Fundamentals and Practices of Advanced Aerodynamic Measurement Technology

Operation Manual for Lab #4

2022.11

Static Temperature Calibration of TSP

1. Experiment Setup

CCD camera, calibration box, UV-LED light, temperature controller, host computer, TSP sample. The whole system are connected as shown in Figure 1

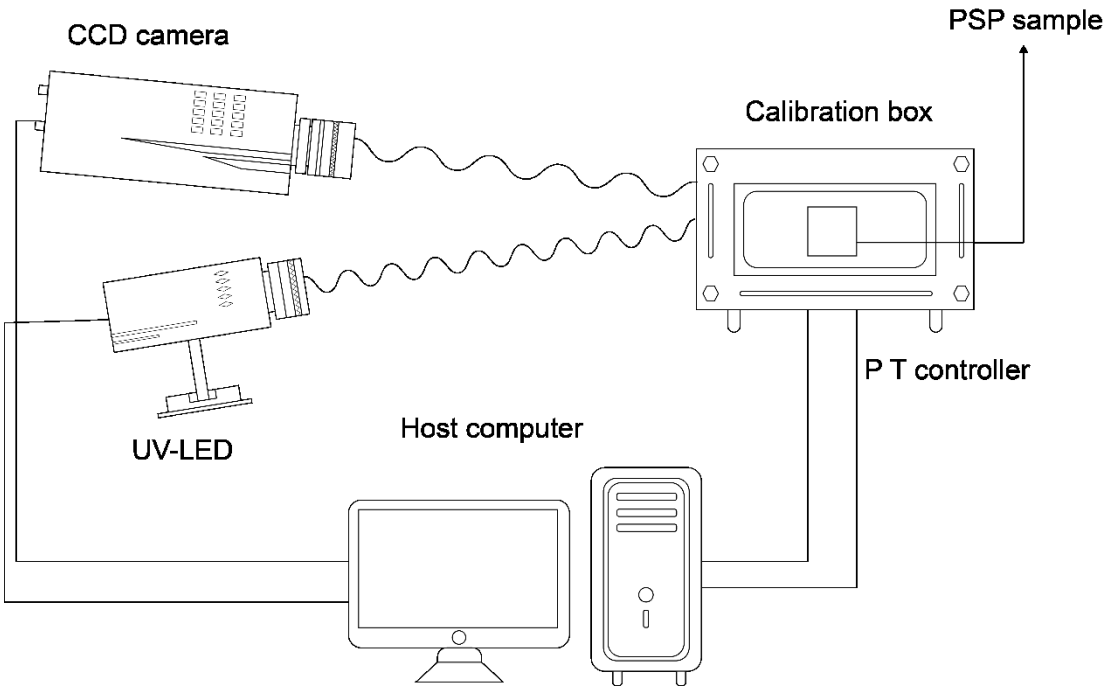


Figure 1 Experiment Setup of Static Temperature Calibration

(1) CCD Camera

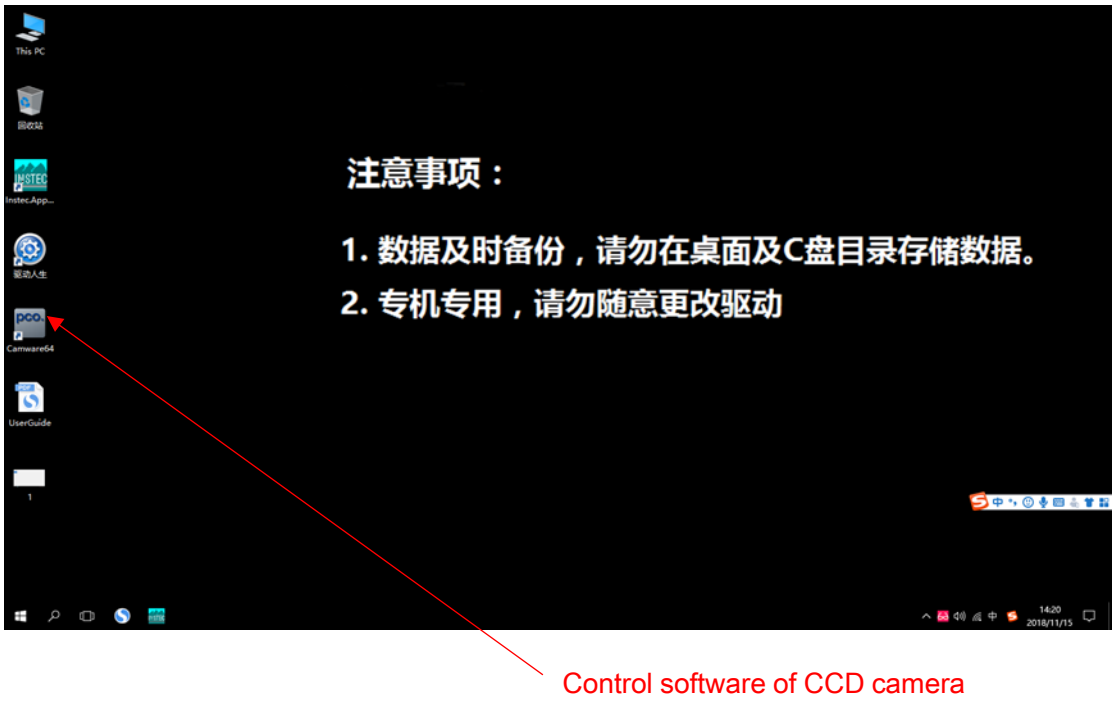
The CCD camera consists of two parts, power supply and the camera. (Attention: make sure the CCD camera is in a dark environment before turn on. There is a shade cloth in lab.)

Figure 2 Camera power supply

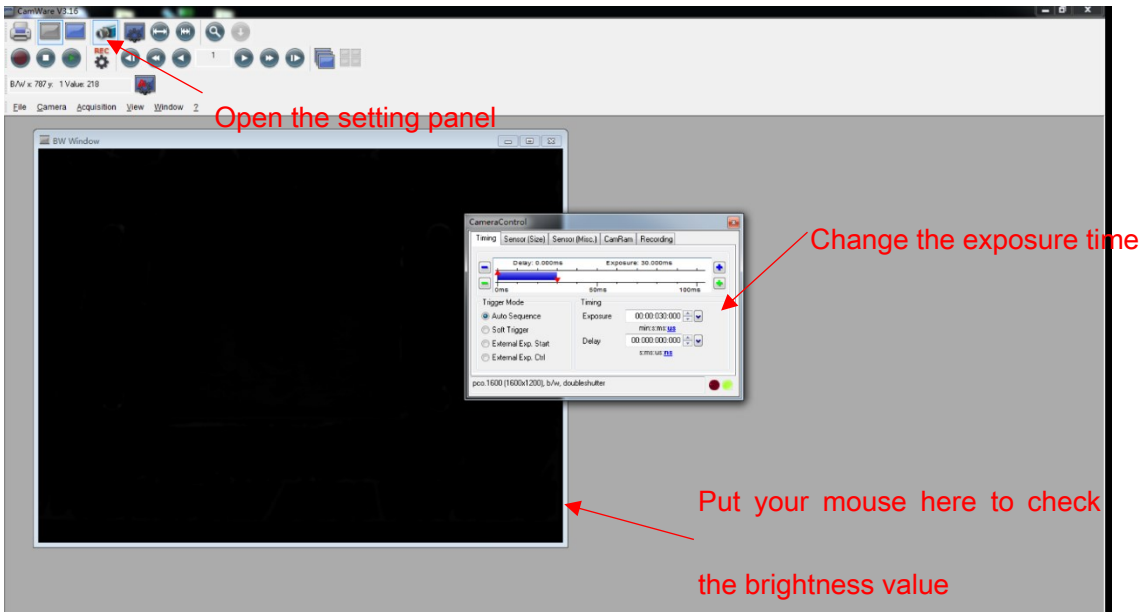
Figure 3 Camera with lens

Figure 3 camera

You can find the control software in the host computer's desktop.



When you use the CCD camera, you should adjust the exposure time and the aperture so that the brightest point in the BW Window has a proper value around 8000 counts, which is about half of the maximum.



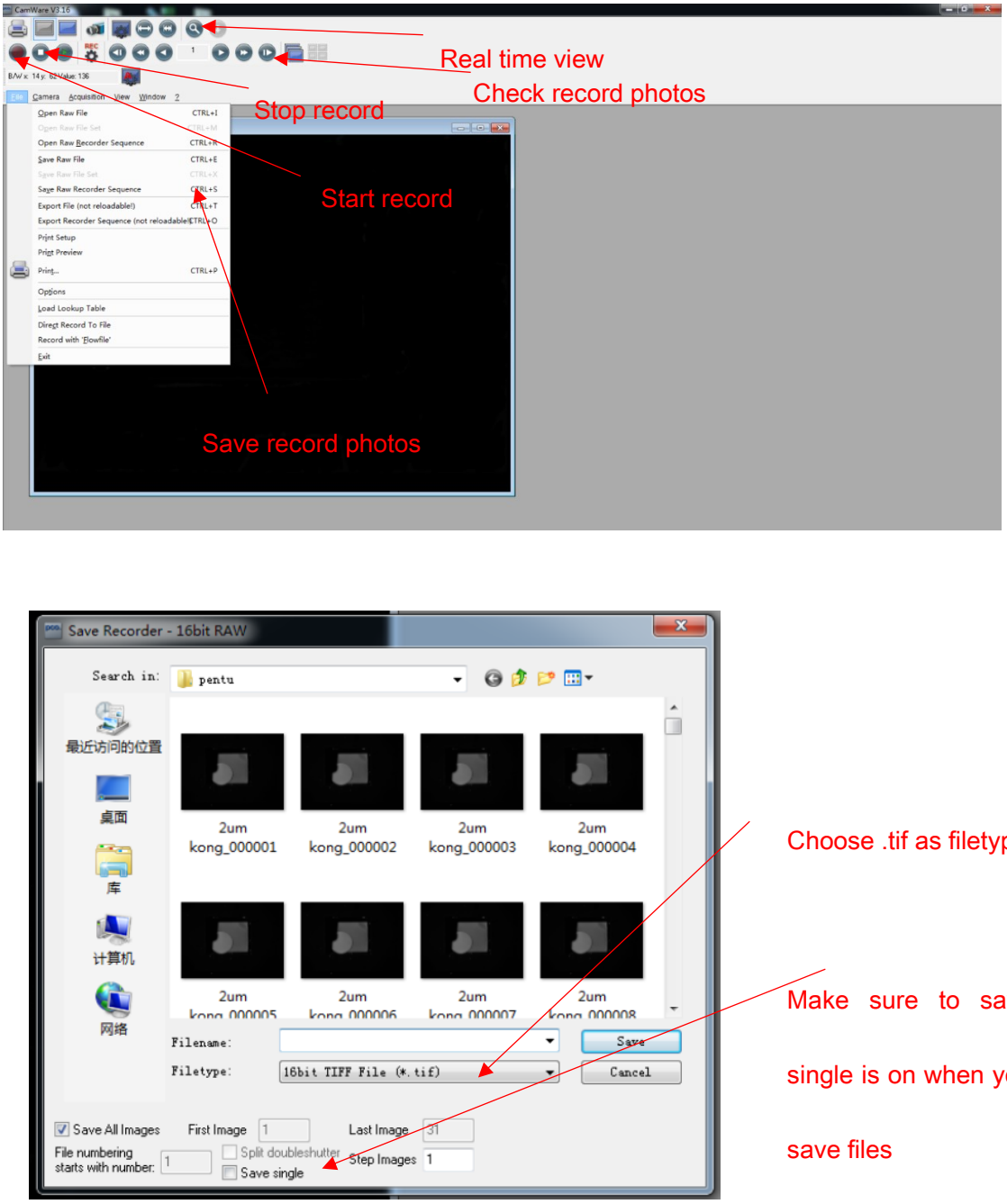


Figure 4 UV-LED Light

(2) The UV-LED Light

This LED can produce excitation light with wavelength around 405 nm.

(3) Temperature Control System

The temperature control system consists of two parts: temperature control box and liquid nitrogen cooling system.

Figure 5 Temperature control system

The control box is connected to the host computer. The temperature can be controlled by software. This software is also in the taskbar.

(4) Calibration Box

The calibration box is an airtight box connected with the pressure and temperature control system, tightened by 12 screws.

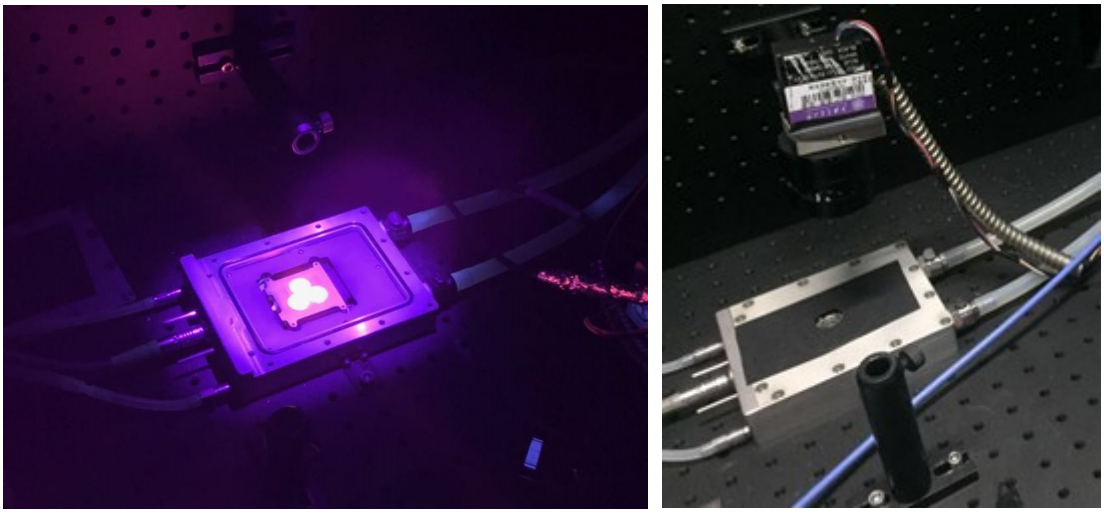


Figure 7 Calibration box

(5) The TSP Sample

The TSP Sample use $Ru(dpp)_2$ as the temperature-sensitive dye. Its excitation wavelength is between 400-500 nm. Its emission wavelength is around 600nm. We use a 600/50nm filter to remove the excitation light.

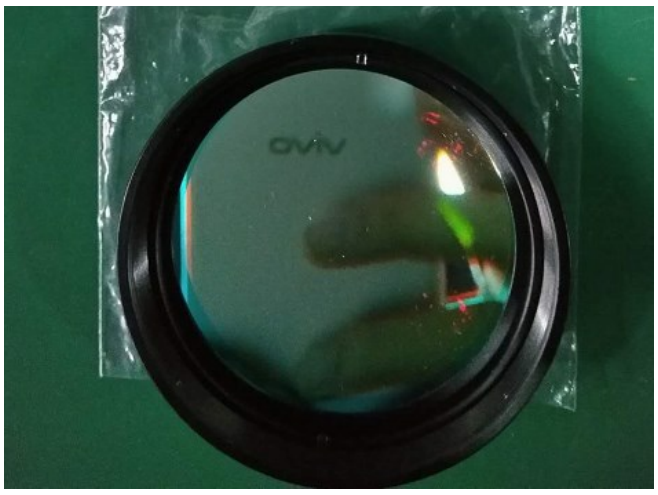


Figure 8 Bandpass filter

2. Experimental Principle

This experiment is designed to get the relationship between the luminescence

signal intensity and temperature of TSP sample. As we know, the intensity of luminescence signal decrease as temperature rises due to thermal quenching effect (more energy transfer through collision). The relationship between intensity and temperature is typically nonlinear, as shown below. The calibration curve can be fitted with the following equation:

$$\frac{I_{ref}}{I} = A * \left(\frac{T}{T_{ref}} \right)^{B} + C$$

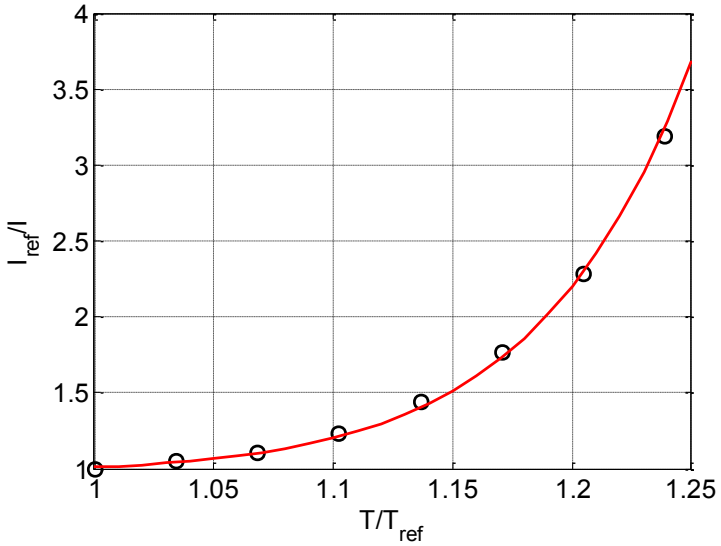


Figure 9 Calibration Curve

3. Experimental Procedure

(1) Get the TSP sample, fix it in the calibration box using thermal grease, and then close the box.
(2) Turn on two power supplies of temperature control system. Adjust the temperature to 15℃. Wait until it is steady.
(3) Turn on the LED light and CCD camera. Check the intensity in the software, then adjust the exposure time and aperture to get a proper intensity.
(4) Record dark images to remove the influence of environment light.
(5) Record images in different temperature (15℃ 20℃ 25℃ 30℃ 35℃ 40℃ 45℃). Each recording need at least 20 photos. Turn off the light when each recording ends.
(6) Turn off all equipment after the calibration is finished.

4. Data Processing

Choose an area of the TSP sample with fairly uniform intensity as the calibration area. Take the average of the intensity value in this area as the intensity of TSP in a specific temperature. Then subtract the mean intensity of the dark image in the same area to eliminate the influence of environment light. Finally generate the calibration curve with the intensity data and the corresponding temperature values.

The above data processing can be conducted using software such as matlab or JAVA. Please include a copy of your code in the report.

5. Key issues to be addressed in the report

1. Based on the calibration curve, determine the temperature sensitivity (in %/K) of the TSP sample at 20 ºC and 40 ºC, respectively.
2. Include error bars for each data point on the calibration plot based on the 20 images obtained at each temperature. Estimate the uncertainty of the calibration and give the results in the form of temperature sensitivity K +/- ΔK at 20 ºC and 40 ºC, respectively.