Effect of Equivalence Ratio on Ignition and Flame Propagation of *n*-Hexane-Air Mixtures using Moving Hot Particles

Stephanie Coronel   Joseph E. Shepherd

Graduate Aerospace Laboratories, California Institute of Technology

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Accidental Ignition

- Accidental ignition
  - → electrostatic ignition of fuel
  - → lightning strike
  - → electrical faults in pumps, fuel quantity instrumentation
  - → hot surface ignition
- Characterize fuel-oxidizer properties (*n*-hexane)
  - → ignition delay time (Burcat et al. and Zhukov et al.)
  - → heating rate on the low temperature oxidation of hexane by air (Boettcher et al.)
  - → minimum ignition temperature (Boettcher)
  - → minimum ignition energy (Bane)
  - → laminar burning speed (Coronel)

TWA 800, NY 747-100, July 17, 1996

China Air Flight 120 caught fire in Okinawa Japan (BBC News, August 20, 2007)

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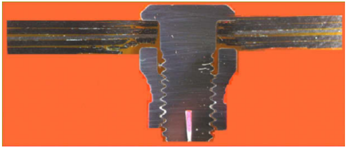
Hot Particle Ignition Sources

- Lightning attaches to the top of the fastener and causes damage to the resin and fibers on the backface of the composite laminate
- The breakup of the composite is due to its poor electrical conductivity that leads to resistive heating



P. Feraboli, M. Miller. Composites Part A: Applied Science and Manufacturing, Volume 40, Issues 6-7, July 2009, Pages 954-967

Ignition at edge of carbon fiber composite structure, Boeing

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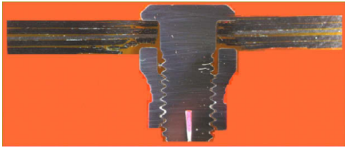

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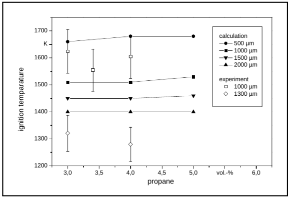
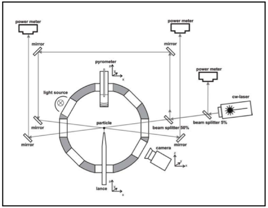
Stationary Hot Particle Ignition

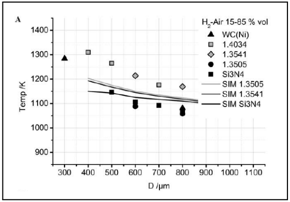
- H. Bothe et al. In Explosion Safety in Hazardous Areas, 1999. International Conference on (Conf. Publ. No. 469), pages 44–49, 1999
- T. H. Dubaniewicz et al. (2000, 2003)
- T. H. Dubaniewicz. Journal of Laser Applications, 18 (2006) 312–319



M. Beyer and D. Markus (2012)

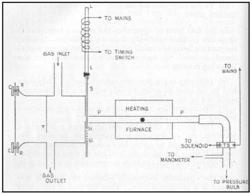


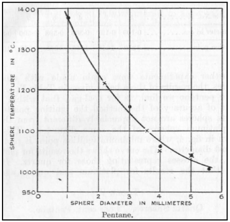
- M. Beyer and D. Markus. Sci. Tech. Energetic Materials, (2012)
- D. Roth et al. Combustion Science and Technology, 186 (2014) 1606–1617



Roth et al. (2014)

Moving Hot Particle Ignition





R. Silver (1937)

- R. S. Silver. The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, 23 (1937) 633-657
- S. Patterson. The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, 28 (1939) 1-22
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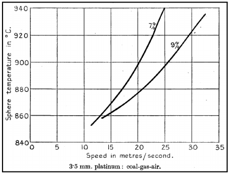

S. Patterson (1940)

Current study

Material	d (mm)	V_p (m/s)	T_{sphere} (K)
alumina	$6.0, 3.5, 1.8$	$2.3 - 2.4$	$750 - 1200$

Mixture	T_0 (K)	P_0 (kPa)	Φ
n-hexane–air	300	100	$0.7 - 2.2$

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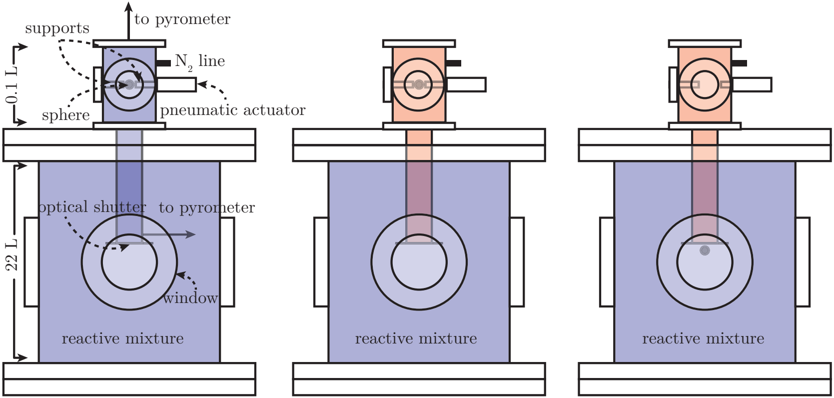
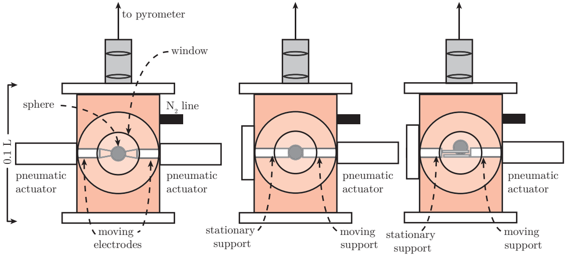
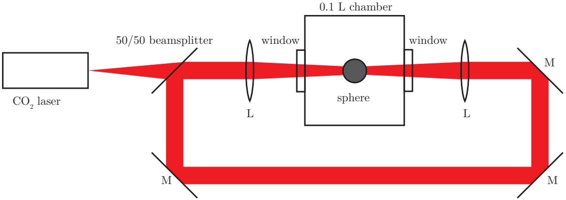
$d = 6.0$ mm

Experimental Setup: Combustion Vessel



Experimental Setup: Particle Heating Chamber





- CW CO_2 laser: $P_{max} = 80$ W
- Irradiation from two sides
- Feedback control during heating
- Temperature measurements at two locations

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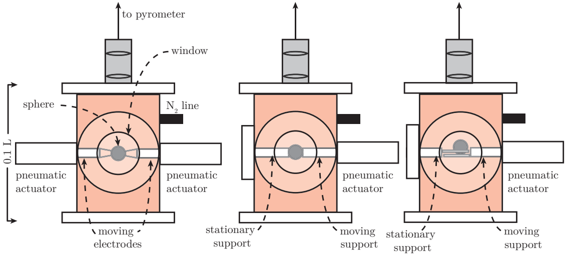

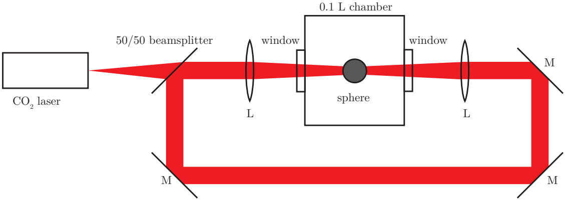

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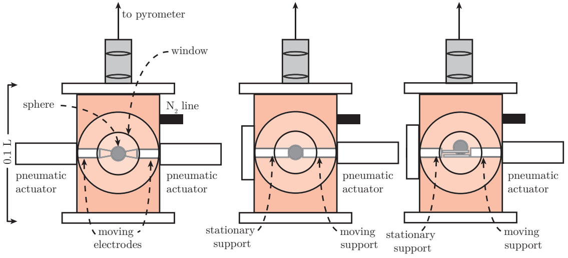

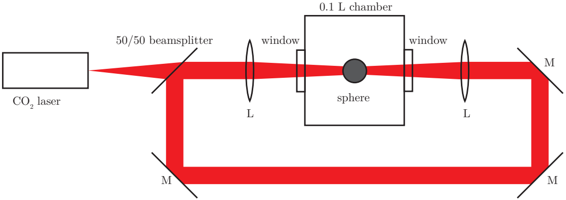

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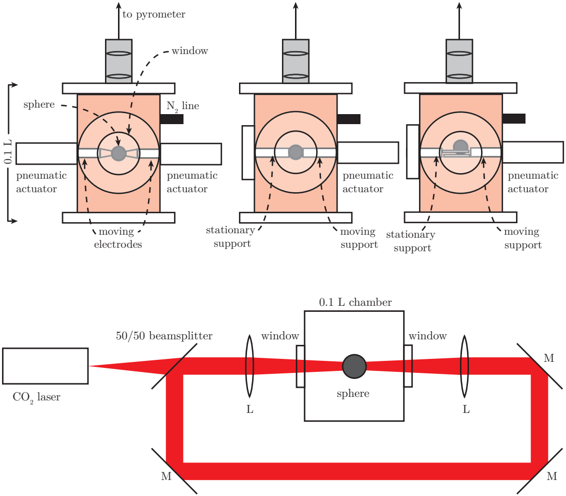

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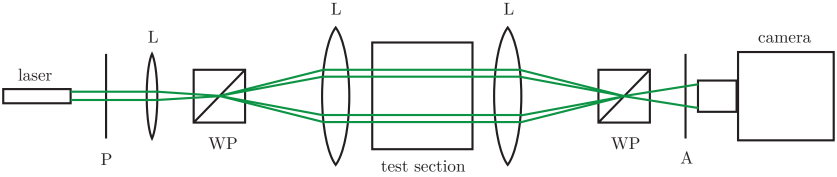
Optical Diagnostics: Shearing Interferometer



P: polarizer, L: lens, WP: Wollaston prism, A: Analyzer

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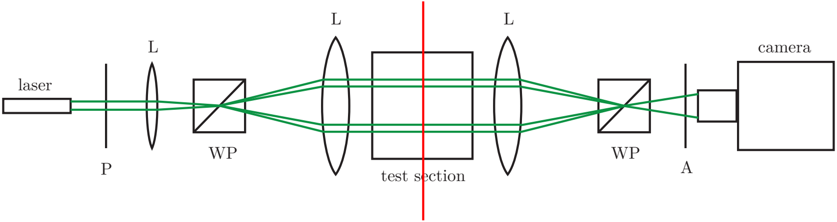

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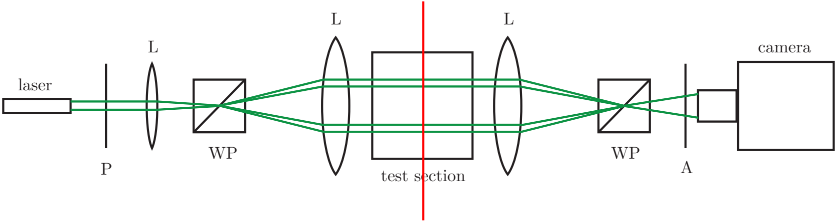

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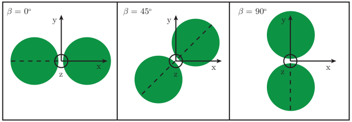

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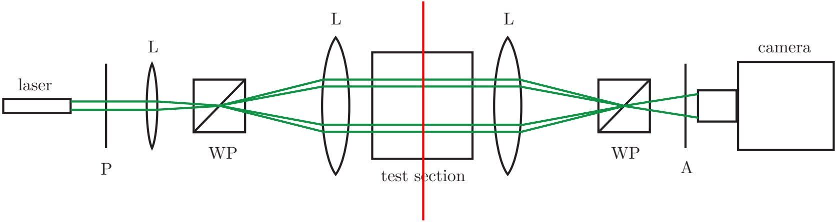

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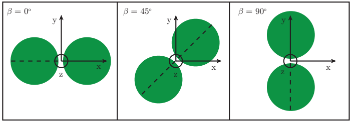
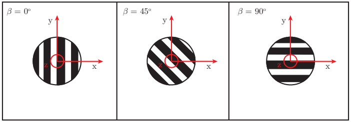
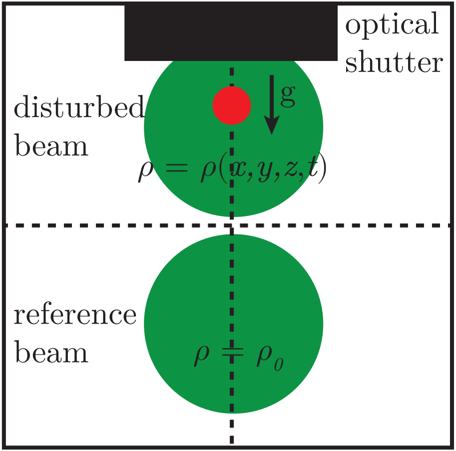




Finite fringe configurations

Optical Diagnostics: Shearing Interferometer



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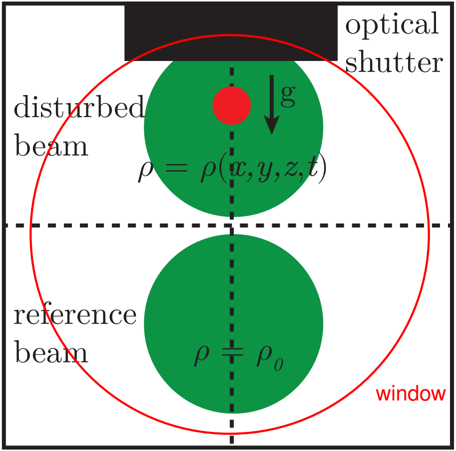

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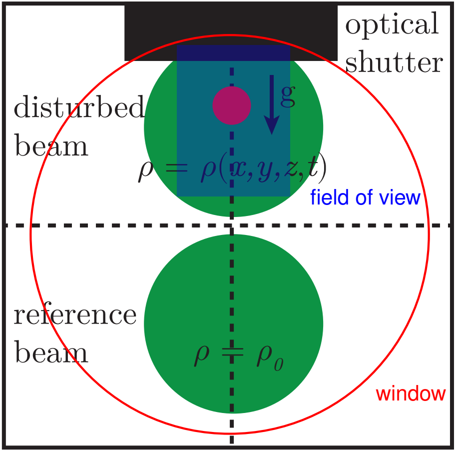
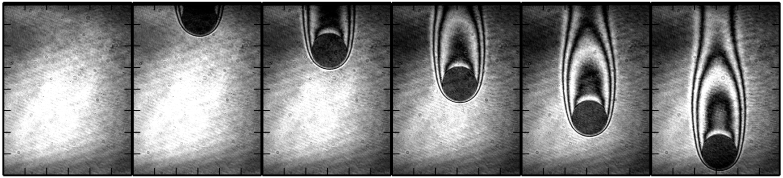
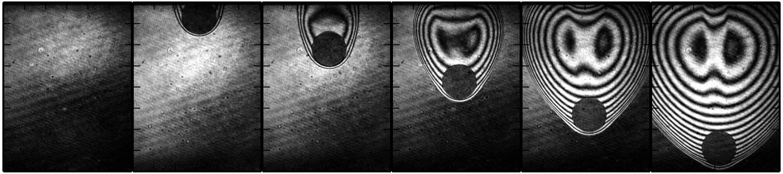


Interferograms of Hot Particle Wake: $\Phi = 0.9$

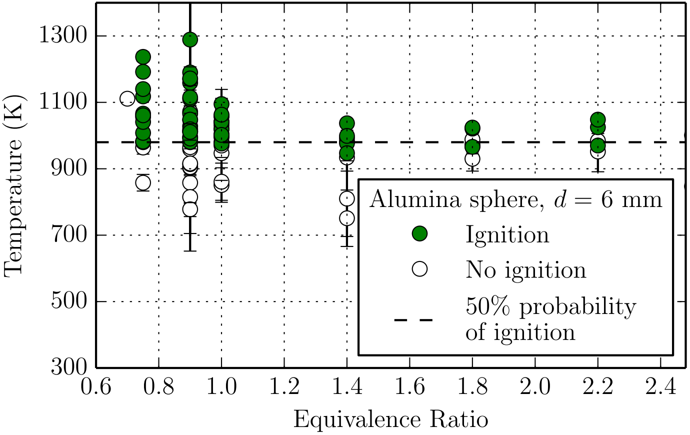
$T_{\text{sphere}} = 979 \pm 27$ K



$T_{\text{sphere}} = 981 \pm 20$ K

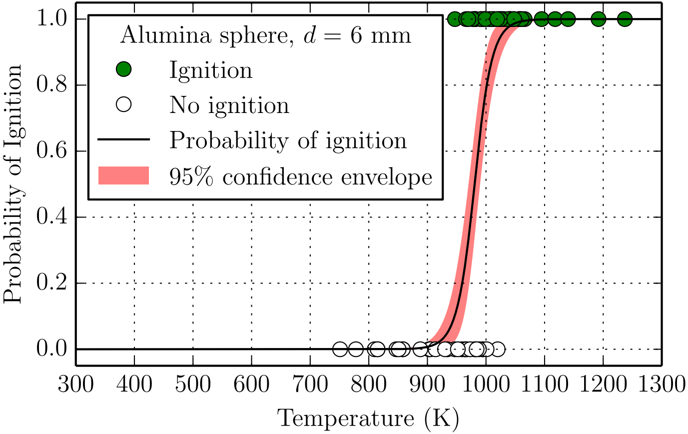


Ignition Threshold: $d = 6.0$ mm



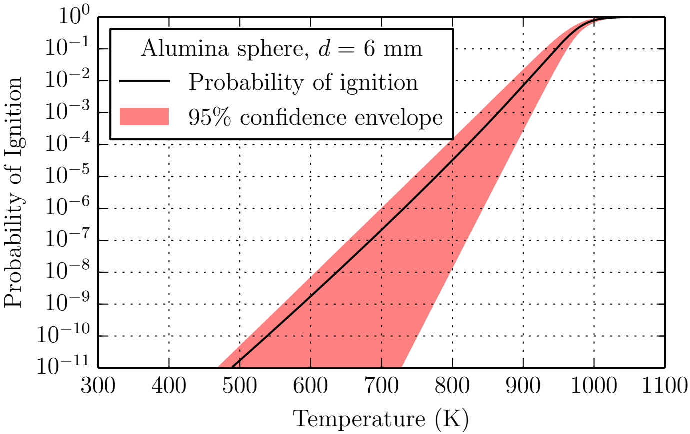
INSENSITIVE TO COMPOSITION

Probability of Ignition Distribution

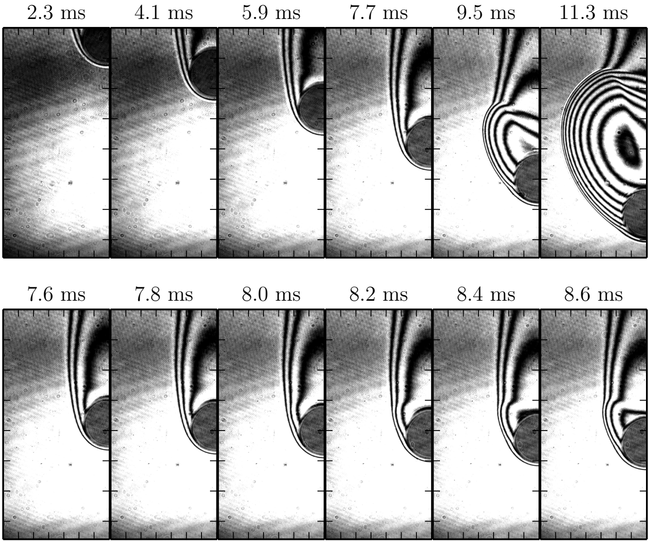


NARROW OVERLAP REGION

Probability of Ignition Distribution



Ignition Location: $\Phi = 0.9$

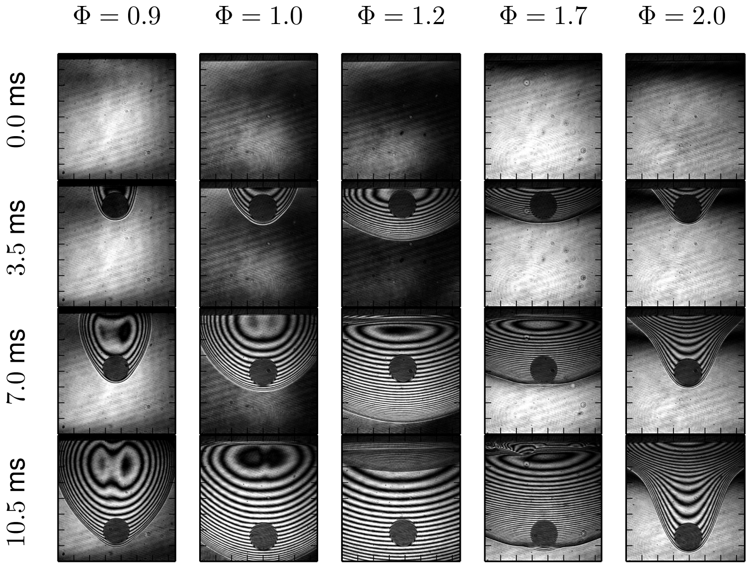


Ignition Location: Comments

IGNITION OCCURS NEAR SEPARATION REGION OF SPHERE

J. MELGUIZO-GAVILANES and J. E. SHEPHERD, HOT SURFACE IGNITION AND FLOW SEPARATION #267

Flame Propagation



Conclusions

Acknowledgements

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