URSI AP-RASC 2019, New Delhi, India; 09 - 15 March 2019

Picometer scale single-shot photo-mechanical dynamics of candle flame plasma

Pooja Munjal*, Vishavdeep Vashisht, and Kamal P. Singh
Department of Physical Sciences, IISER Mohali, Sector-81, Manauli 140306, India.

1 Extended Abstract

Candles have been an integral part of our lives since time immemorial. It was only in 1825 when Faraday revealed different temperatures and properties of regions inside the candle flame through easy yet inquisitive demonstrations [1]. Since then many invasive and non-invasive techniques have been performed to characterize the various regions of the flame. Use of thermocouple to directly measure the change in flame temperature is the most common invasive technique [2]. These single point measurements, disturbs the flow inside the flame, in addition, deposition of soot particles on the surface may also alter affect actual temperature values, and hence, a major source of error in the output.

Non-intruding optical techniques include interferometry [3, 4], holography [5], speckle techniques [6], Rayleigh scattering [7], color-ratio pyrometry using DSLR camera [8] for characterizing the flame. The experiments performed with these methods are not only tedious but also require a lot of care and analysis power to measure accurately. However, most measurements till now have been done at a single point in the flame with a precision of sub-μm.

In this paper we report a novel, simple and versatile laser-interferometer based technique to measure time-resolved picometer resolved dynamics of the flame. By scanning the flame in the interferometric cavity we obtained the full 2-D color profile of the flame. From the intensity-time graph we measured phase difference, refractive index and the temperature profile of the flame. We also observed a formation of plasma when the flame was brought in contact with ns-pulses. We isolated nano-scale dynamics of the flame medium by the single ns-pulse and formation of dark-band due to excitation of the soot particles inside the flame. Our technique may be useful to understand intriguing properties of the flame subjected to optical, magnetic and electrical excitations.

References

[1] Michael Faraday, "The chemical History of a Candle: a course of lectures delivered before a juvenile audience at the royal institution", 1886.

[2] A. Van Maaren, D. S. Thung, L. R. H. DE GOEY, "Measurement of flame temperature and adiabatic burning velocity of methane/air mixtures", *Combustion Science and Technology*, **96**, 4-6, 327-344, 1994.

[3] Chandra Shakher, and Anil Kumar Nirala, "A review on refractive index and temperature profile measurements using laser-based interferometric techniques", *Optics and lasers in Engineering*, **31**, 455-491, 1999.

[4] Depang Yan, and Soyoung S. Cha, "Single-path interferometer for measuring fluid flows in real time with low-quality optics", *Optics and lasers in engineering*, **29**, 33-40, 1998.

[5] David L. Reuss, "Temperature measurements in a radially symmetric flame using holographic interferometry", *Combustion and Flame*, **49**, (1-3), 207-219, 1983.

[6] N. Barakat, H. El-Ghandoor, A. M. Hamed, and S. Diab, "Refractive index profiling across a candle flame using speckle techniques", *Experiments in fluids*, **16**(1), 42-45, 1993.

[7] V. Bergmann, W. Meier, D. Wolff, and W. Stricker, "Application of spontaneous Raman and Rayleigh scattering and 2D LIF for the characterization of a turbulent CH4/H2/N2 jet diffusion flame", *Applied Physics B*, **66**(4), 489-502, 1998.

[8] Jean-Michel Desse, Pascal Picart, and Patrice Tankam, "Digital three-color holographic interferometry for flow analysis", *Optics express*, **16**, 5471-5480, 2008.