Mesure de température par fluorescence induite par laser

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Emitted light intensity function of the temperature:

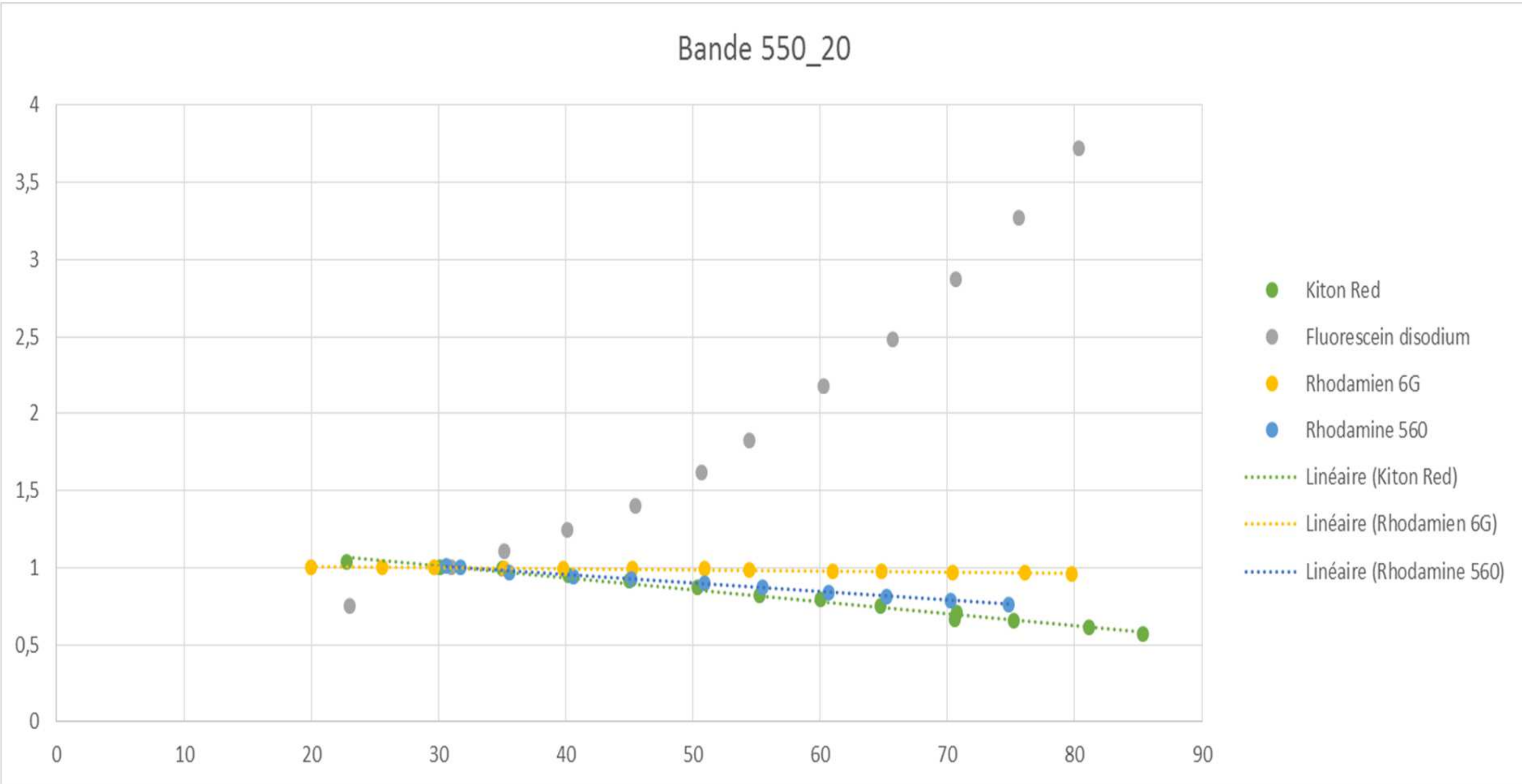
$$I_f(\lambda) = \underbrace{K_{opt}(\lambda) K_{spec}(\lambda) V_C I_0 C}_{\sim \text{constant}} e^{\frac{\beta(\lambda)}{T}}$$

λ: wavelenth, K_{opt} : optical constant
K_{spec}: constant, spectroscopic properties of the tracer
V_c : collection volume of the fluorescence photons,
I_0 laser excitation intensity
C: concentration of the tracer
β: temperature sensitivity parameter, *T*: temperature in °K

In place measurement of the temperature sensitivity parameter

$$I_{f_1}(\lambda) = cst \, . \, e^{\frac{\beta_1(\lambda)}{T}}$$

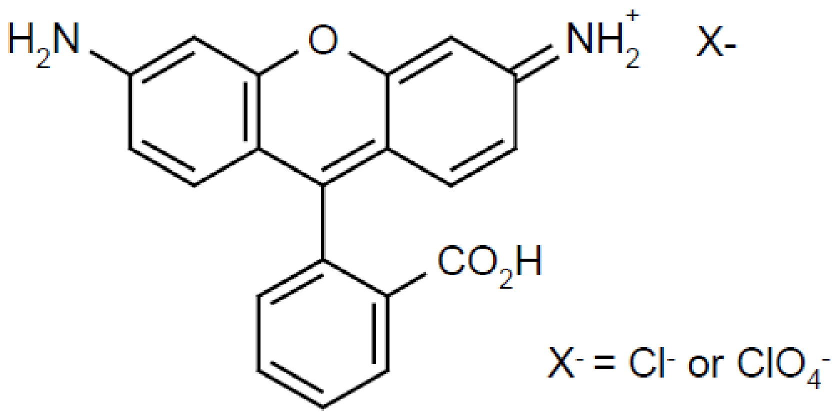
$$\frac{I_{f_1}(T)}{I_{f_1}(T_0)}$$



T [°C]

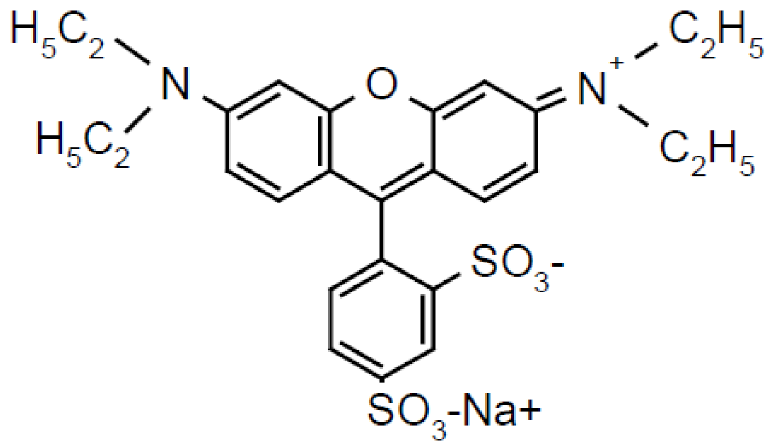
Rhodamine 560

Mw 366.8 g/mol



Keton Red 560

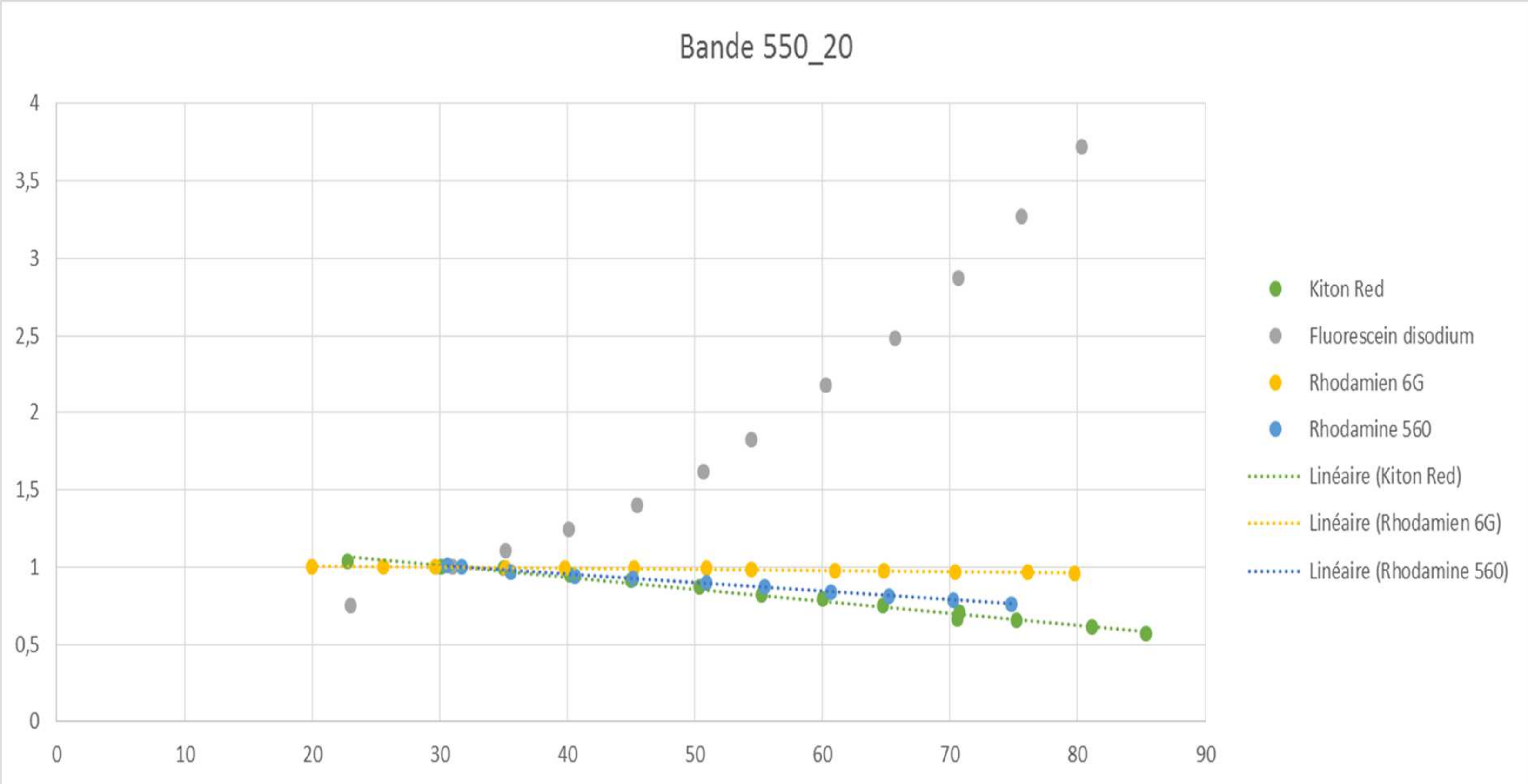
M_w 580.6 g/mol



In place measurement of the temperature sensitivity parameter

$$I_{f_1}(\lambda) = cst \,.\, e^{\frac{\beta_1(\lambda)}{T}}$$

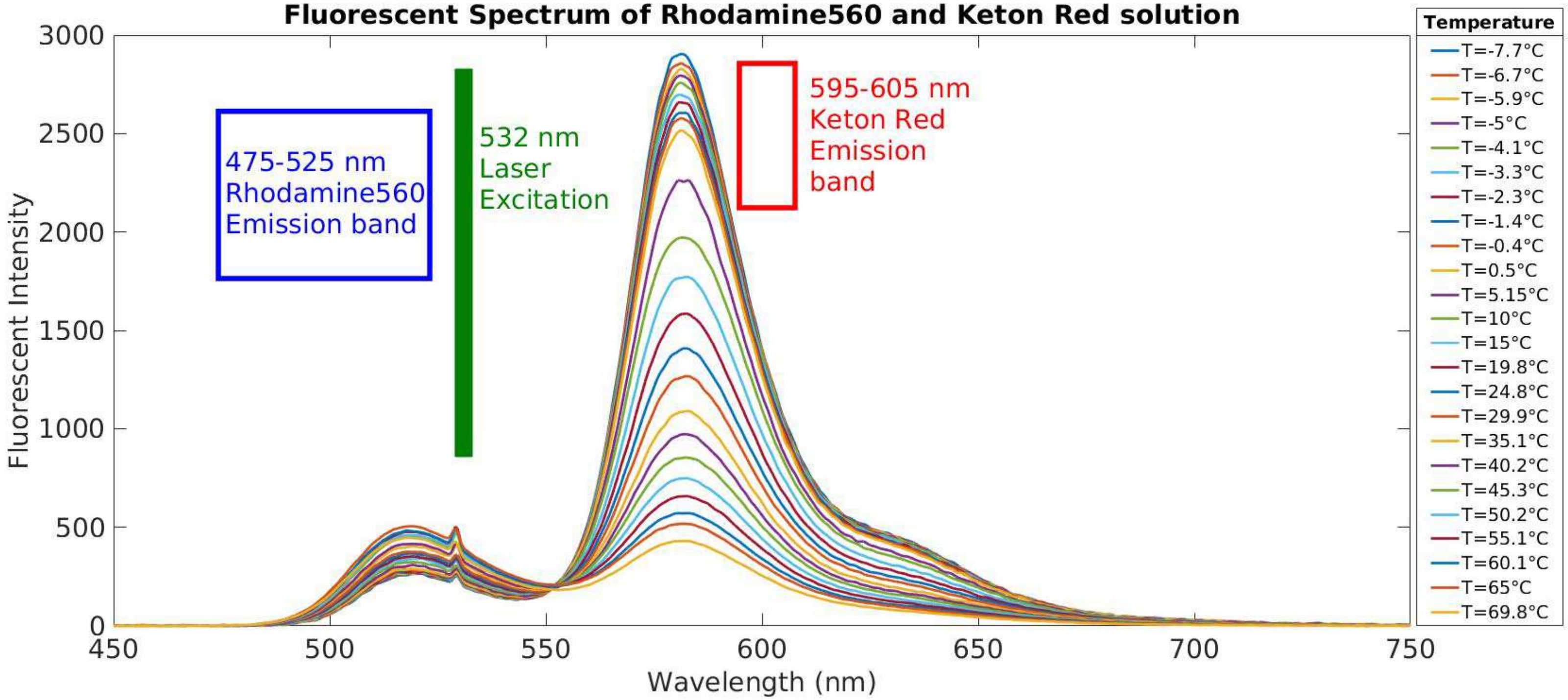
$$\frac{I_{f_1}(T)}{I_{f_1}(T_0)}$$



T [°C]

Fluorescence spectra I(T)

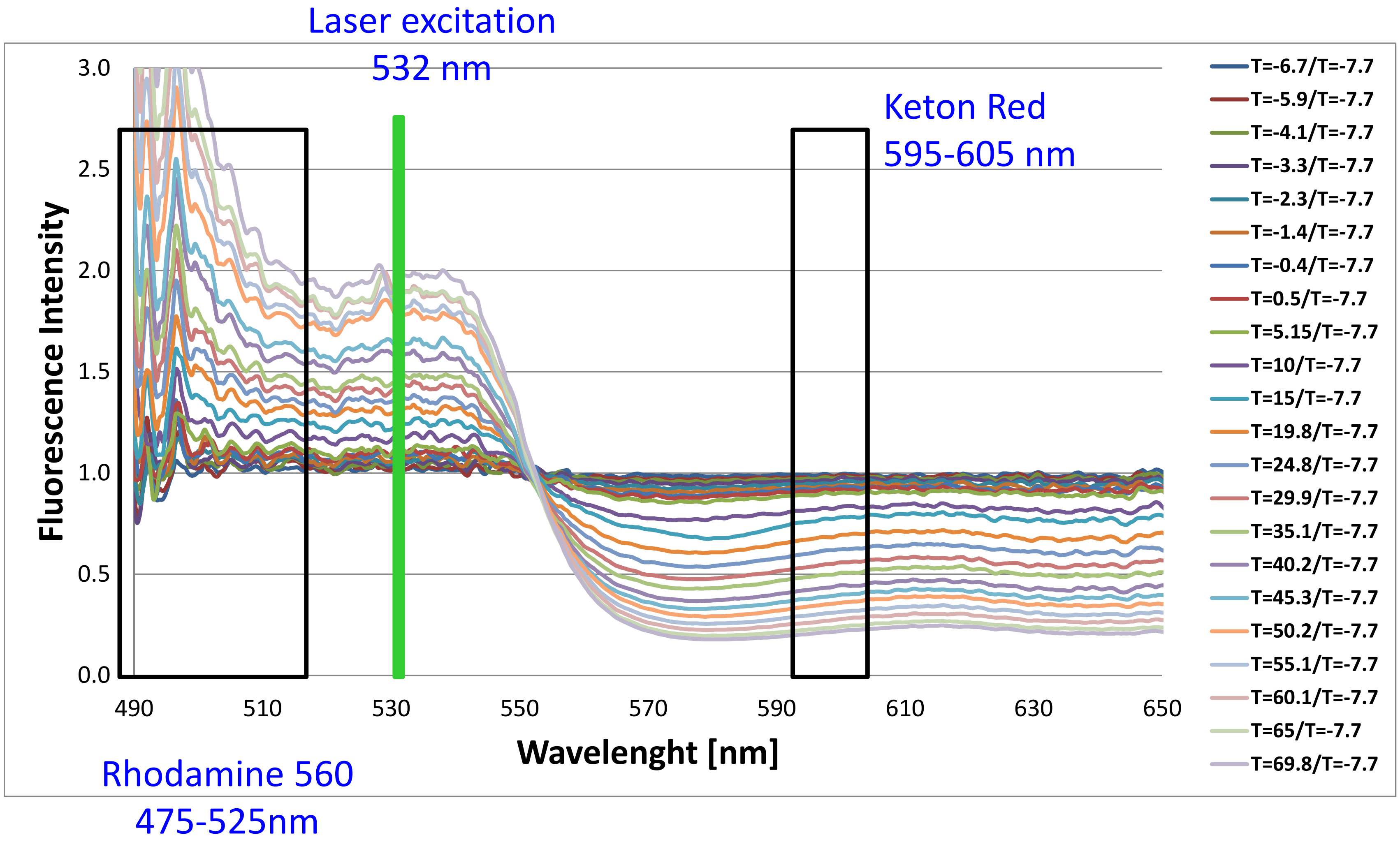
Keton Red 2.5x10^{-6} mol/l, Rhodamine 560: 10^{-5} mol/l



Fluorescent Spectrum of Rhodamine560 and Kiton Red

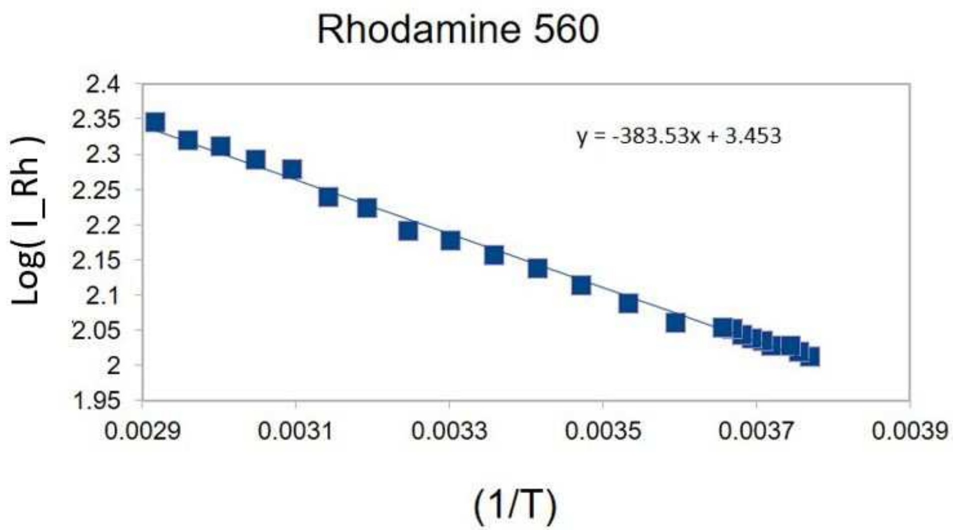
Relative intensity $I(T)/I(T_0)$

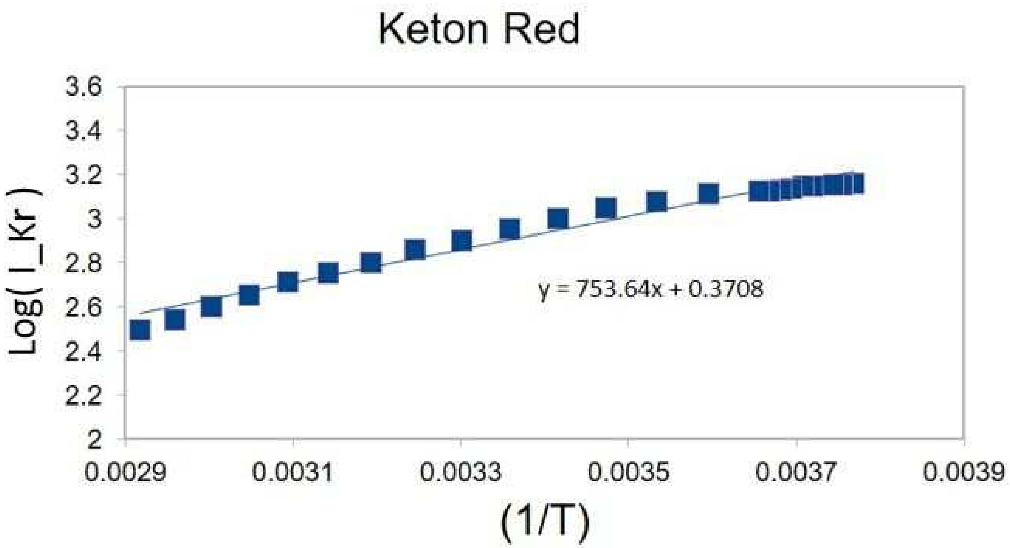
Keton Red 2.5×10^{-6} mol/l, Rhodamine 560: 10^{-5} mol/l



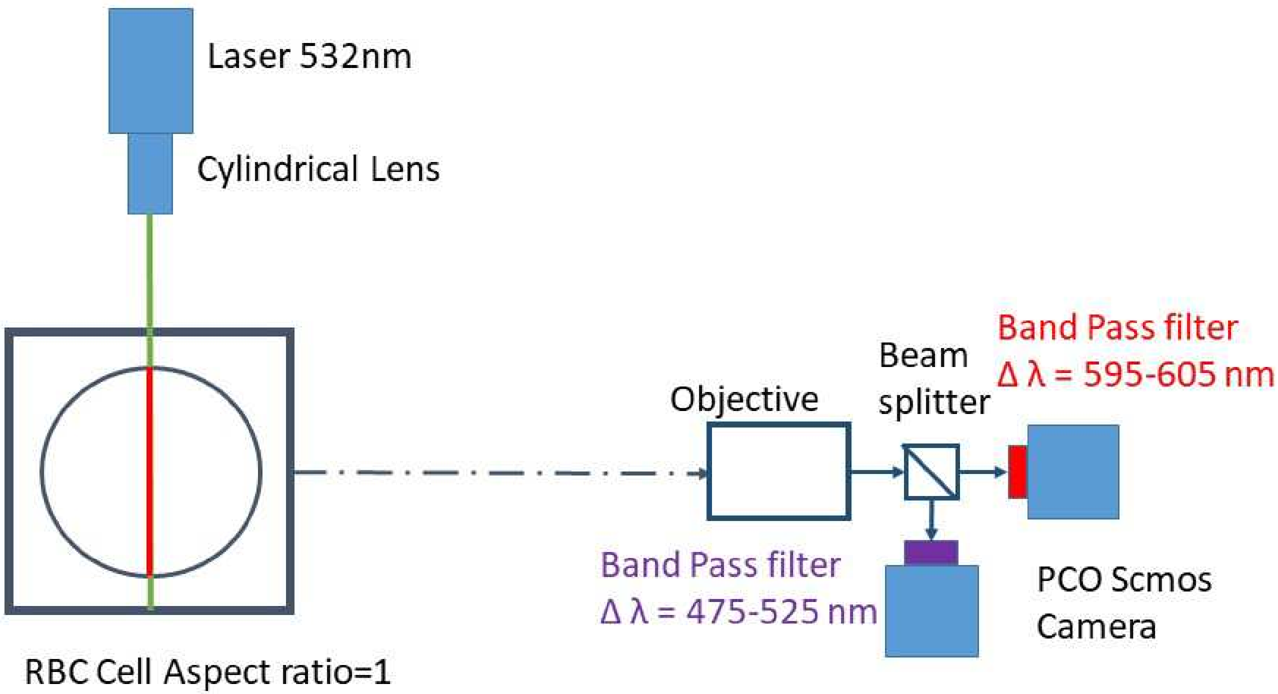
Relative intensity in function of the temperature

Keton Red 2.5x10^{-6} mol/l, Rhodamine 560: 10^{-5} mol/l

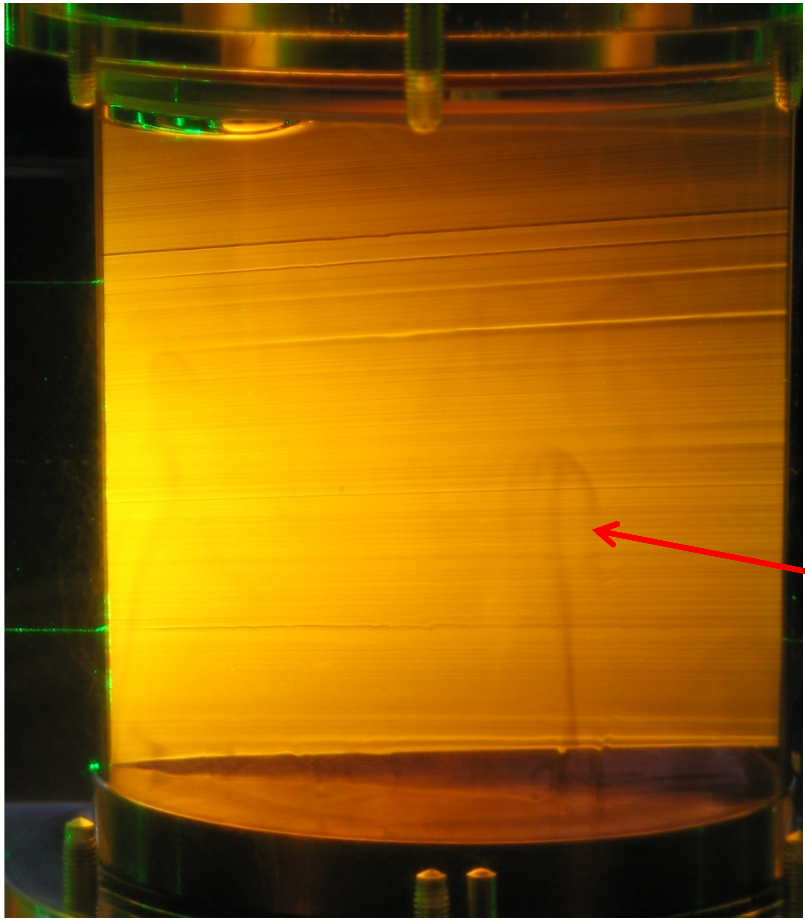




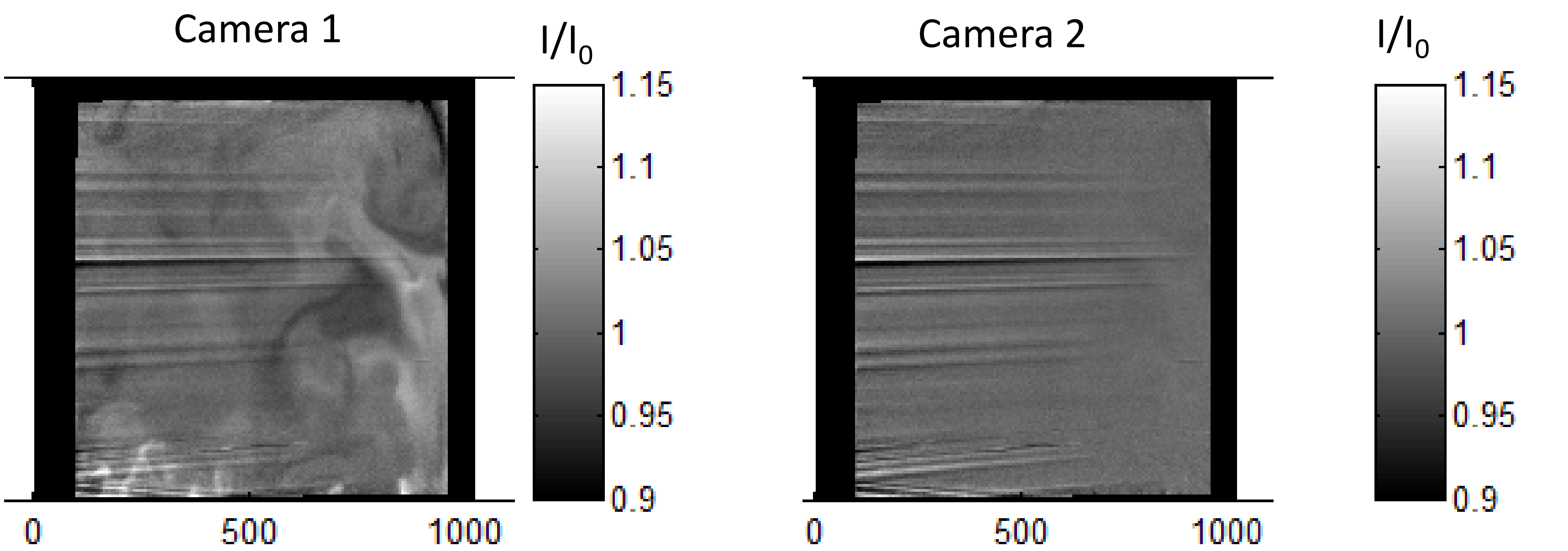
Experimental set-up 2 colors laser induced fluorescence



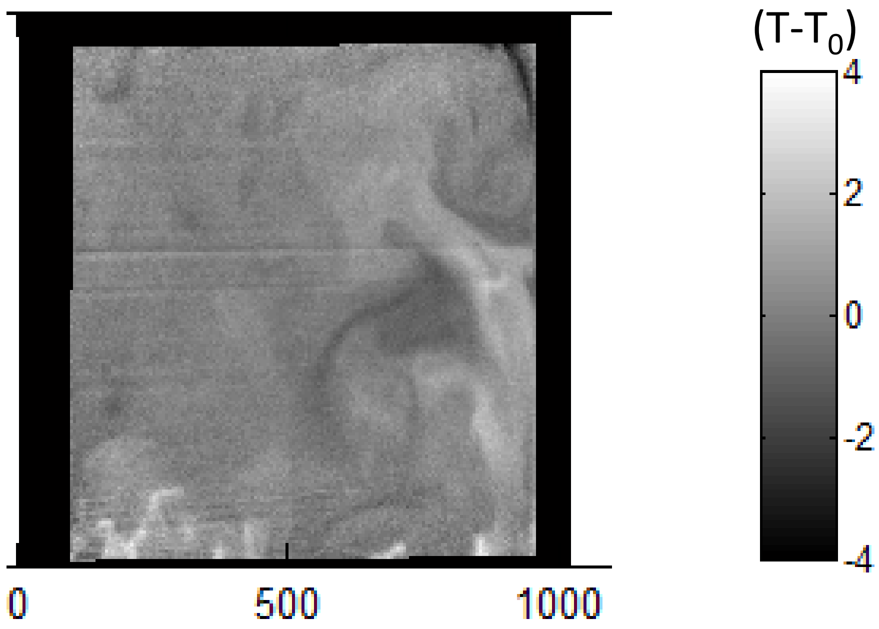
Cylindrical cell, aspect ratio 1, ϕ = 10 cm diameter



Hot plumes rising



Division of one image by the other ➡ eliminate the stripes (illumination defects)



Procedure

A reference frame is taken at a temperature T_0

- For the fluorescent dye 1, division by the reference frame: $\frac{I_{f_1}}{I_{Ref_1}} = \frac{I_0}{I_{0_{Ref}}} e^{\beta_1(\lambda_1)\left(\frac{1}{T} - \frac{1}{T_0}\right)}$

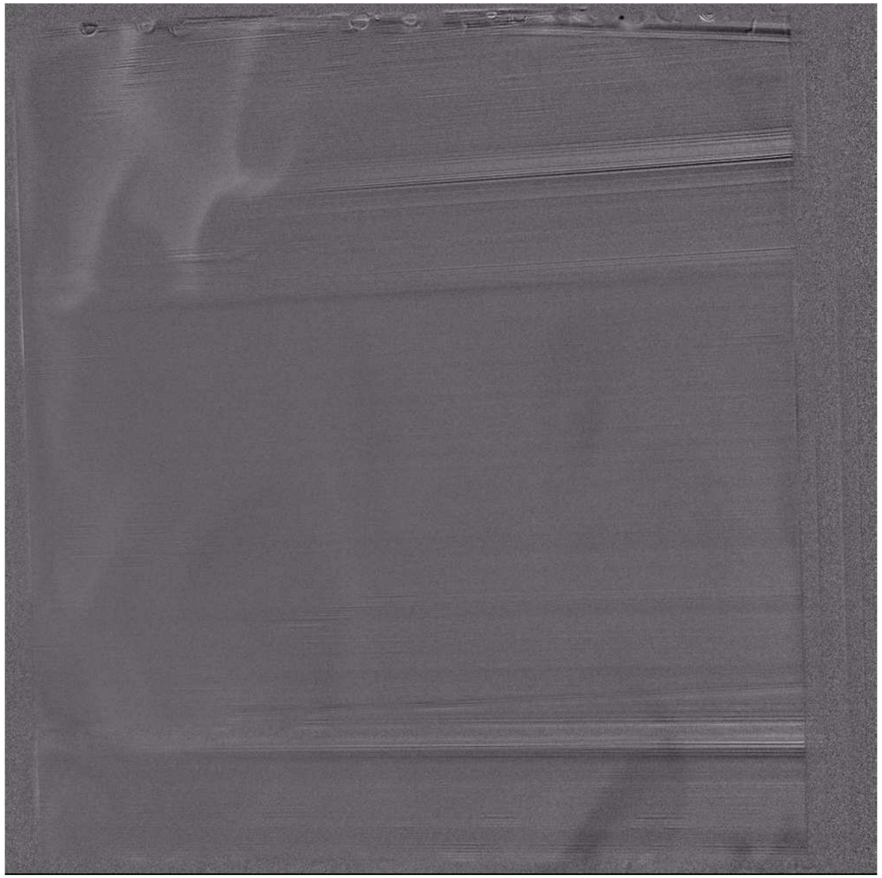
- For the fluorescent dye 2, division by the reference frame: $\frac{I_{f_2}}{I_{Ref_2}} = \frac{I_0}{I_{0_{Ref}}} e^{\beta_2(\lambda_2)\left(\frac{1}{T} - \frac{1}{T_0}\right)}$

- By doing the ratio of these two quantities, we obtain:

$$\frac{I_{f_1}}{I_{f_2}} = \frac{I_{Ref_1}}{I_{Ref_2}}(T_0) e^{(\beta_1(\lambda_1) - \beta_2(\lambda_2))\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

Rayleigh Bénard convection without rotation: velocity magnitude

10 cm



$Ra = 1.38 \times 10^8$, $Pr = 6.9$

$\Gamma = 1$, $Ro = \infty$

Rayleigh Bénard convection with rotation : velocity magnitude (rotation dominated regime)

Ra = 1.38×10^8 , Pr = 6.9
$\Gamma = 1$, Ro = 0.07, T = 2.1s

Merci de votre attention