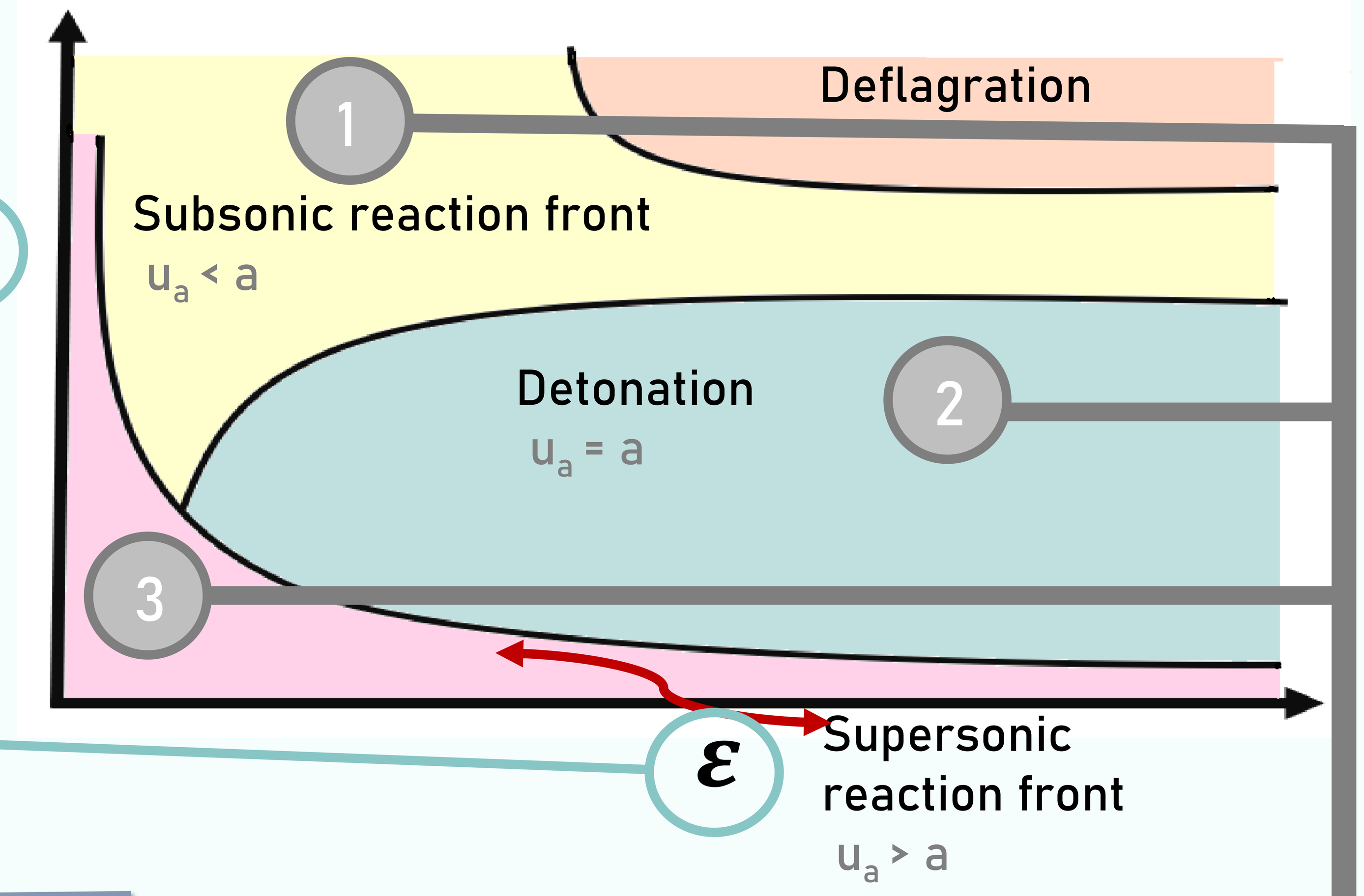
03 REGIME DIAGRAM

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.

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

- 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

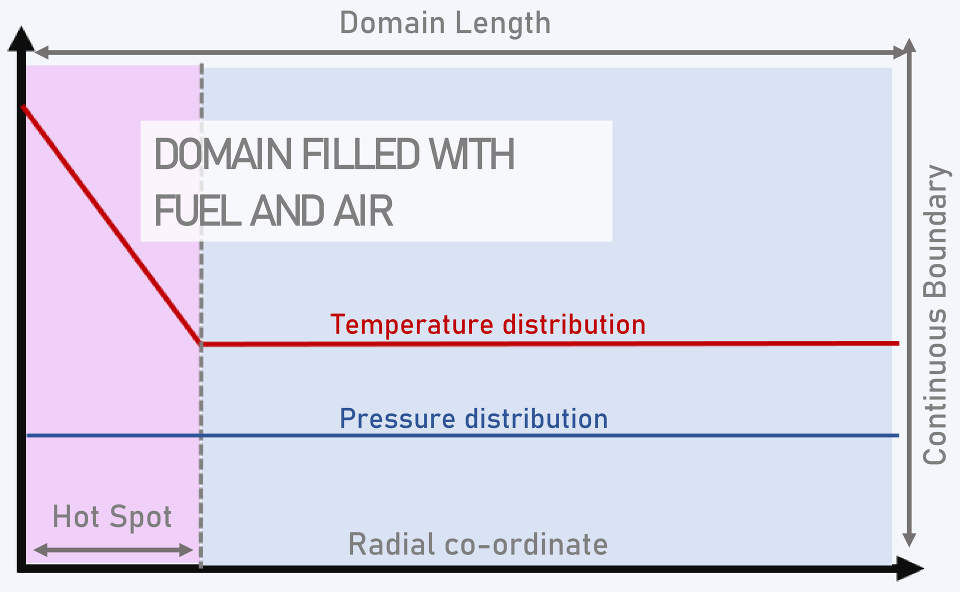
$$\varepsilon = (r_0/a)/t_e$$



METHODOLOGY

04 STAGE 1 METHODOLOGY

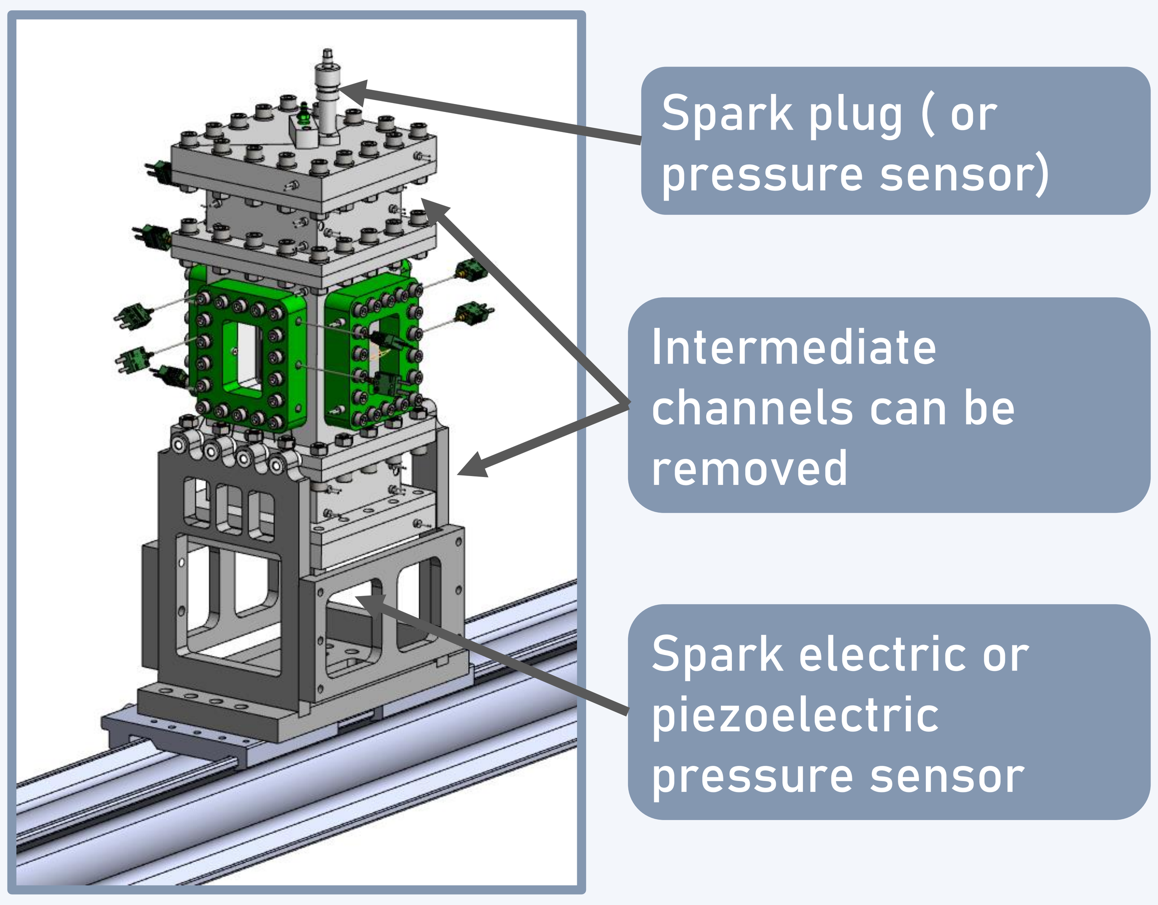
The INSFLA code provided by the Karlsruhe Institute of Technology is capable of providing time and space solutions for 1-D compressible reacting flows for both planar and spherical configurations. The diagram below shows the Initial conditions and set-up for a 1D spherical hotspot simulation.



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 mm³
- 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.

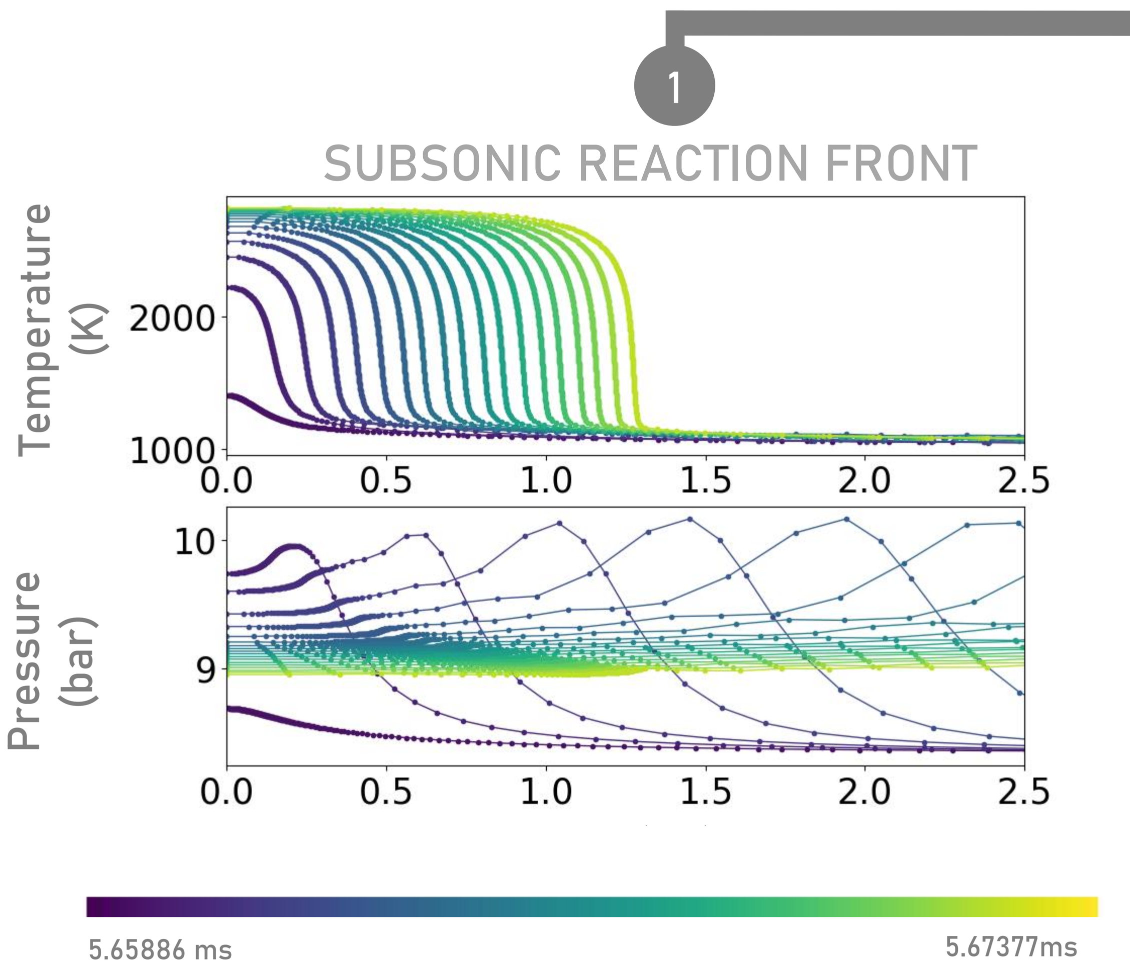


Figure 1: Stochiometric hydrogen in air at 1000K, 8 bar with a 2cm domain length and 2.5mm hotspot length and temperature gradient of 2K/mm in a planar configuration.

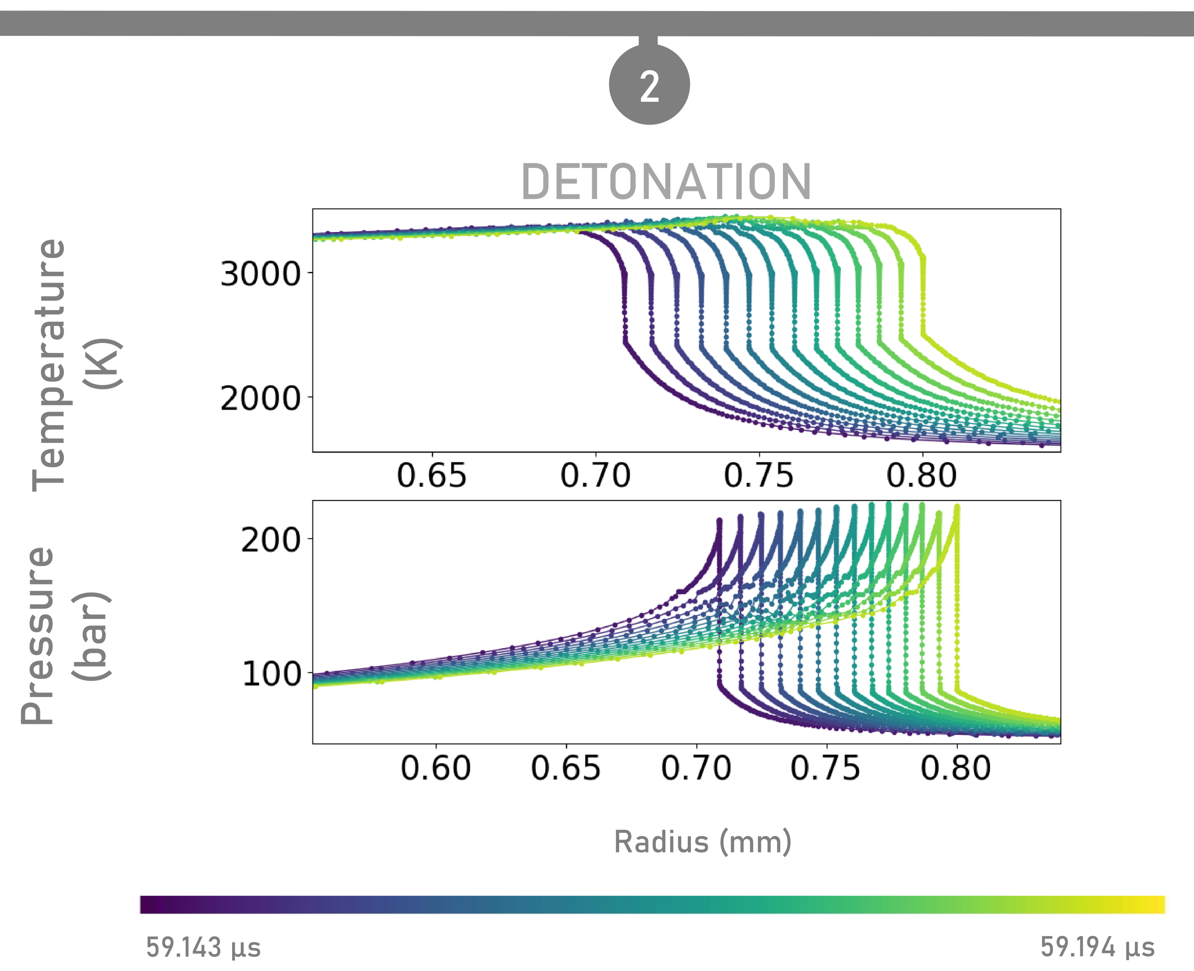


Figure 2: Stochiometric hydrogen in air at 1250K, 40 bar with a 10mm domain length, 8mm hotspot length and a temperature gradient of 0.125K/mm in a planar configuration.

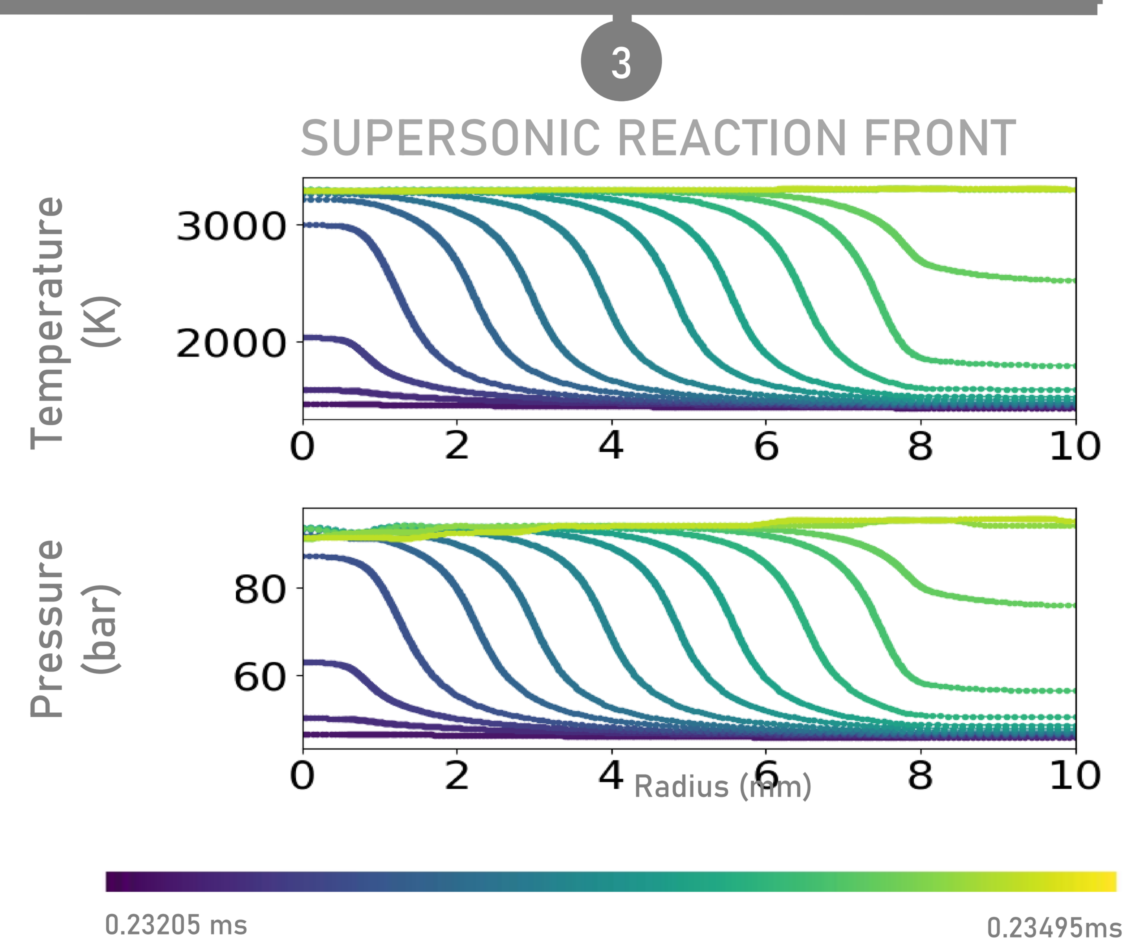


Figure 3: Stochiometric hydrogen in air, at 1250K, 40 bar with a 10mm domain length, 8mm hotspot length and temperature gradient of 0.0125 K/mm in a planar configuration.

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