Characterization of dynamic optical nonlinearities in aniline tetramers solution with pulse trains

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Abstract

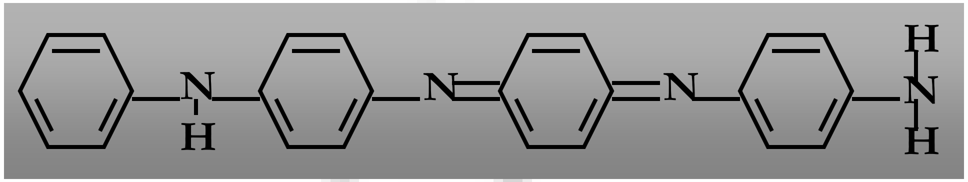
In this work we investigated the dynamic nonlinearities in aniline tetramer solution with different concentrations, using the Z-scan technique with pulse trains. The experimental results showed a predominant cumulative effect. A decrease in the cumulative effect characteristic time with increasing the tetramer concentration was also observed.

Objectives

- Study of nonlinear optical properties in aniline tetramer solutions as a function of the concentration.

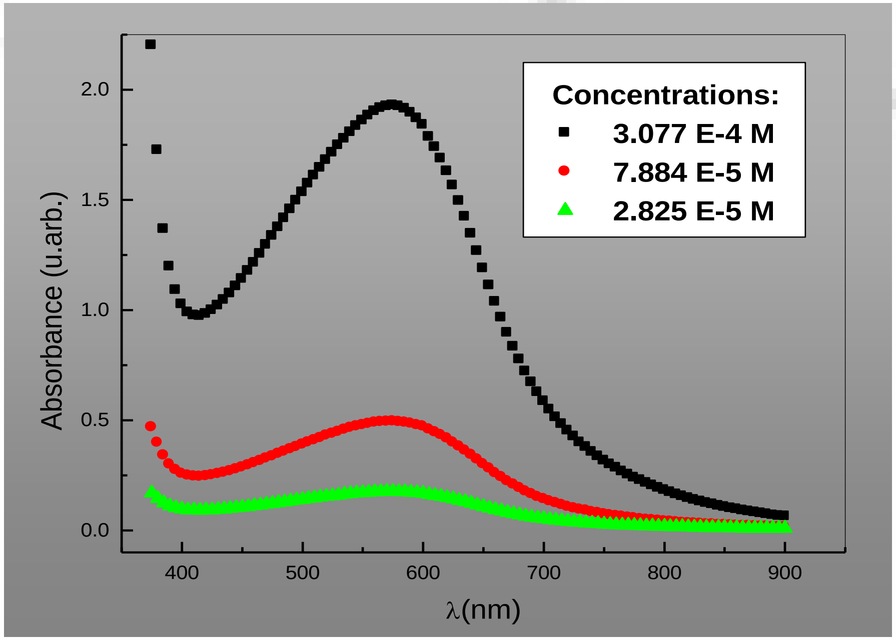
Introduction

♦The aniline tetramer.



♣ Study of fundamental physical and chemical properties to the comprehension of the parent polymers.

♦Sample Characterization



♣ Absorbance spectra of aniline tetramers in DMSO solutions. This results clearly shows a non aggregation of the tetramers molecules.

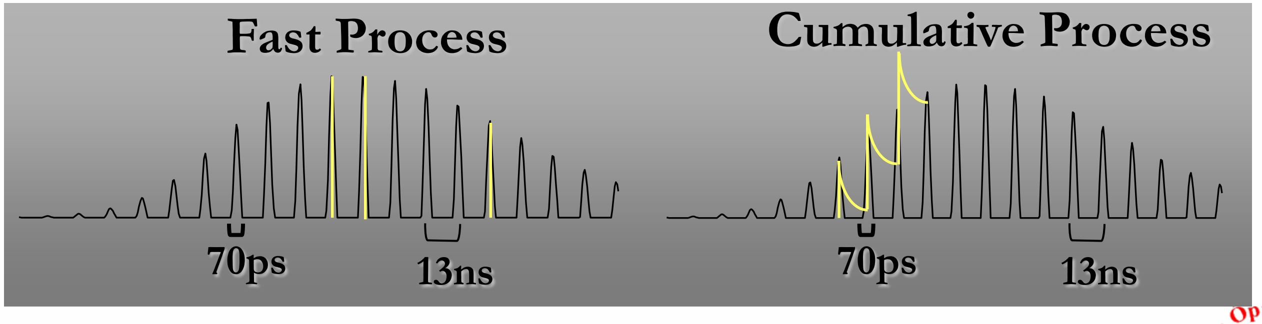
♦The Z-Scan pulse trains technique

♣ This technique is able to discriminate between fast and cumulative contribution to the nonlinear effect.

♣ The nonlinear effects can be separated in two contributions, a fast electronic and slower cumulative processes.

$$P = \chi_g^{(1)}E + \chi_g^{(3)}EEE + \eta(\chi_e^{1)} - \chi_g^{(1)})E + \ldots$$

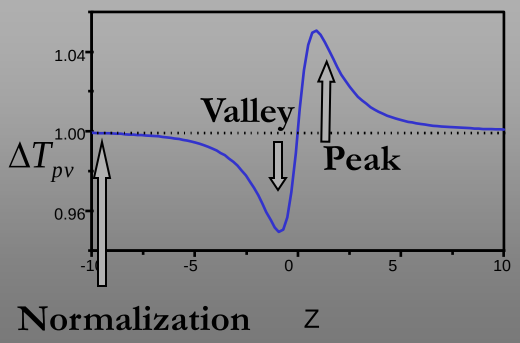
η is the fraction of molecules in the excited state



$$\langle \Delta n \rangle_j = \underbrace{\frac{n_2 I_j}{\sqrt{2}}}_{\substack{\text{electronic}\\ \text{effect}}} + \underbrace{\frac{n_{2c}}{2}\sum_{i\le j} F_i \exp\left[-(j-i)\Delta t/\tau'\right]}_{\substack{\text{accumulative}\\ \text{effect}}}$$

Fitting parameters: n_{2ele}, n_{2c}, τ'

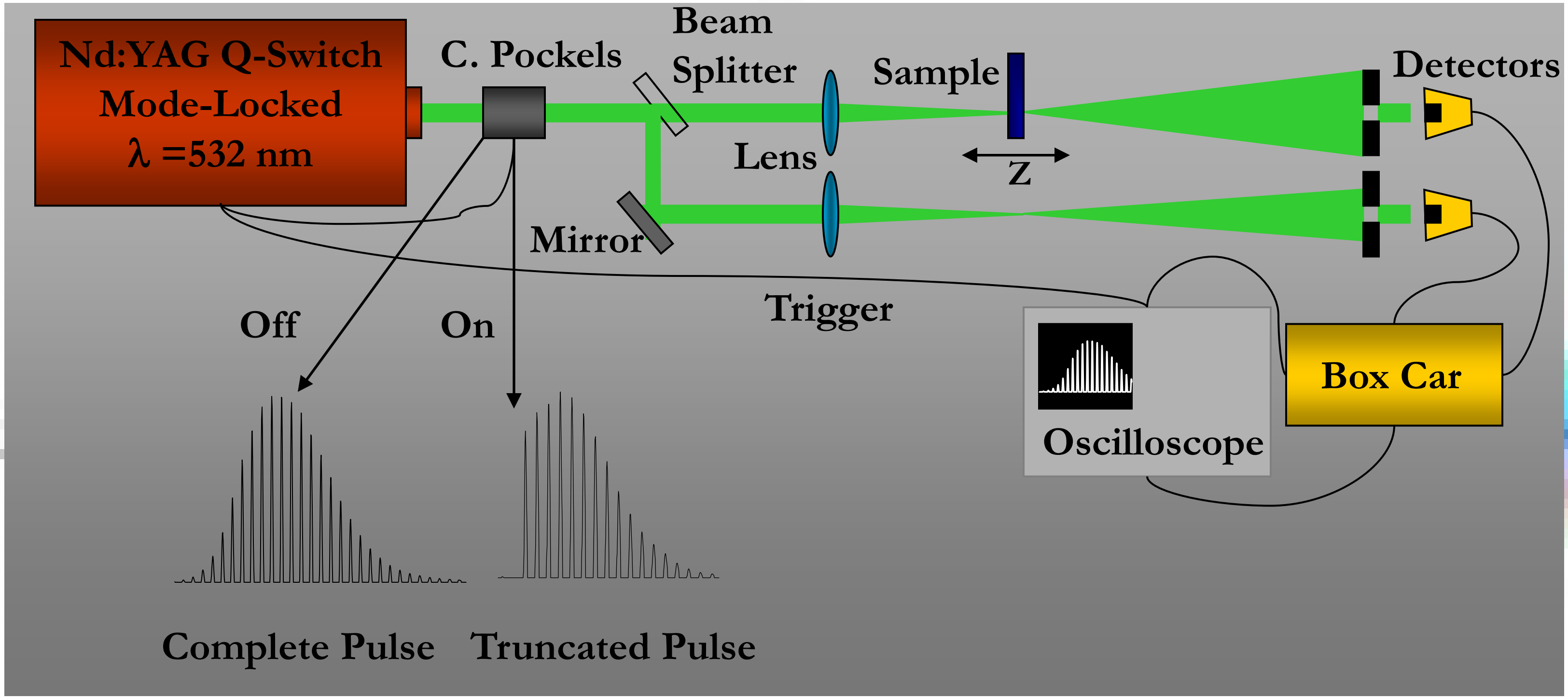
♣ **We acquire pulse trains at the peak and valley position, generating a set of transmittance change, ΔT_{PV}, one for each pulses.**



$$\Delta T_{pv} \approx 0.405(1-S)^{0.25}\left(\frac{2\pi L}{\lambda}\right)\Delta n$$

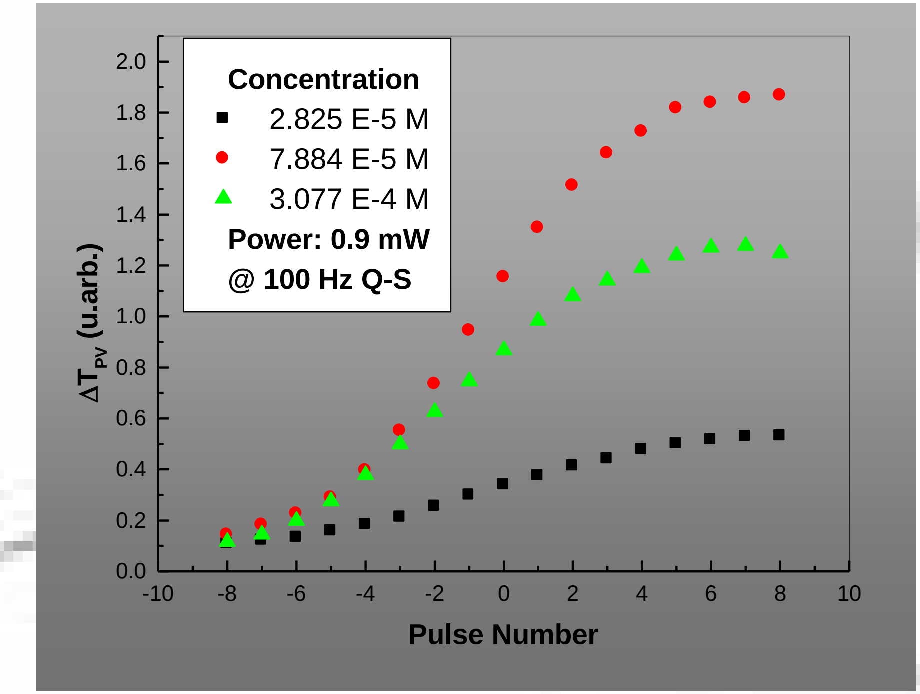
$$\Delta n = n_2 I$$

♦The Z-Scan pulse trains experimental setup.



♣ The envelope containing about 20 pulses (70 ps is the temporal width of each pulse, separated by 13.2 ns) at 10 Hz. This low repetition rate is used to avoid cumulative thermal nonlinearities.

Results (pulse trains)



♣ The experimental results showed a predominant cumulative effect.

♣ A decrease in the cumulative effect characteristic time with increasing the tetramer concentration.

♣ Envelope time = 250 ns.

♦The frequency resolved Z-Scan technique.

♣ This method allows a significative increase in the sensitivy of the z-scan technique for measurements of slow absorbers.

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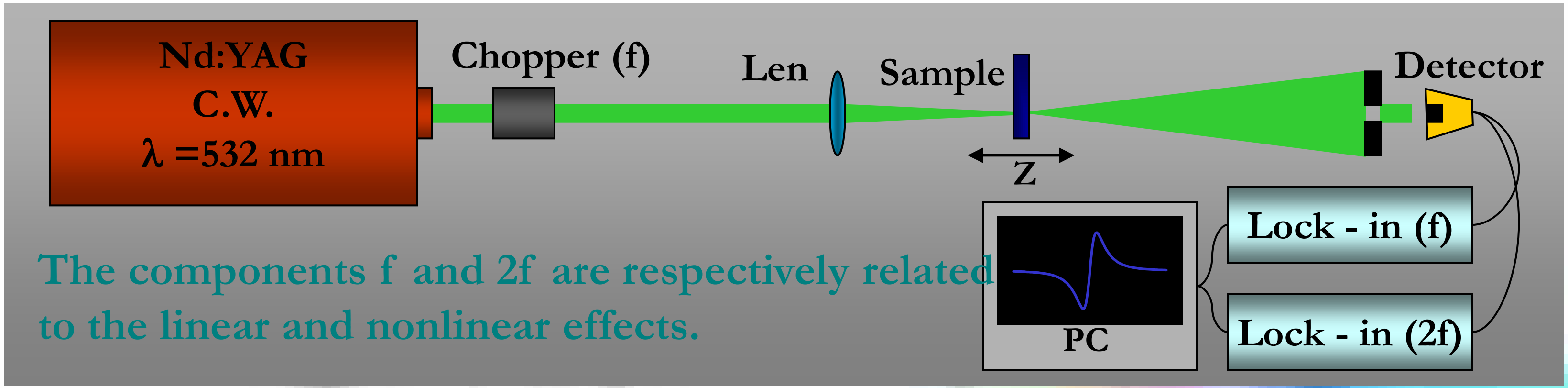
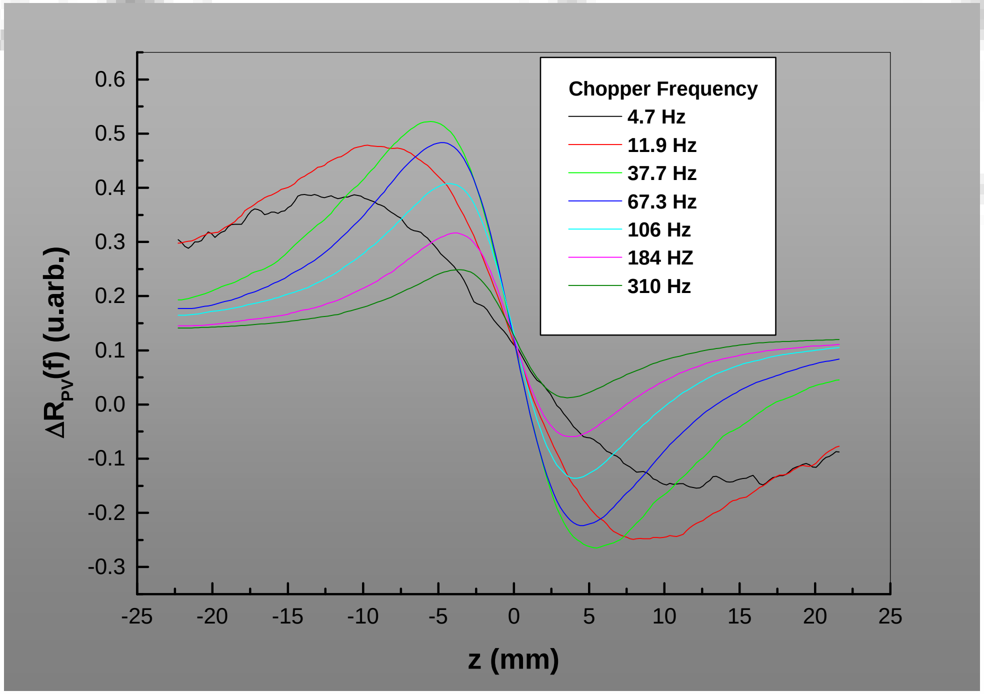
♦ The Z-Scan frequency resolved experimental setup.

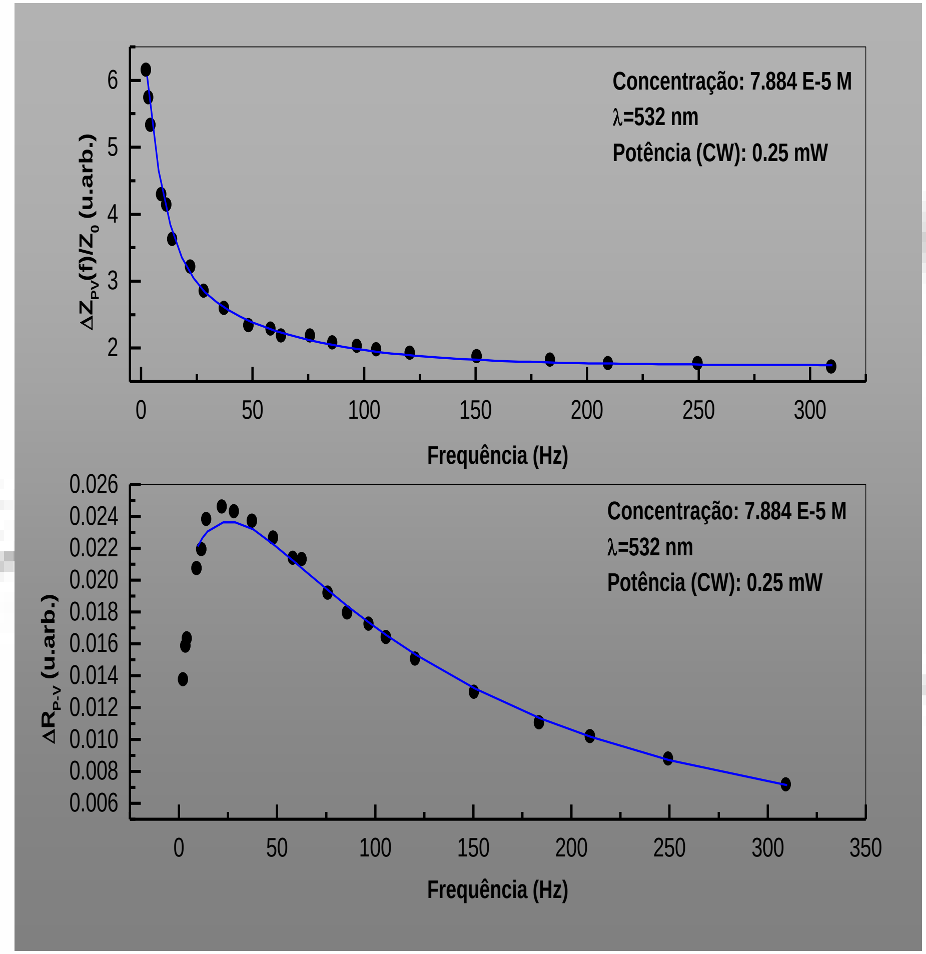


The components f and 2f are respectively related to the linear and nonlinear effects.



This behaviour is typical of thermal effects.

Results (C.W. frequency resolved)



$$T_{th} = \frac{\omega_0^{\,2}}{4D}\left(1+\left[\frac{\Delta Z_{PV}(f)}{Z_0}\right]^2\right)$$

$$R(z,f) = \frac{g_2}{g_1}\cdot \pi f T_{th}\cdot\left(\frac{1-e^{\frac{-1}{2fT_{th}}}}{1-e^{\frac{-1}{fT_{th}}}}\right)\cdot\left(\frac{1-e^{\frac{-1}{2fT_{th}}}}{\sqrt{1+\left(4\pi f T_{th}\right)^2}}\right)\cdot\Delta T(z,0)$$

$\Delta T(z,0) = .11505$

Thermal Diffusivity Coefficient

D =1.065 E-4 cm^2/s

Good agreement with values presented in the literature for a pure DMSO solvent.

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Conclusions

- Non aggregation was observed in the tetramers solutions.
- The characteristic time cumulative effect is dependent with the concentration.
- We have only observed thermal lens formation for higher concentrations.
- Thermal effects (ms) were obtained in Z-scan frequency resolved technique.
- The thermal diffusivity coefficient is independent of the concentration.

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