LaVision
FOCUS ON IMAGING

In Application

Thermographic Phosphor Particles for simultaneous Velocimetry and Thermometry

Department of Mechanical Engineering, Imperial College London, UK

Introduction

Particle Image Velocimetry (PIV) is widely employed in the field of optical flow and combustion diagnostics. For PIV, micrometre-size particles or droplets are seeded into a fluid flow and their movement is tracked in time to determine the velocity field. However, the presence of these particles makes the simultaneous measurement of scalar quantities, such as the gas phase temperature, difficult.

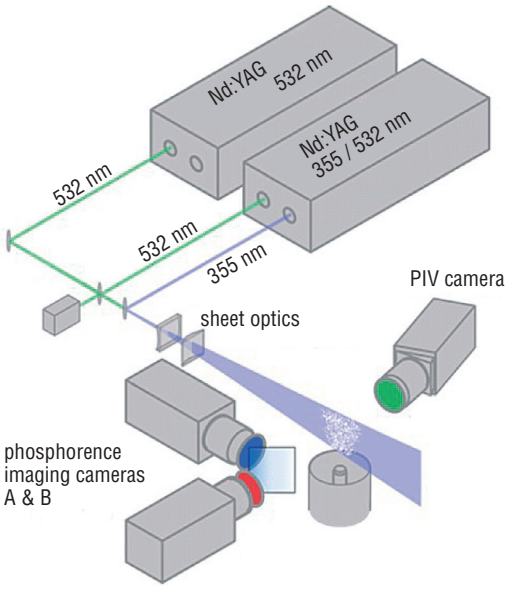


Figure 2: *Experimental setup for phosphor thermometry and velocimetry*

Experimental Setup

For thermometry, two non-intensified CCD cameras simultaneously capture spectrally filtered images A and B of the particle phosphorescence. The two images are divided and converted to a temperature image using calibration data. The velocity field is determined using a conventional PIV approach.

Images by courtesy of
B. Fond, C. Abram, A.L. Heyes, A.M. Kempf and F. Beyrau, Optics Express 20 (2012), 22118-22133
C. Abram, B. Fond, A.L. Heyes and F. Beyrau, Applied Physics B (2013), 111:155–160

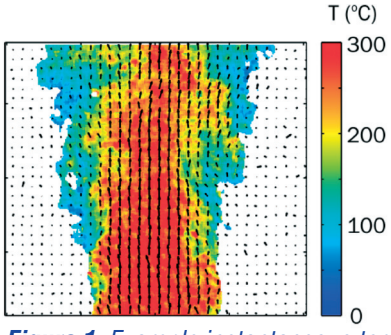
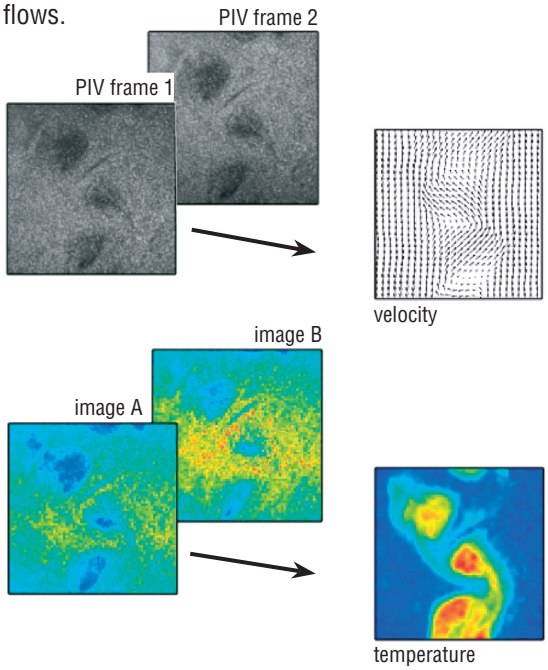


Figure 1: *Example instantaneous temperature and velocity field from a heated jet*

Principle

An extension of the classical PIV approach to simultaneous temperature measurements can be achieved by using tracer particles from thermographic phosphor materials. After illumination with ultraviolet light, these particles emit phosphorescence with a temperature dependent emission spectrum which can be used for thermometry. Using heat transfer modeling, it can be shown that sufficiently small particles track the gas temperature very well, even in turbulent flows.



LaVisionUK Ltd
2 Minton Place / Victoria Road
Bicester, Oxon / OX26 6QB / United Kingdom
E-Mail: sales@lavision.com / www.lavisionuk.com
Phone: +44-(0)-870-997-6532 / Fax: +44-(0)-870-762-6252

LaVision GmbH
Anna-Vandenhoeck-Ring 19
D-37081 Göttingen / Germany
E-Mail: info@lavision.com / www.lavision.com
Tel. +49-(0)551-9004-0 / Fax +49-(0)551-9004-100

LaVision Inc.
211 W. Michigan Ave. / Suite 100
Ypsilanti, MI 48197 / USA
E-mail: sales@lavisioninc.com / www.lavisioninc.com
Phone: (734) 485 - 0913 / Fax: (240) 465 - 4306

LAVISION
FOCUS ON IMAGING

Thermographic Phosphor Particles for simultaneous Velocimetry and Thermometry

Department of Mechanical Engineering, Imperial College London, UK

Advantages

- simultaneous single-shot planar velocimetry and thermometry using a single tracer
- experimental simplicity – apart from a standard PIV setup, only a frequency tripling crystal, two non-intensified CCD cameras and two spectral filters are needed
- straightforward data evaluation – temperature is evaluated using standard image processing and calibration data

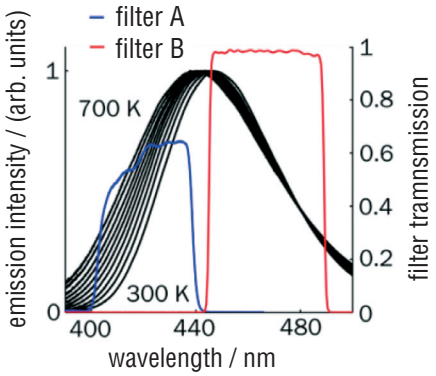


***Figure 3**: Phosphorescence spectra of the BAM:Eu²⁺ particles for different temperatures between 300 K and 700 K.*

Tracer Properties

- tracer particles are chemically inert, resistant to high temperatures and insensitive to gas composition and pressure
- phosphorescence emission is short enough (< 1µs) to ensure efficient signal collection, even in turbulent flows

kHz Repetition Rate Measurements

Excitation and imaging at high repetition rates permit visualization of unsteady phenomena related to combustion and heat transfer. The combined phosphor thermometry / velocimetry technique can also be applied at kHz rates using high-speed CMOS cameras and diode-pumped solid state lasers at 355 and 532 nm.

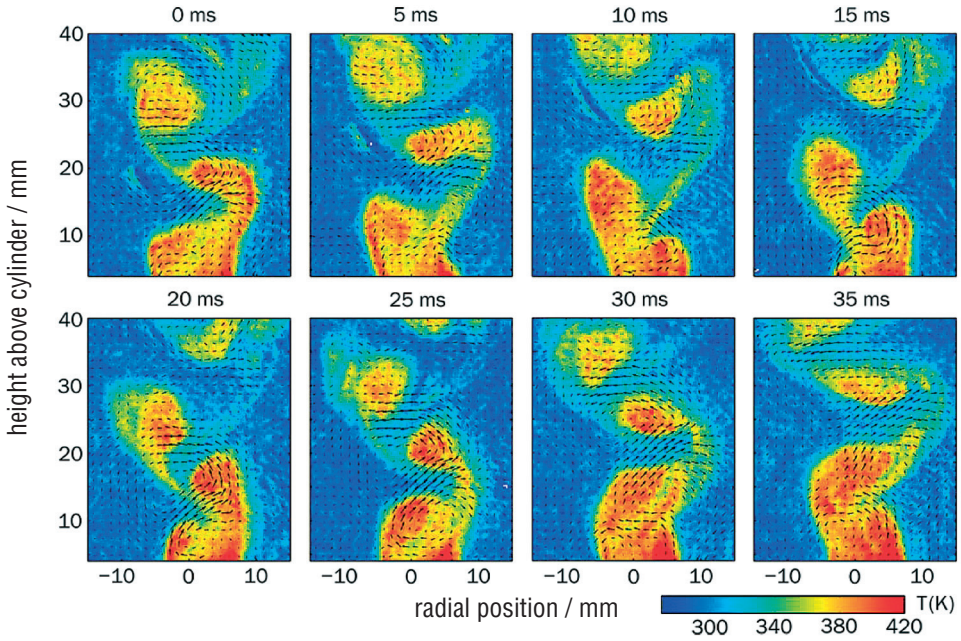


***Figure 4**: Time-series of temperature and velocity measurements in the wake of a heated cylinder. The recording was made using a high-speed system at a repetition rate of 3 kHz. Only every fifteenth image is displayed for clarity, and the mean velocity has been subtracted from the instantaneous fields to better visualize the movement of the wakes.*

05/13

LaVisionUK Ltd
2 Minton Place / Victoria Road
Bicester, Oxon / OX26 6QB / United Kingdom
E-Mail: sales@lavision.com / www.lavisionuk.com
Phone: +44-(0)-870-997-6532 / Fax: +44-(0)-870-762-6252

LaVision GmbH
Anna-Vandenhoeck-Ring 19
D-37081 Göttingen / Germany
E-Mail: info@lavision.com / www.lavision.com
Tel. +49-(0)551-9004-0 / Fax +49-(0)551-9004-100

LaVision Inc.
211 W. Michigan Ave. / Suite 100
Ypsilanti, MI 48197 / USA
E-mail: sales@lavisioninc.com / www.lavisioninc.com
Phone: (734) 485 - 0913 / Fax: (240) 465 - 4306