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TWO-LINE ATOMIC FLUORESCENCE OF Ga

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Introduction

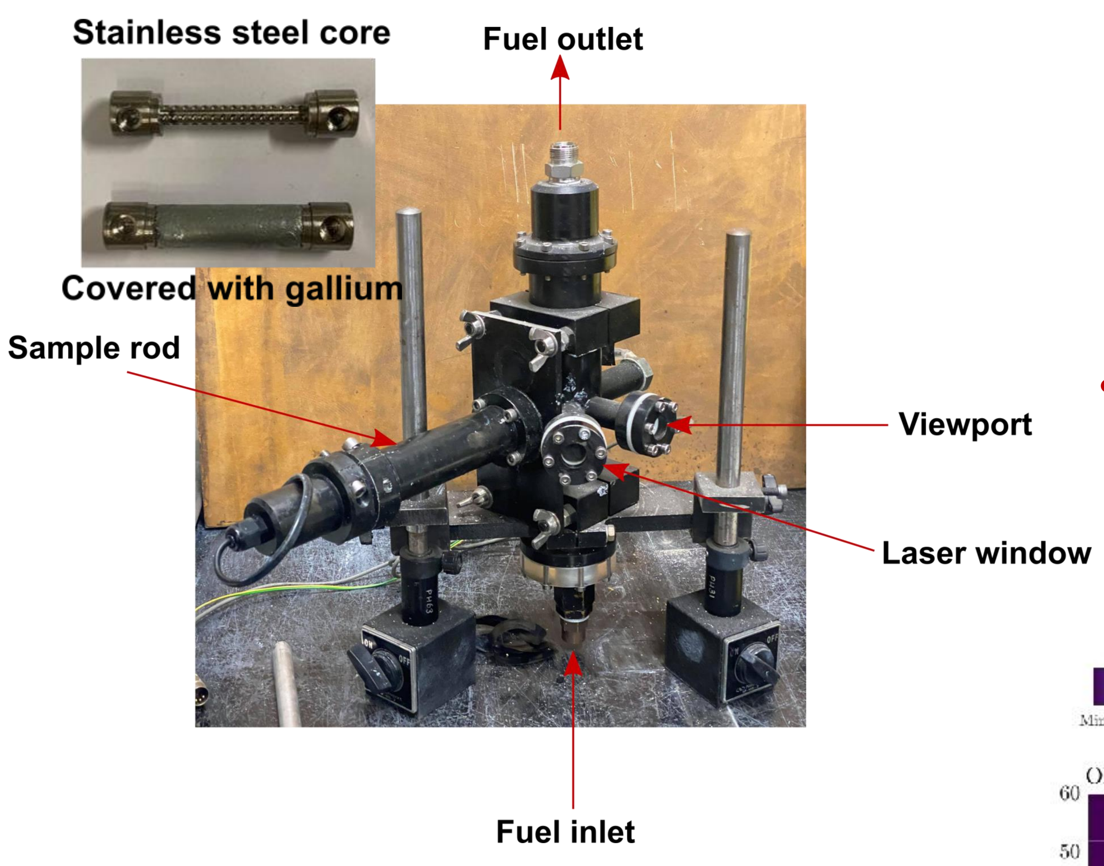
Two-line atomic fluorescence (TLAF) is a robust laser diagnostic technique that allows planar temperature measurements with high accuracy (~2.7%) and precision (~1%) [1]. Unlike Rayleigh scattering thermometry, which is only employable in particle-free reacting environments, previous studies [2] have demonstrated the feasibility of applying TLAF in sooting and particulate-laden flames. While Coherent Anti-Stokes Raman Spectroscopy (CARS) has proven its high accuracy and versatility in various combustion systems, the complex experimental setup associated with CARS has limited its application to point-wise measurements. Hence, TLAF remains one of the most promising thermometry techniques that are applicable in practical combustion systems. One of the drawbacks of TLAF is that an atomic species, not exist in flames naturally, has to be seeded into the system. In the past, most, if not all, TLAF measurements used atomic indium as the thermometric species. Recently, Borggren et al. [1] have demonstrated that gallium can be another excellent candidate as it has the potential to provide measurements at lower temperatures than indium, without sacrificing its high accuracy or precision.

Objectives

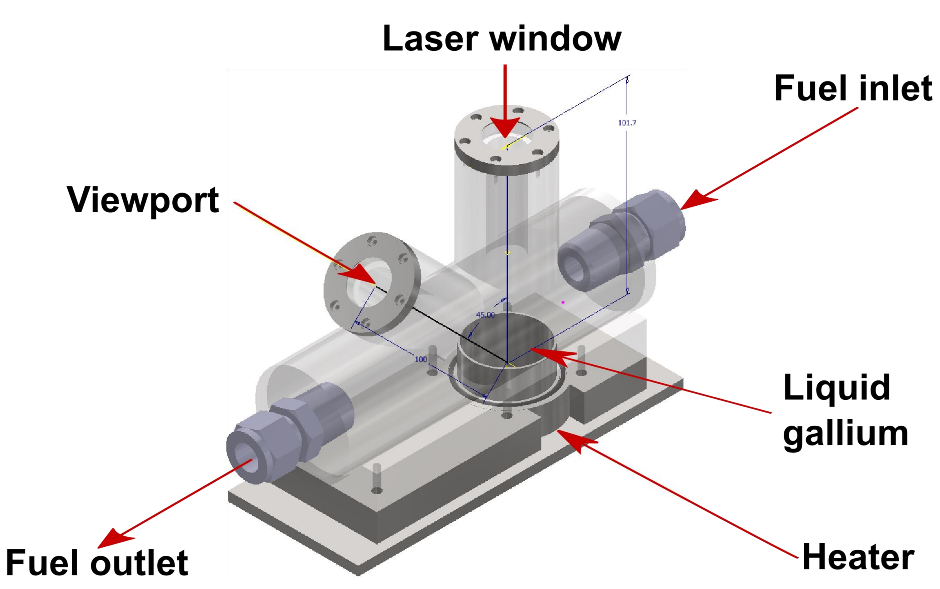
- Develop an effective method to introduce gallium into reacting systems
- Assess the accuracy and precision of TLAF of gallium in turbulent sooting flames
- Investigate and establish the conditions and temperature limits that are measurable using TLAF of gallium

Experimental setup

- Solid gallium ablator



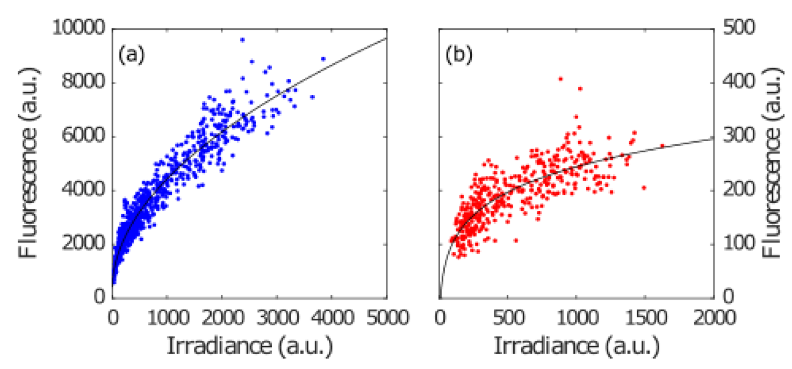
- Liquid gallium ablator



Methodology

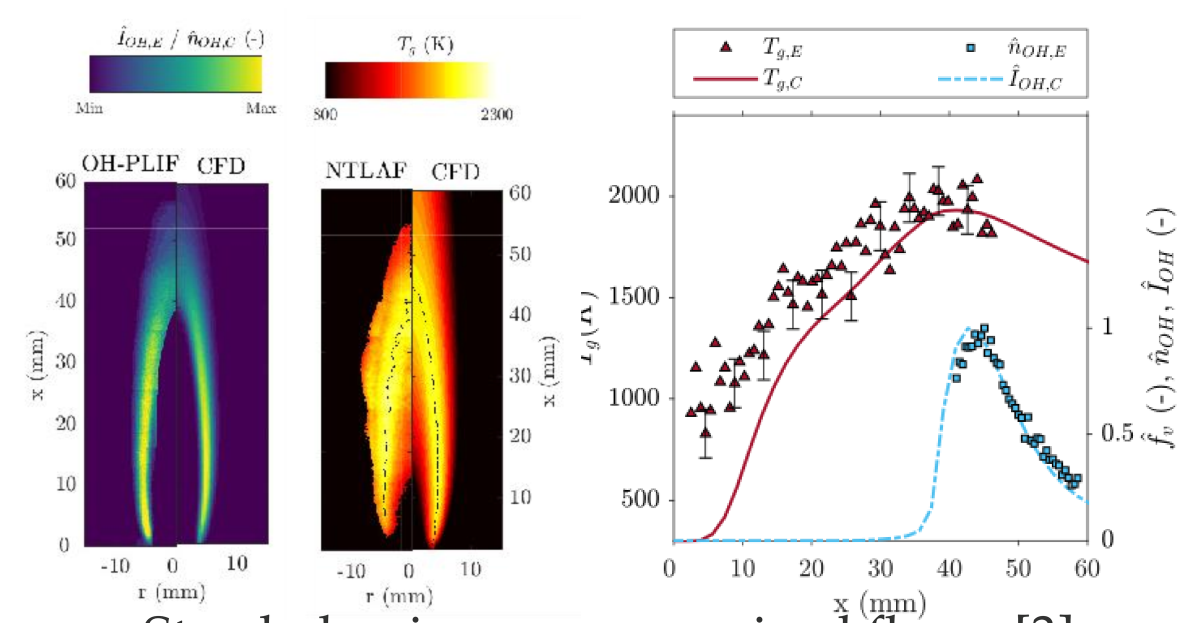
	Stokes	Anti-Stokes
Excitation	403 nm	417 nm
Detection	417 nm	403 nm

- Monitor the laser profile (temporal and spatial)
- Obtain the non-linear relationship between the fluorescence signal and the laser energy

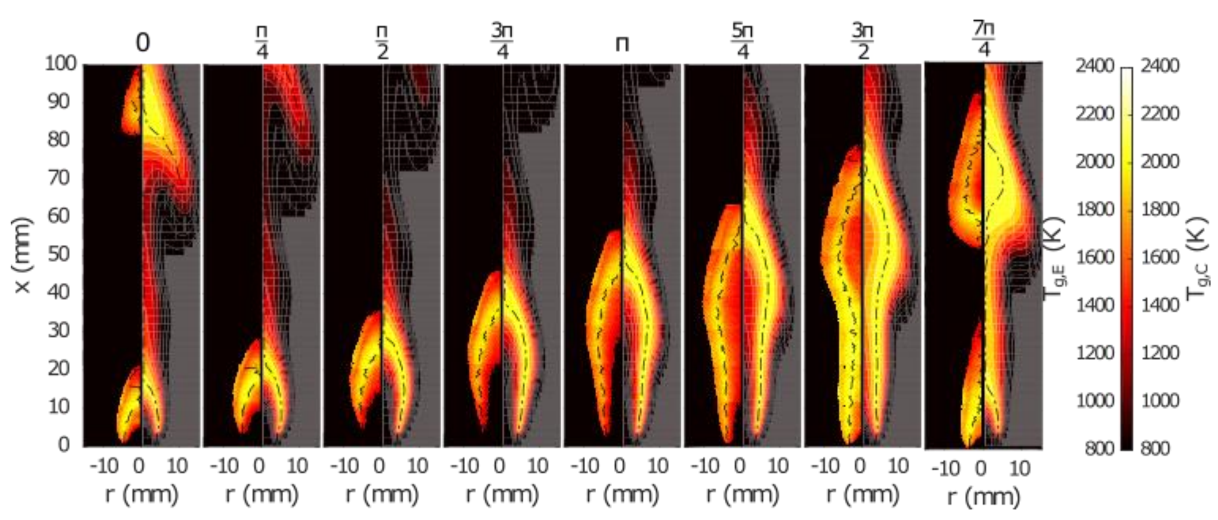


- Sub-pixel precision image matching
- $\Delta E_{10}/_{kT} = \ln\left(F_{21}\times\left(1+\frac{C_s}{I_{20}}\right)\right) - \ln\left(F_{20}\times\left(1+\frac{C_s}{I_{21}}\right)\right) + \ln(C_t)$

Previous results obtained using TLAF of Indium



- Steady laminar non-premixed flame [3]



- Time-dependent laminar non-premixed flame [3]

Summary

- It is the first time Ga ablation is utilized in TLAF measurement
- TLAF of Ga can measure temperatures lower than that of In (>800 K)
- Injection seeded laser will be used in TLAF of Ga to increase the signal to noise ratio
- Ga can be seeded into flames in solid or liquid phase
- Ga ablation in liquid phase may provide a steady surface condition at every ablation
- TLAF of Ga will be the main thermometry technique for most of the combustion studies in our group in the future

Reference

[1] J. Borggren et al., Diode laser-based thermometry using two-line atomic fluorescence of indium and gallium, Appl. Phys. B **123** (2017).

[2] P. Medwell et al., Temperature measurements in turbulent non-premixed flames by two-line atomic fluorescence, *Proc combust Inst* **34** (2013) pp. 3619—3627.

[3] K.K. Foo et al., Calculated concentration distributions and time histories of key species in an acoustically forced laminar flame, *Combust Flame* **204** (2019) pp. 189—203.

Zoom QR

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