Detonation initiation by Shock Wave Refraction

Mathilde Dutreuilh[1]

[1]Mechanics - Modelling in Mechanics
ENSTA Paris

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Introduction

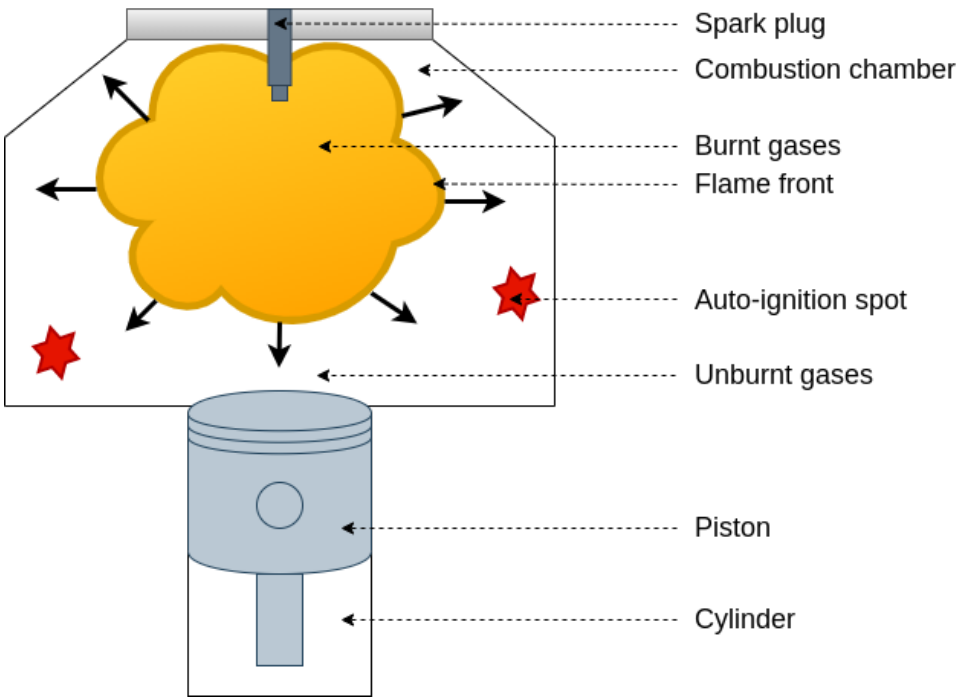

Figure 1: Schematic of super-knock initiation, inspired from Wang et al. [2018].

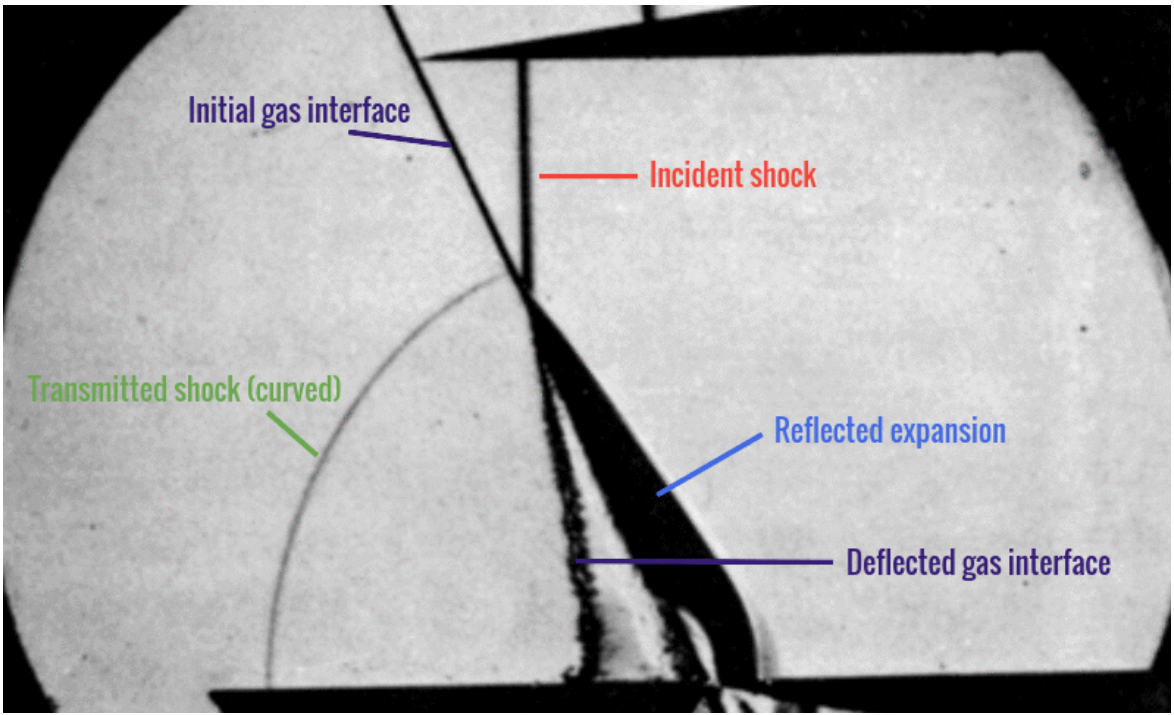

Figure 2: Schlieren photograph of a *Bound Precursor Refraction* at a CO_2-CH_4 interface, from Abd-El-Fattah et al. [1976].

Outline

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Regime diagram
for H_2-O_2/He interface

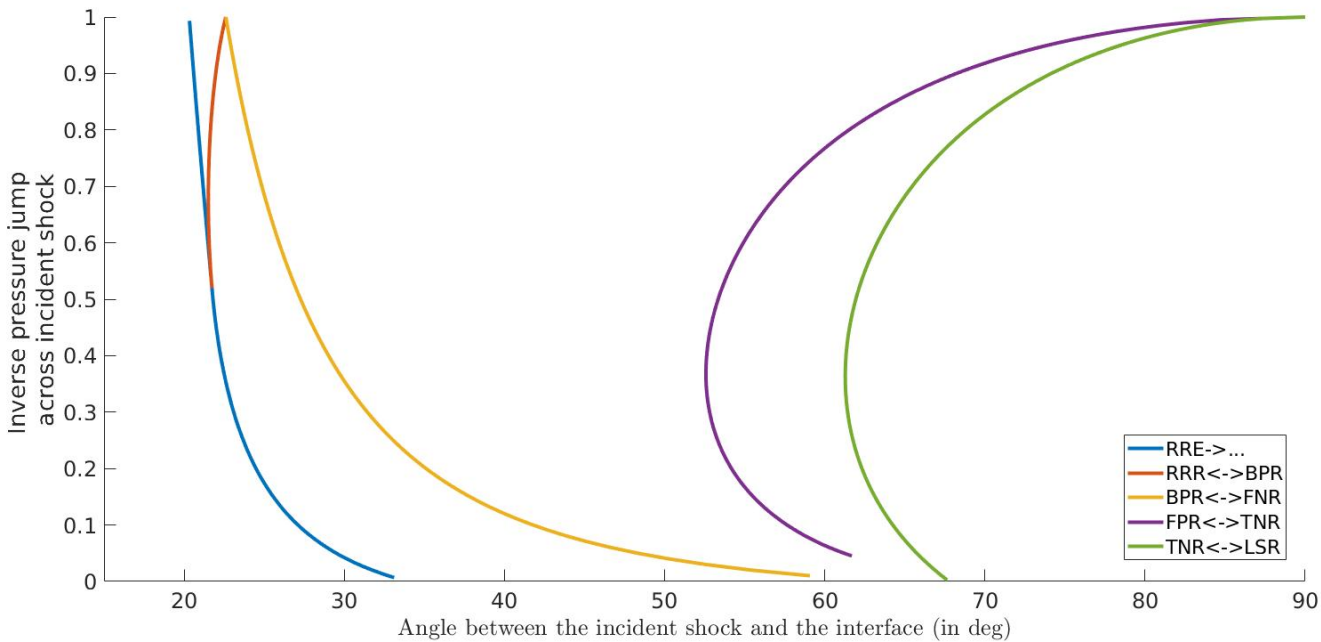

Figure 3: Regime diagram for H_2-O_2/He interface, from de Gouvello [2019].

Regime diagram

for H_2-O_2/He interface

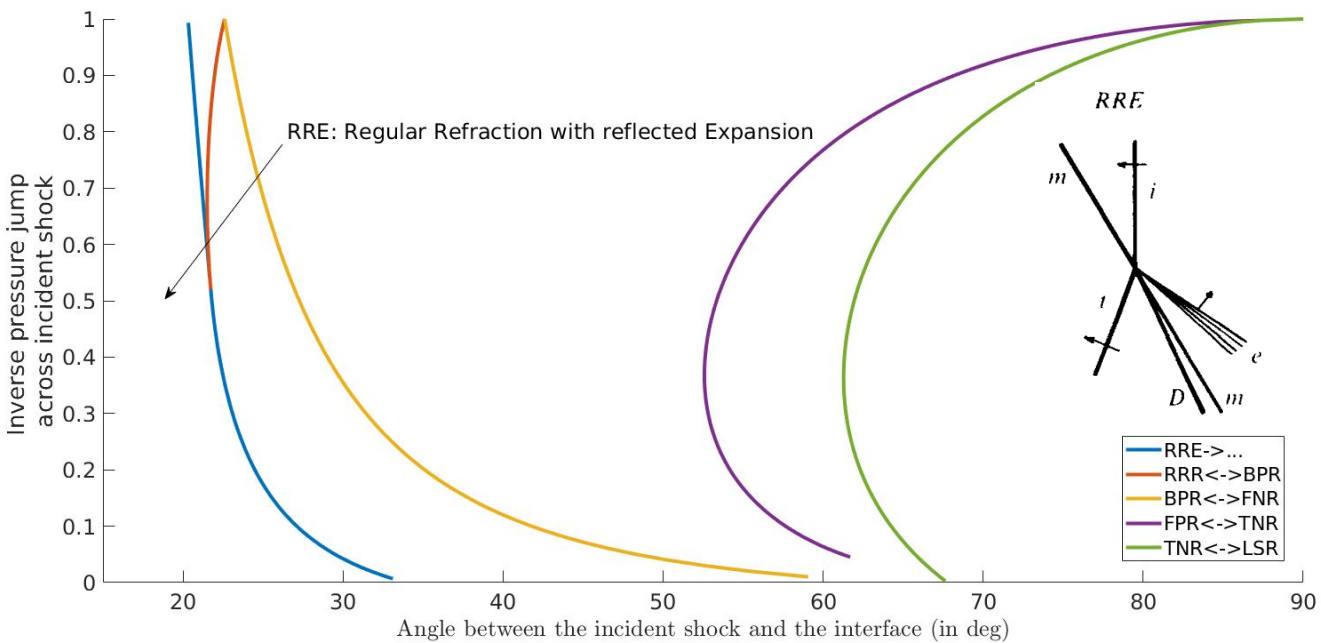

Figure 4: Regime diagram for H_2-O_2/He interface, from de Gouvello [2019]; schematics from Abd-El-Fattah and Henderson [1978].

Regime diagram

for H_2-O_2/He interface

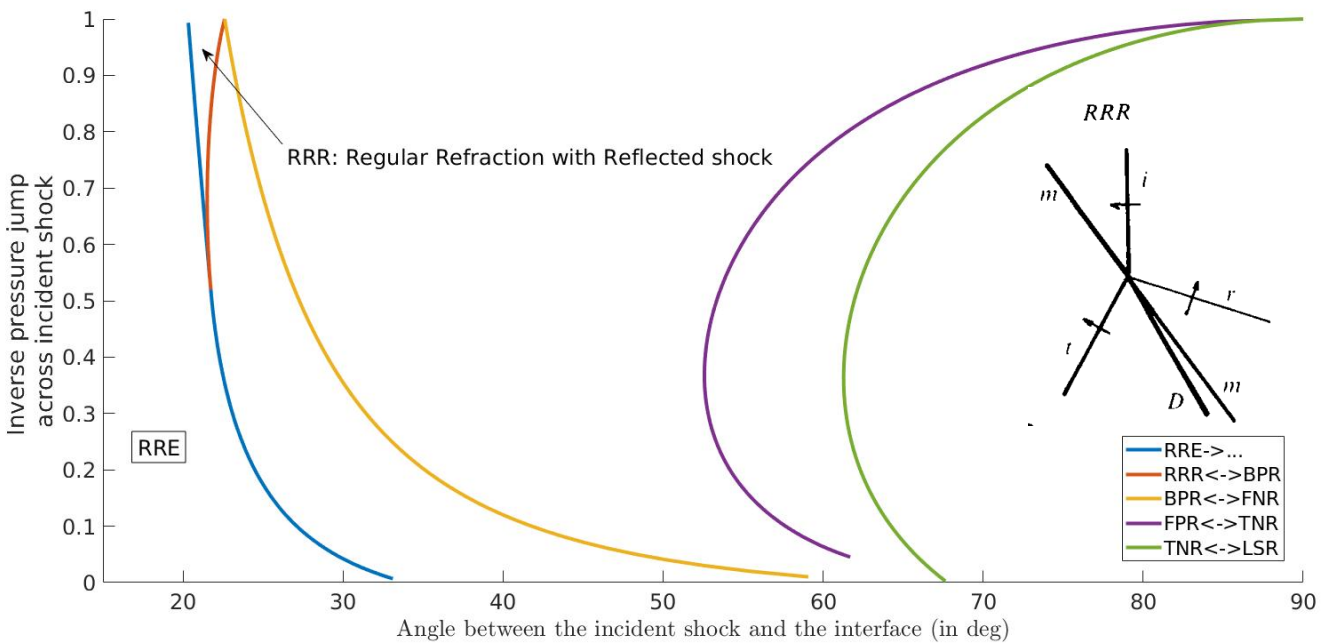

Figure 5: Regime diagram for H_2-O_2/He interface, from de Gouvello [2019]; schematics from Abd-El-Fattah and Henderson [1978].

Regime diagram

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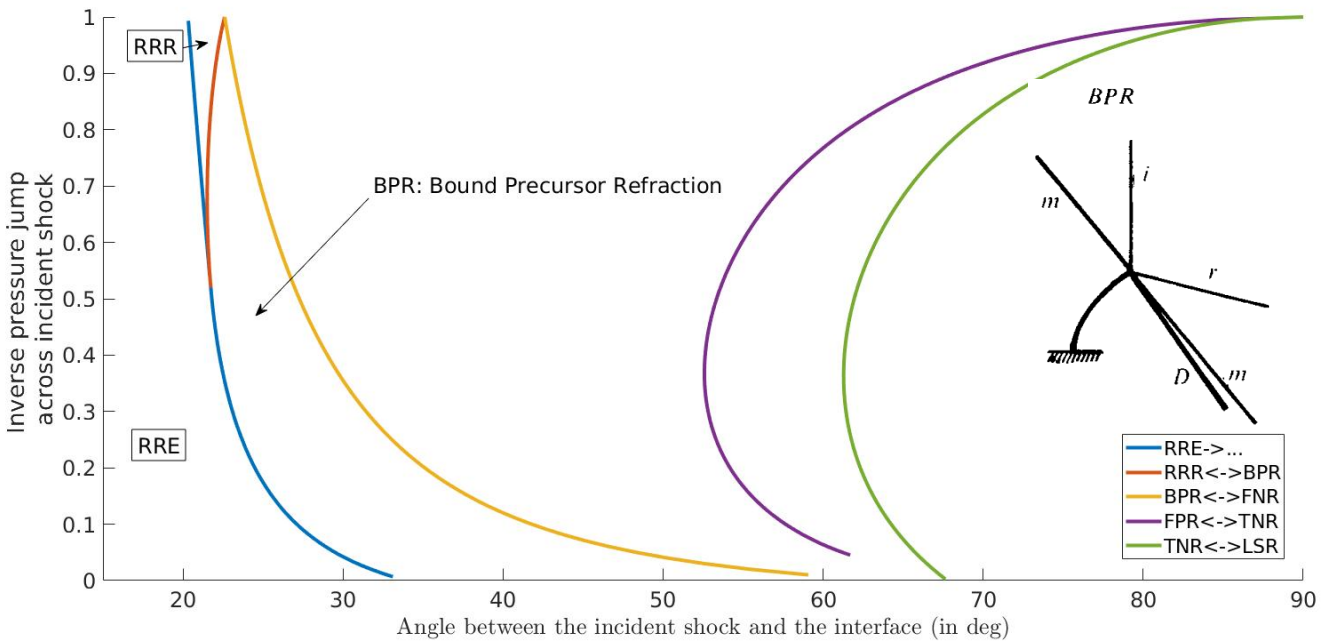

Figure 6: Regime diagram for H_2-O_2/He interface, from de Gouvello [2019]; schematics from Abd-El-Fattah and Henderson [1978].

Regime diagram
for H_2-O_2/He interface

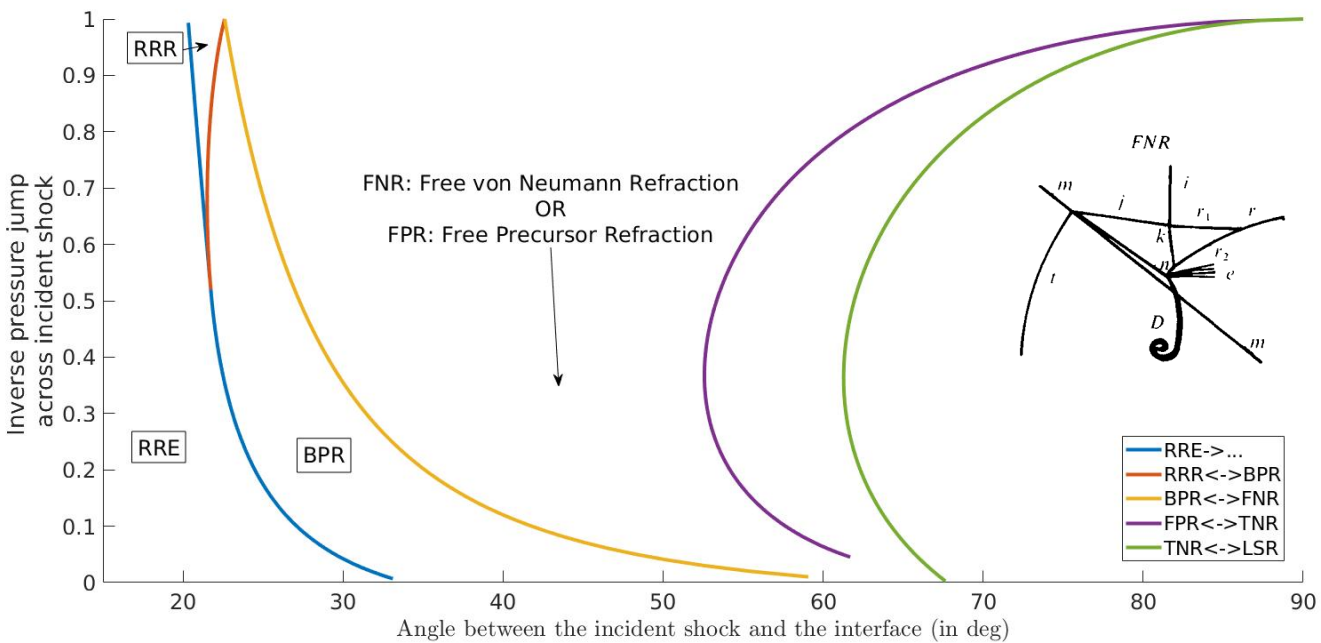

Figure 7: Regime diagram for H_2-O_2/He interface, from de Gouvello [2019]; schematics from Abd-El-Fattah and Henderson [1978].

Regime diagram

for H_2-O_2/He interface

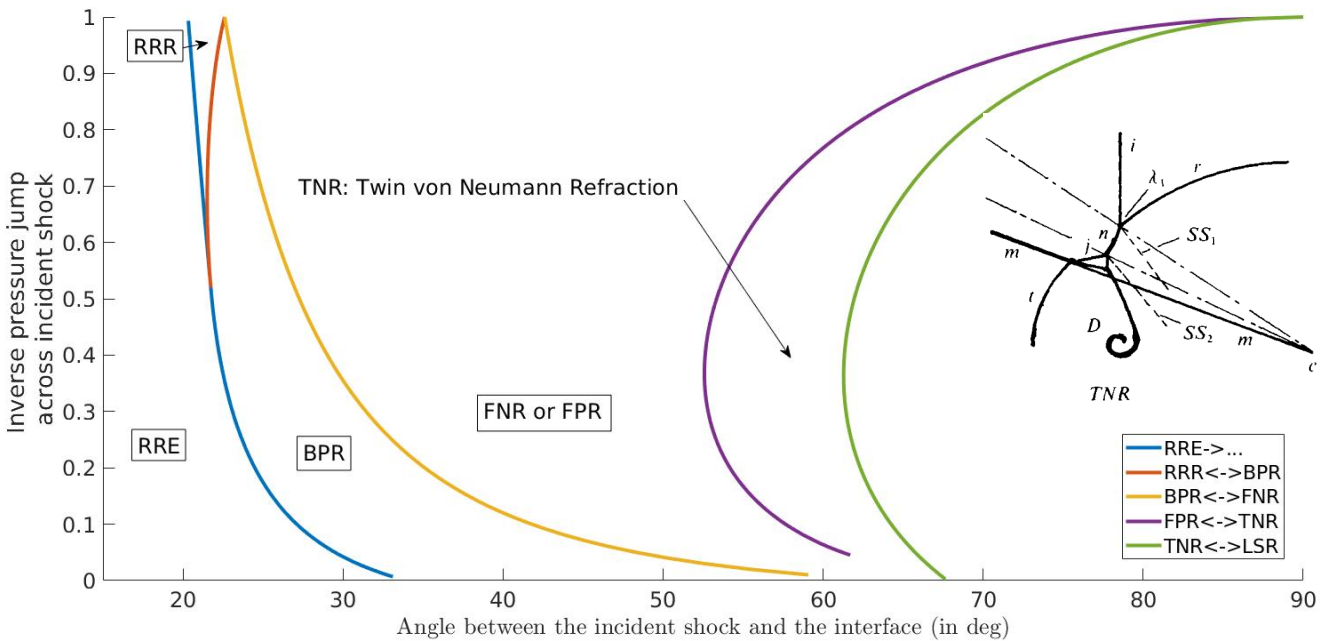

Figure 8: Regime diagram for H_2-O_2/He interface, from de Gouvello [2019]; schematics from Abd-El-Fattah and Henderson [1978].

Regime diagram
for H_2-O_2/He interface

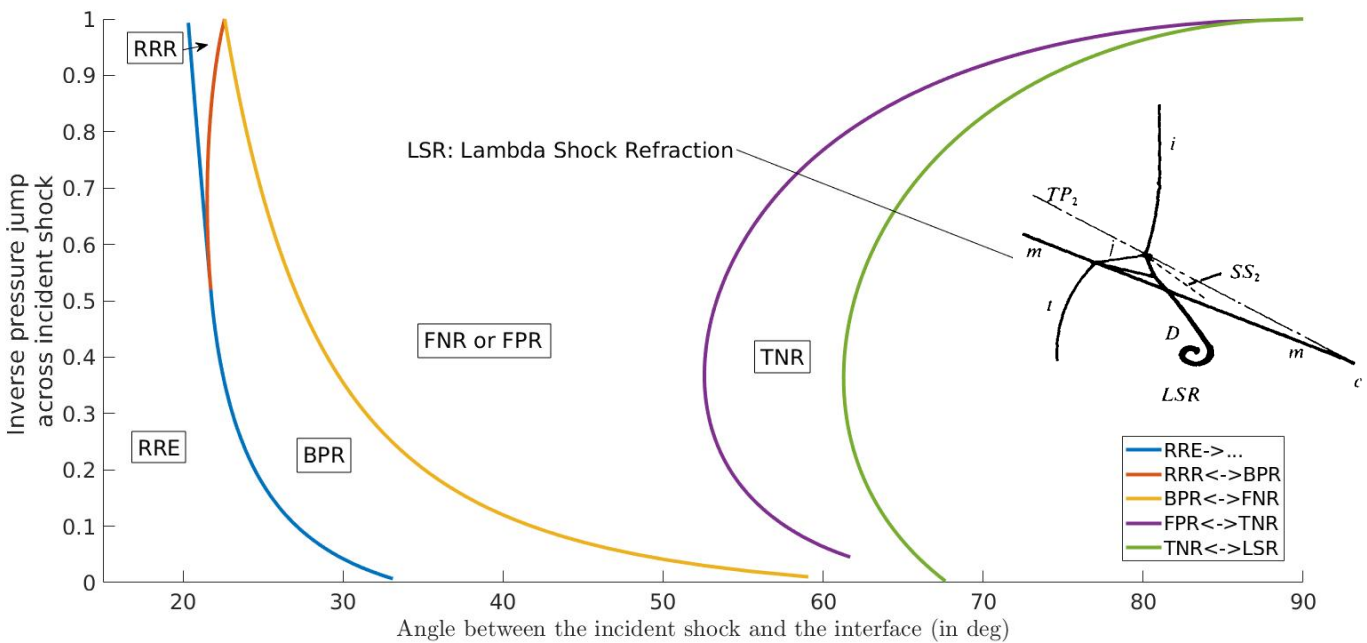

Figure 9: Regime diagram for H_2-O_2/He interface, from de Gouvello [2019]; schematics from Abd-El-Fattah and Henderson [1978].

Regime diagram

for H_2-O_2/He interface

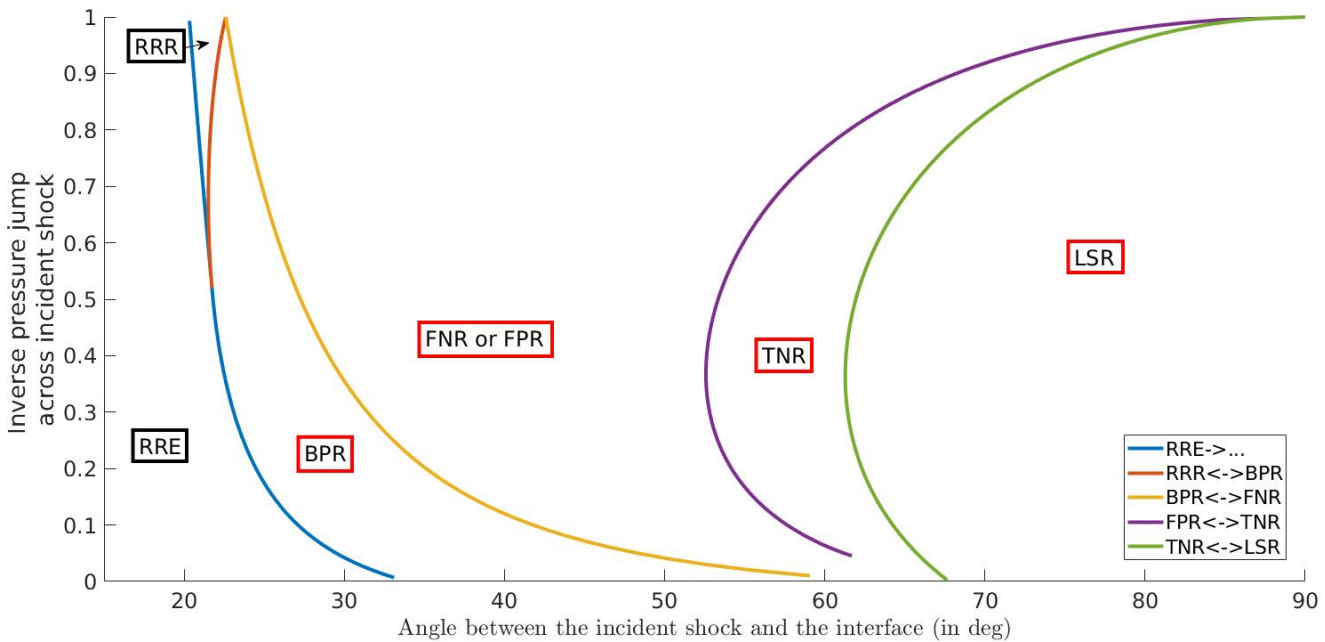

Figure 10: Regime diagram for H_2-O_2/He interface, from de Gouvello [2019].

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Study of regular patterns

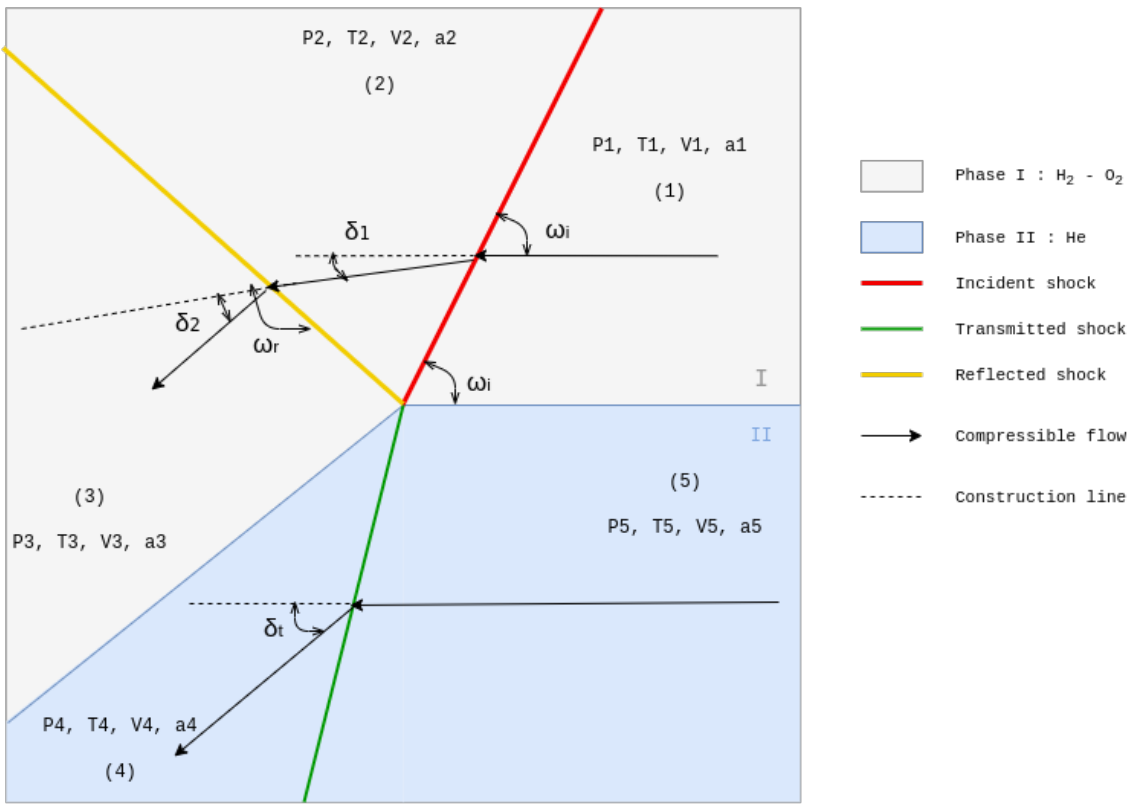

Figure 11: Schematic of a regular refraction pattern.

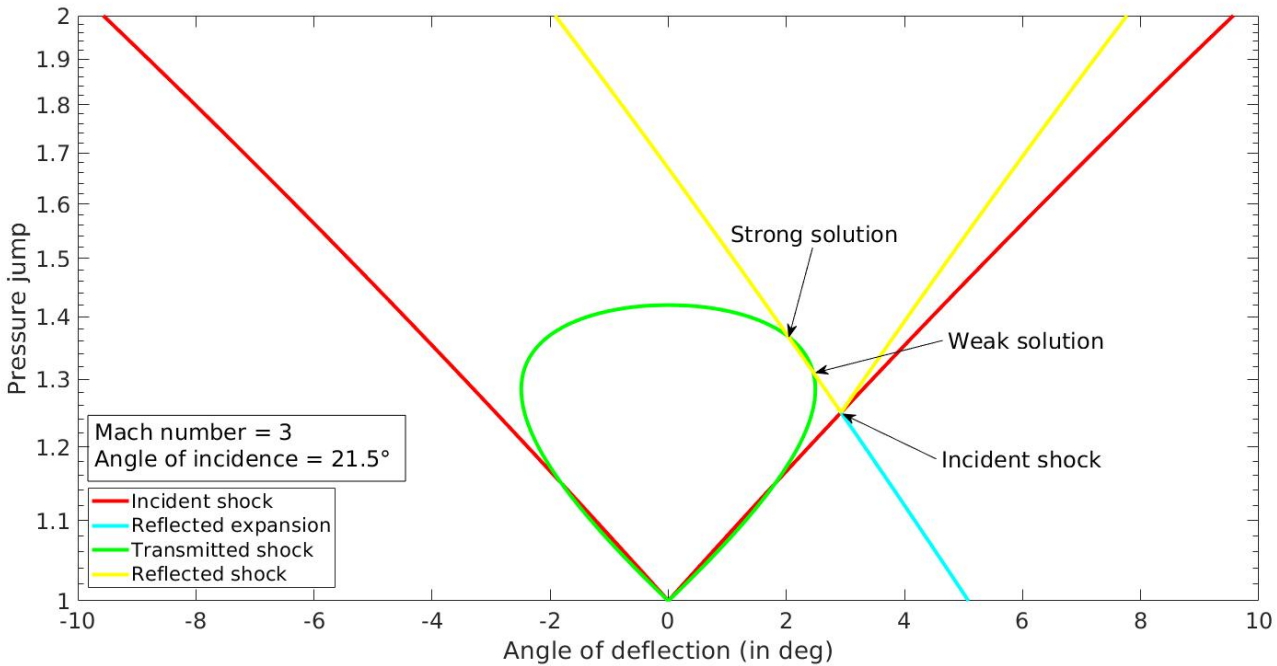

Figure 12: Polar diagram for a regular refraction pattern.

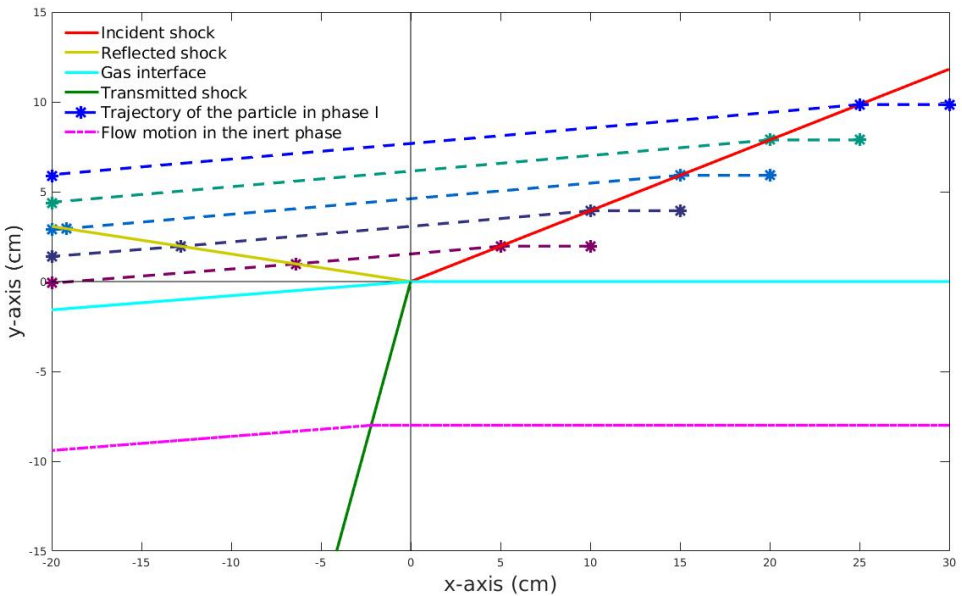

Figure 13: Schematic of a regular refraction pattern, drawn to scale: path of several Lagrangian particles.

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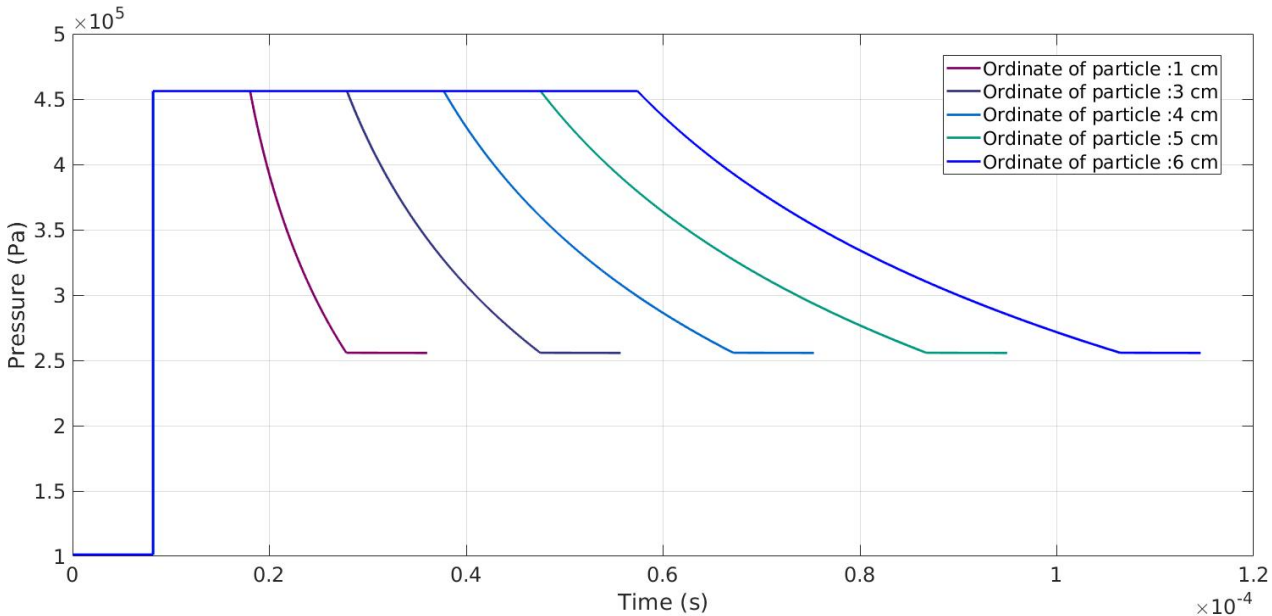

Figure 14: Pressure history across a *Regular Refraction with reflected Expansion* pattern: Mach number of incident flow = 8; Strength of the shock = 4.55; Angle of incidence = 14.5°.

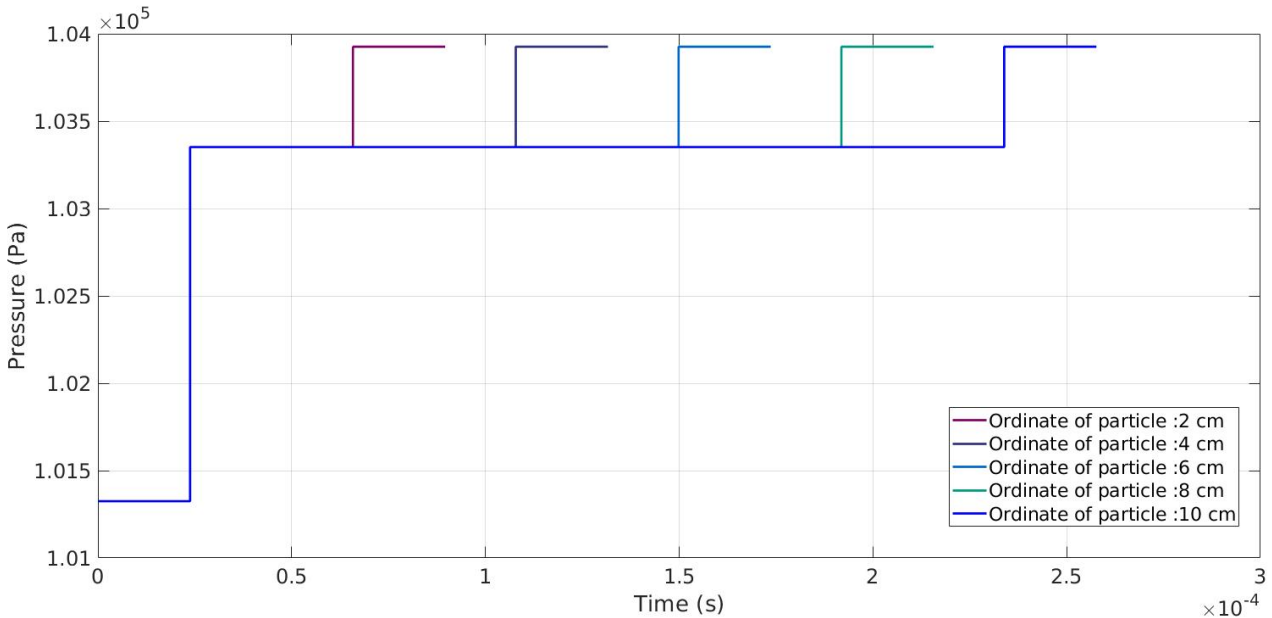

Figure 15: Pressure history across a *Regular Refraction with Reflected shock* pattern: Mach number of incident flow = 3.25; Strength of the shock = 1.49; Angle of incidence = 21.5°.

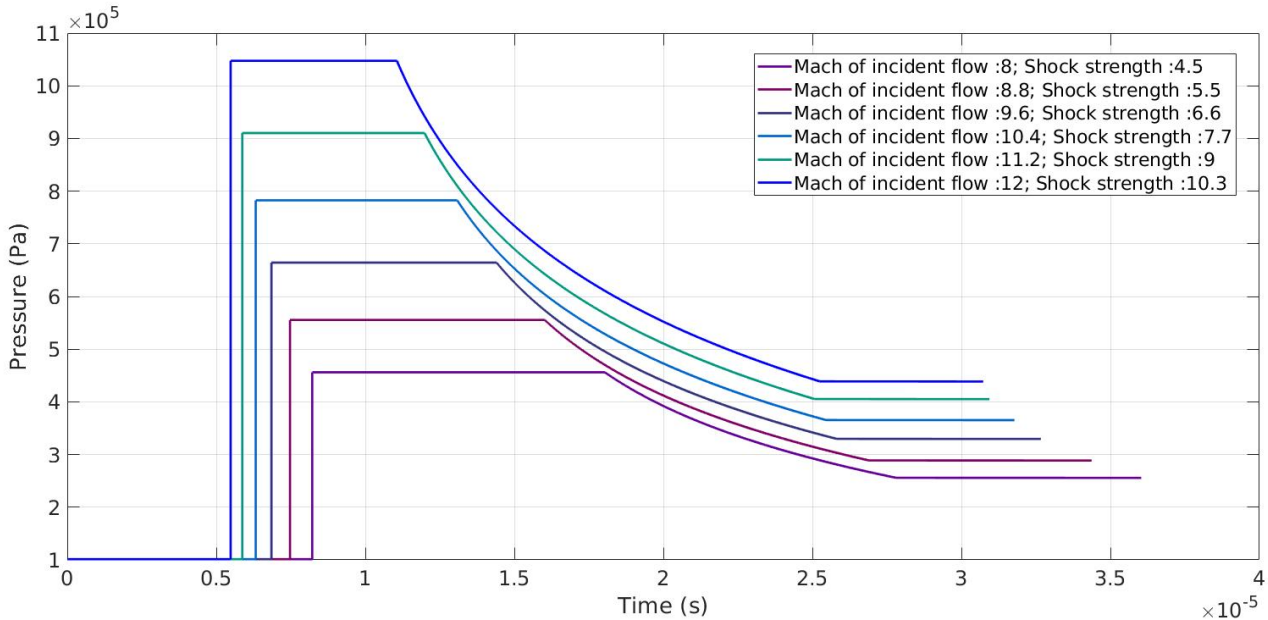

Figure 16: Pressure history across a *Regular Refraction with reflected Expansion* pattern: Ordinate = 1 cm; Angle of incidence = 14.5°.

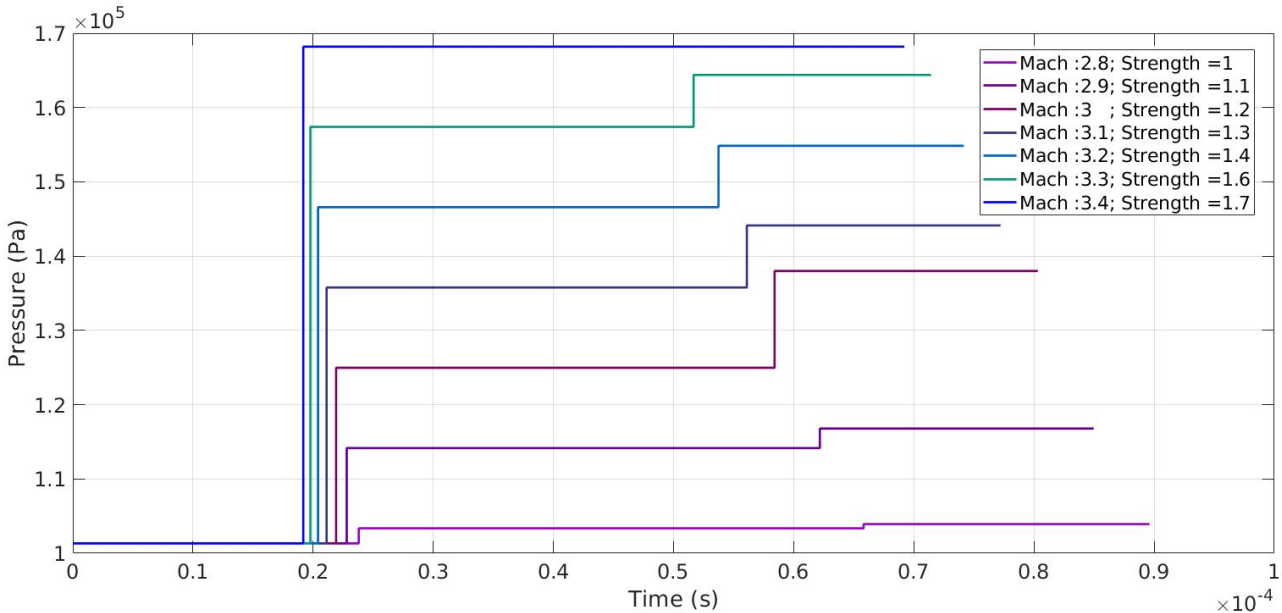

Figure 17: Pressure history across a *Regular Refraction with Reflected shock* pattern: Ordinate = 2 cm; Angle of incidence = 21.5°.

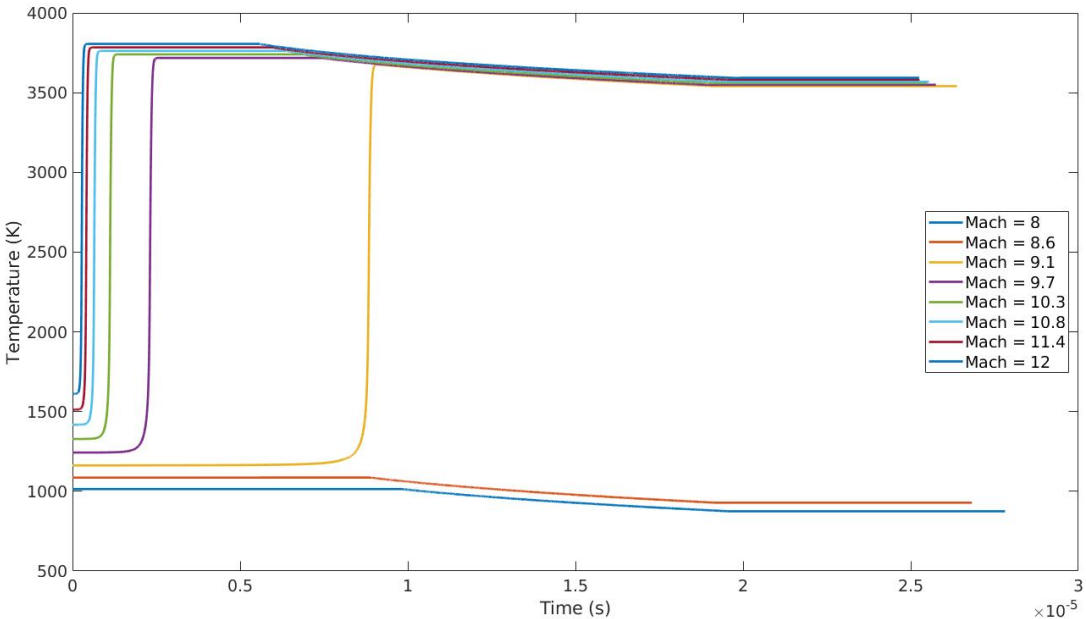

Figure 18: Temperature history across a *Regular Refraction with reflected Expansion* pattern, after chemical simulation.

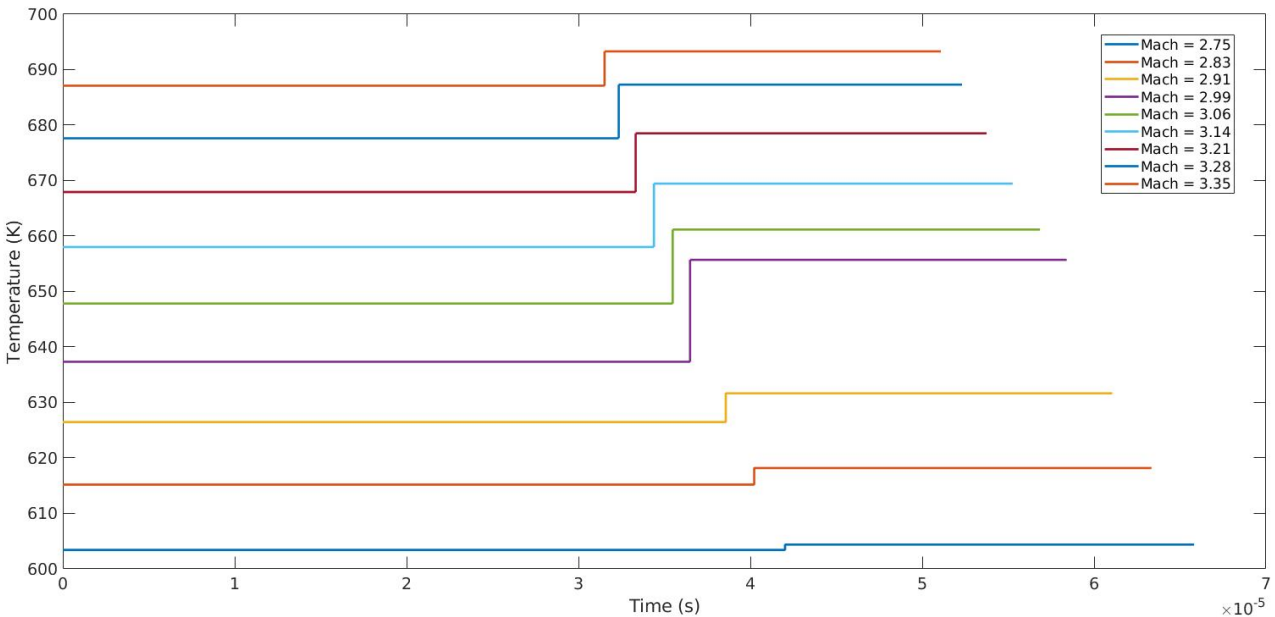

Figure 19: Temperature history across a *Regular Refraction with Reflected shock* pattern, after chemical simulation.

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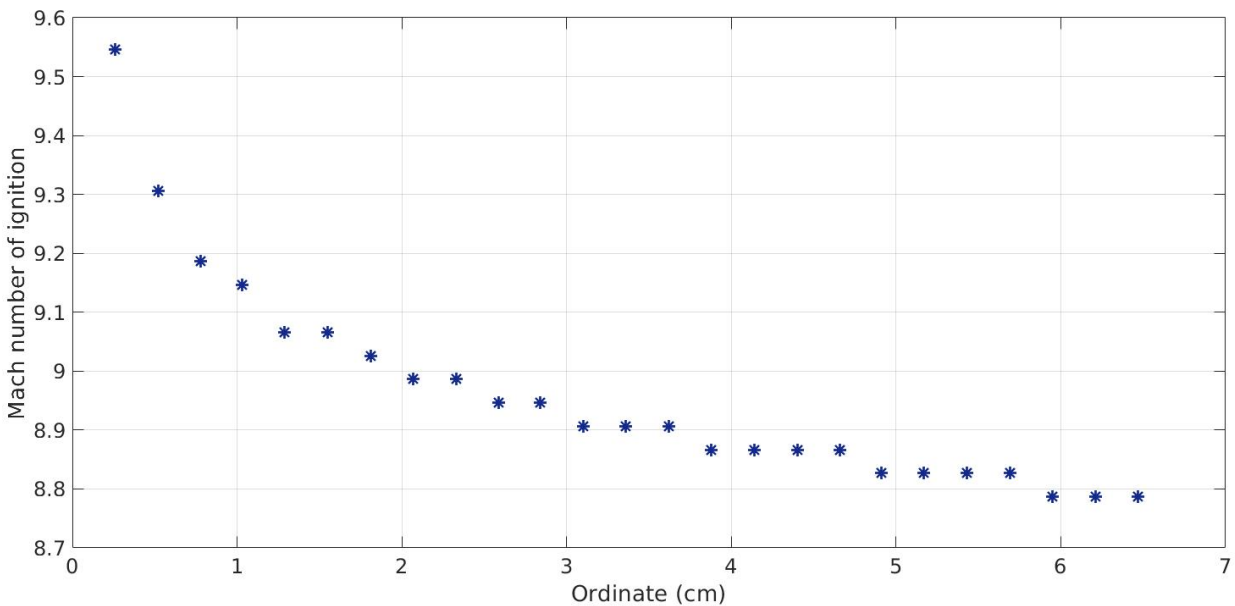

Figure 20: Evolution of the critical Mach number with the position of the particle, for a *Regular Refraction with reflected Expansion*.

Conclusions

More generally...

- For RRR patterns, incident shocks are not strong enough to cause detonation initiation;

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Conclusions

More generally...

- For RRR patterns, incident shocks are not strong enough to cause detonation initiation;
- For RRE patterns, Mach numbers over 8 are rarely reached;
- For irregular patterns, the method implemented here is not valid : CFD computation is needed.

Acknowledgements

- **Dr. Rémy Mével**, Professeur Associé,
  Tsinghua University
- **Dr. Josué Melguizo-Gavilanes**, Chargé de Recherche,
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  ENSTA Paris

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