Nonlinear Optical Properties of New Nanocomposites: Metal Alkanoate Glasses with Semiconductor Quantum Dots

A.G. Lyashchova [1], D.V. Fedorenko[1] , G.V. Klimusheva[1],
T.A. Mirnaya[2], V.N.Asaula[2] ,

1 Institute of Physics, Natl. Acad. of Sci. of Ukraine. Prospect Nauki, 46, Kiev-03680, Ukraine.
2 V. Vernadsky Institute of General and Inorganic Chemistry, Natl. Acad. of Sci. of Ukraine, Acad. Palladina Ave., 32-34, Kiev-03142, Ukraine.

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- Spectral Properties of Nanocomposites: nanocrystals CdSe in the metal alkanoate matrix.
- Experimental Techniques for Measure Nonlinear Optical Constants:
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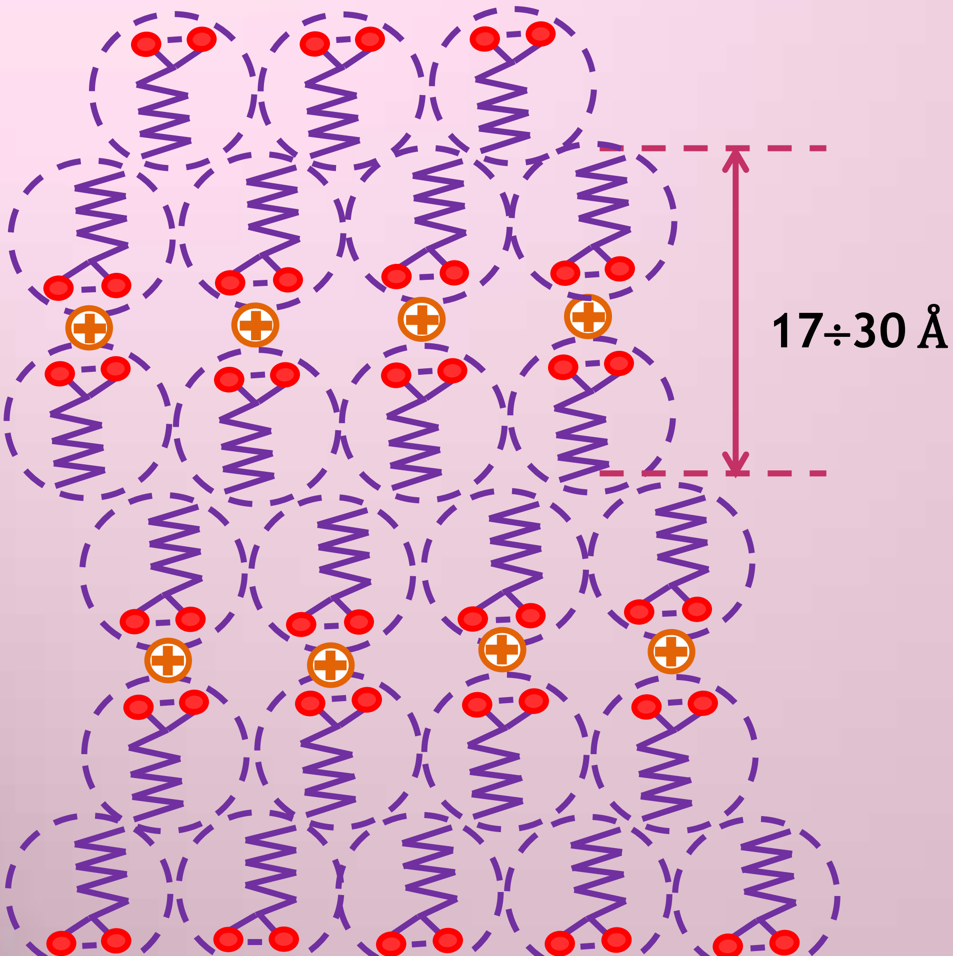
  - Z-scan under CW Diode laser and Model of photoinduced lens;
- Measurement of Nonlinear Refractive Index n_2.
- Measurement of Nonlinear Absorption Coefficient β.
- Conclusions.

Ionic Luquid Crystals and Glasses of Cadmium Alkanoates

$$\left[C_nH_{2n+1}C \begin{matrix} O \\ O \end{matrix} \right]_2^{-1} Cd^{+2} \qquad n \geq 3$$



Cadmium Alkanoates

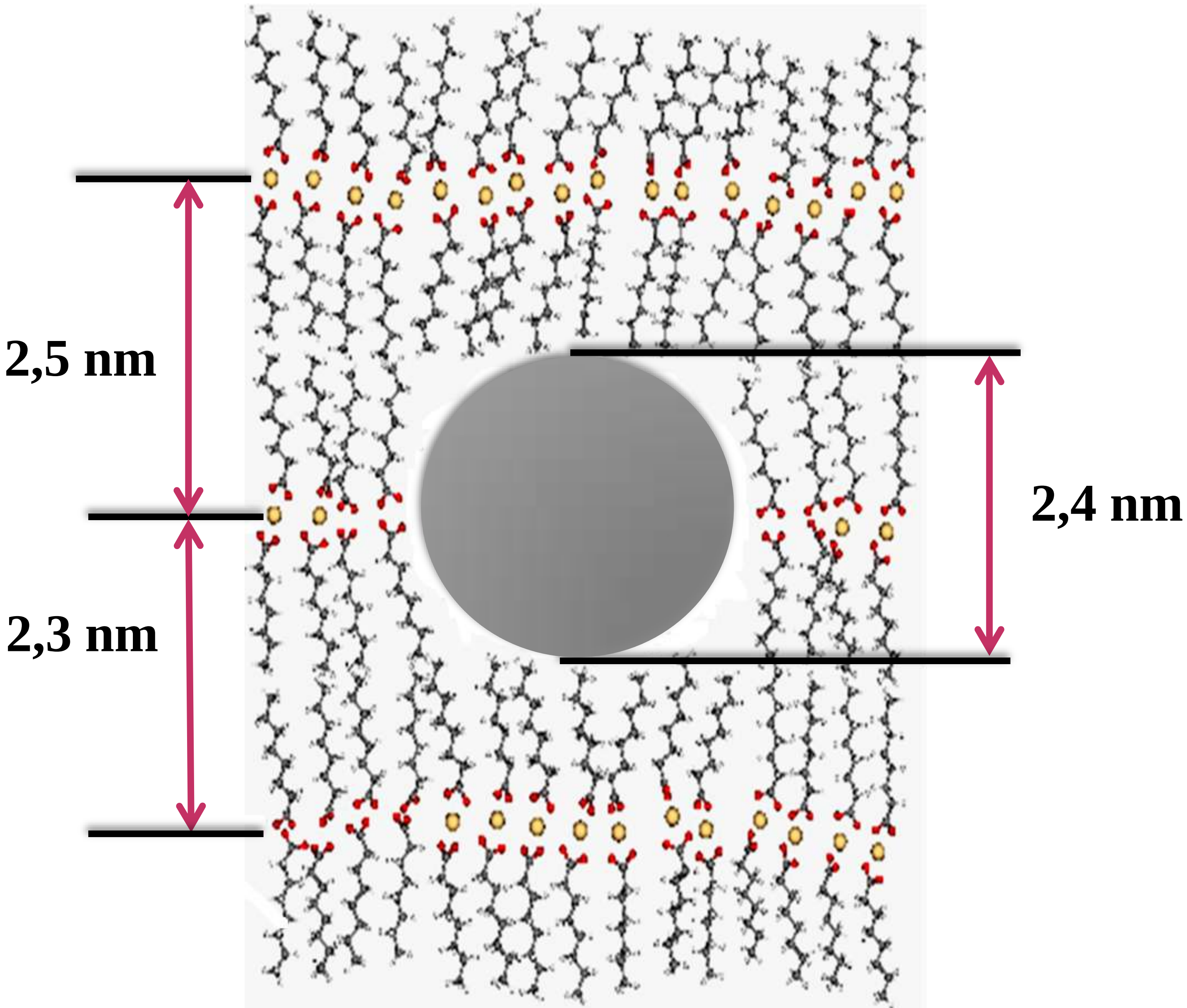
- Thermotropic ionic liquid crystals (Smectic A) $T_m \sim 100\ ^0C$
- Ionic smectic glasses

Cadmium Caprilate

$$\left[C_7H_{15}C \begin{matrix} O \\ O \end{matrix} \right]_2^{-1} Cd^{+2}$$

Structural model of nanocomposite:

spherical CdS nanocrystal in cadmium caprilate matrix



Absorption spectra of nanocomposites

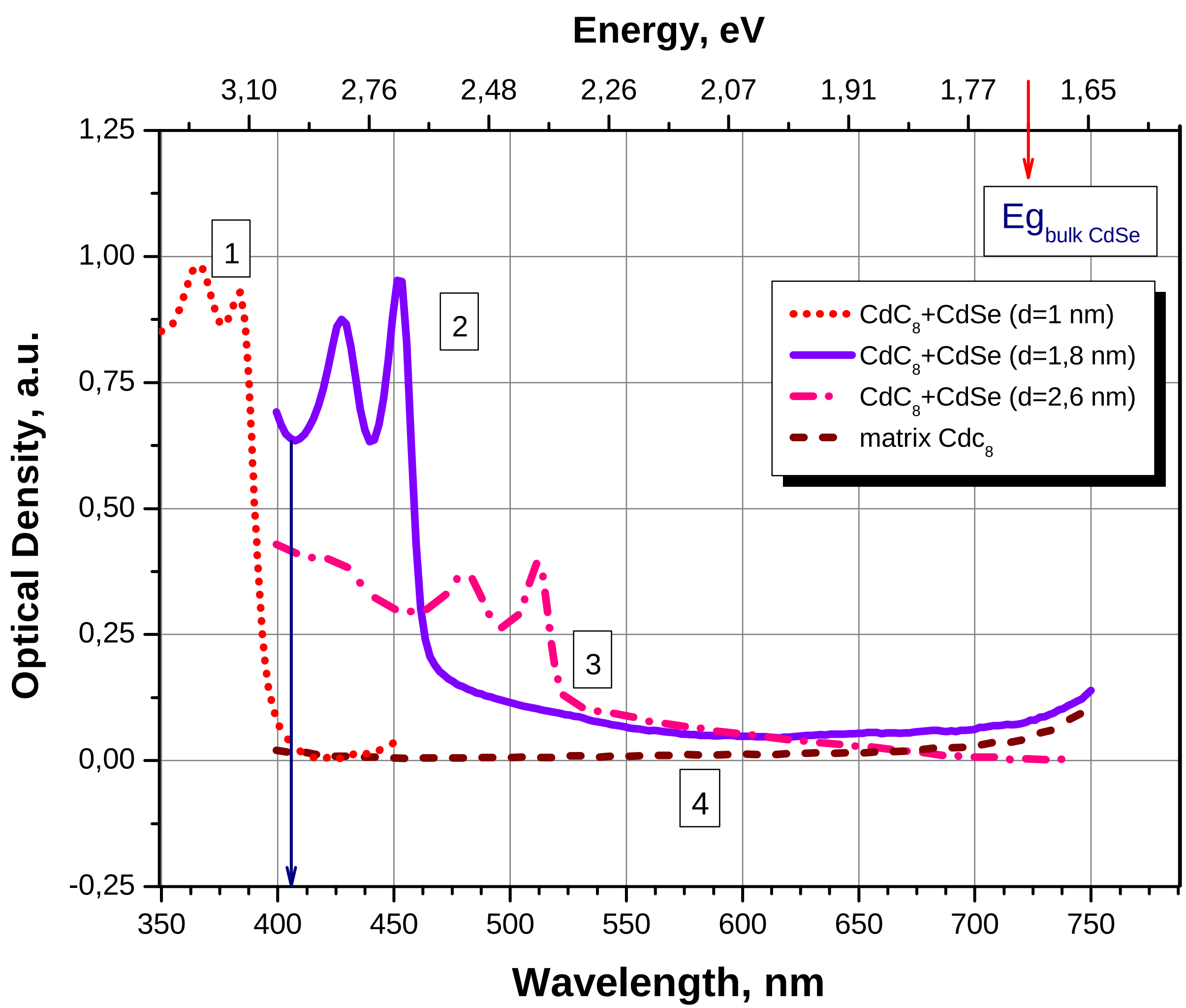
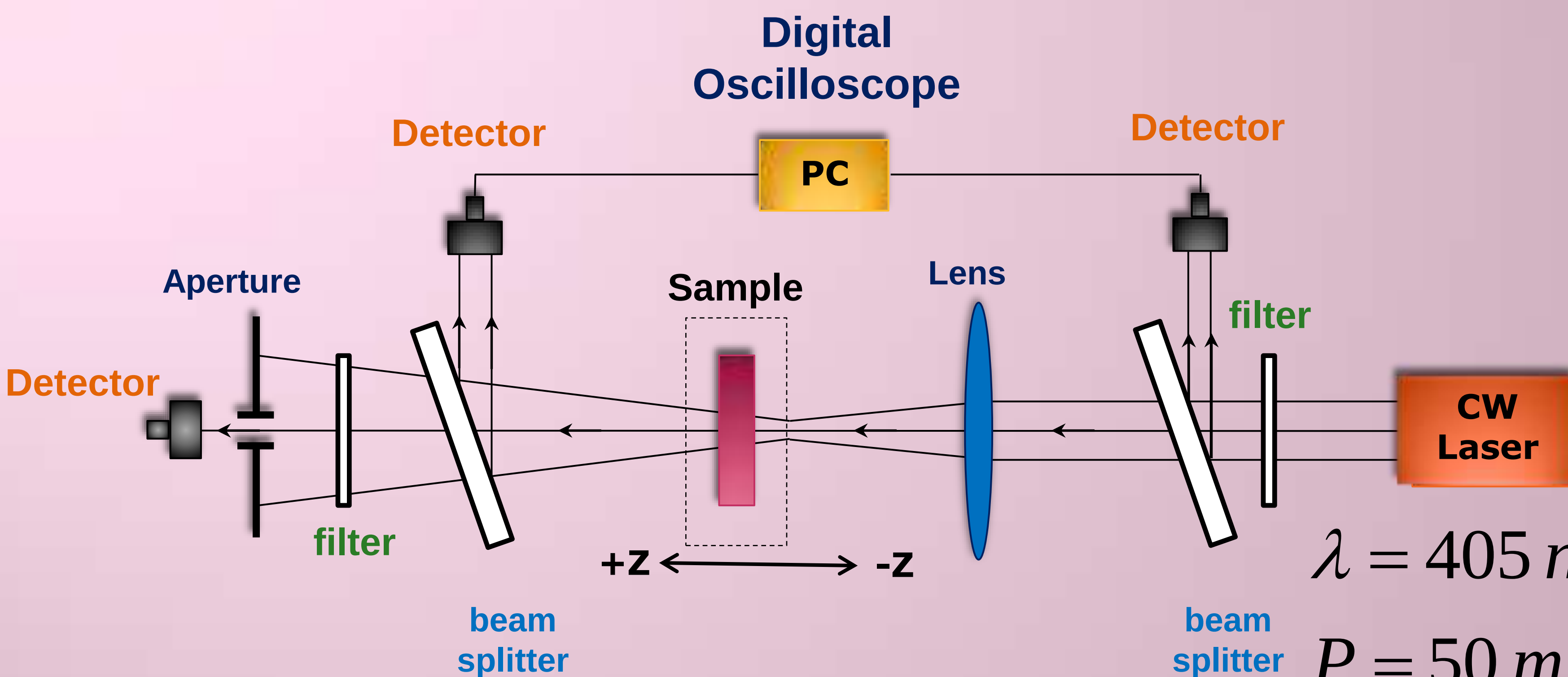


Fig. 1. The absorption spectra of nanocomposites for different size of CdSe nanocrystals in cadmium caprilate matrix.

Experimental Z – scan Set up for Optical Nonlinearity Measurements



$$\lambda = 405\,nm$$

$$P = 50\,mW$$

Thermal Photorefraction (closed aperture)

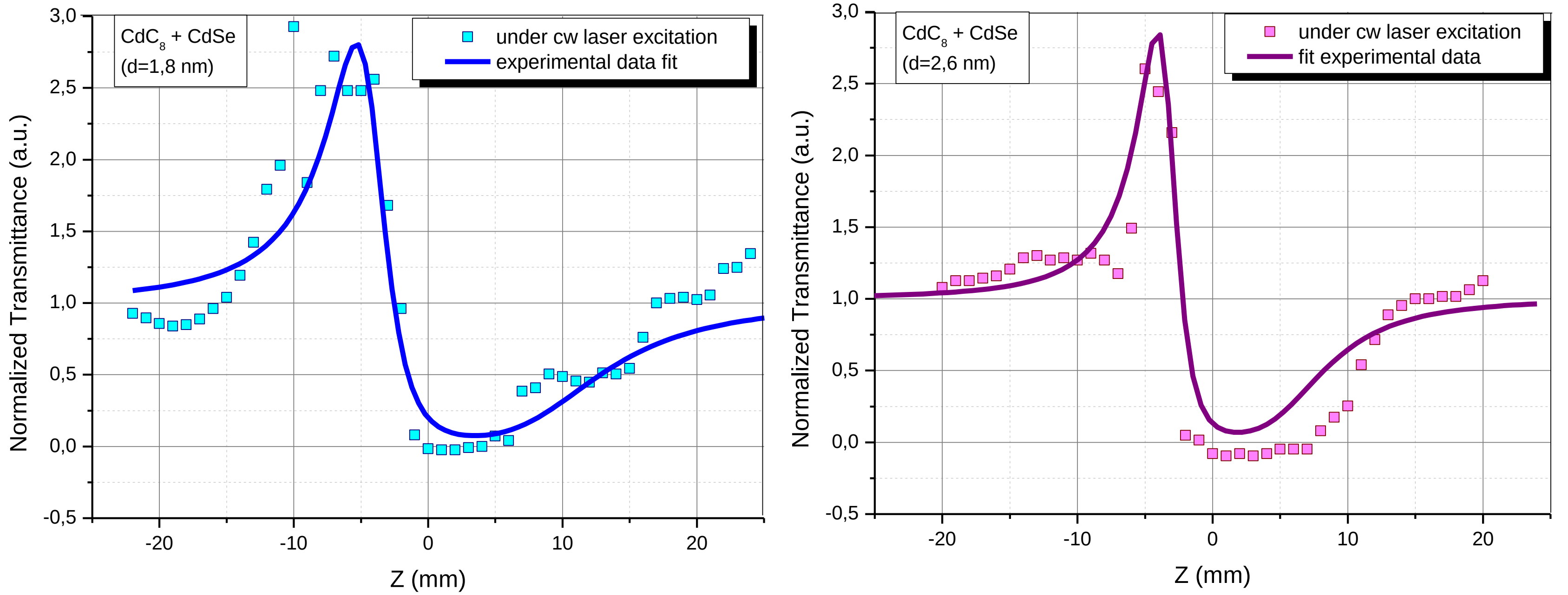


Figure 2. Typical normalized transmittance dependence on the sample position for nanocomposite: cadmium sulfide QDs in the cadmium caprilate matrix for different size of nanocrystals. The solid curve corresponds to the PhLM fitting.

Self-defocusing

Nonlinear Absorption (open aperture)

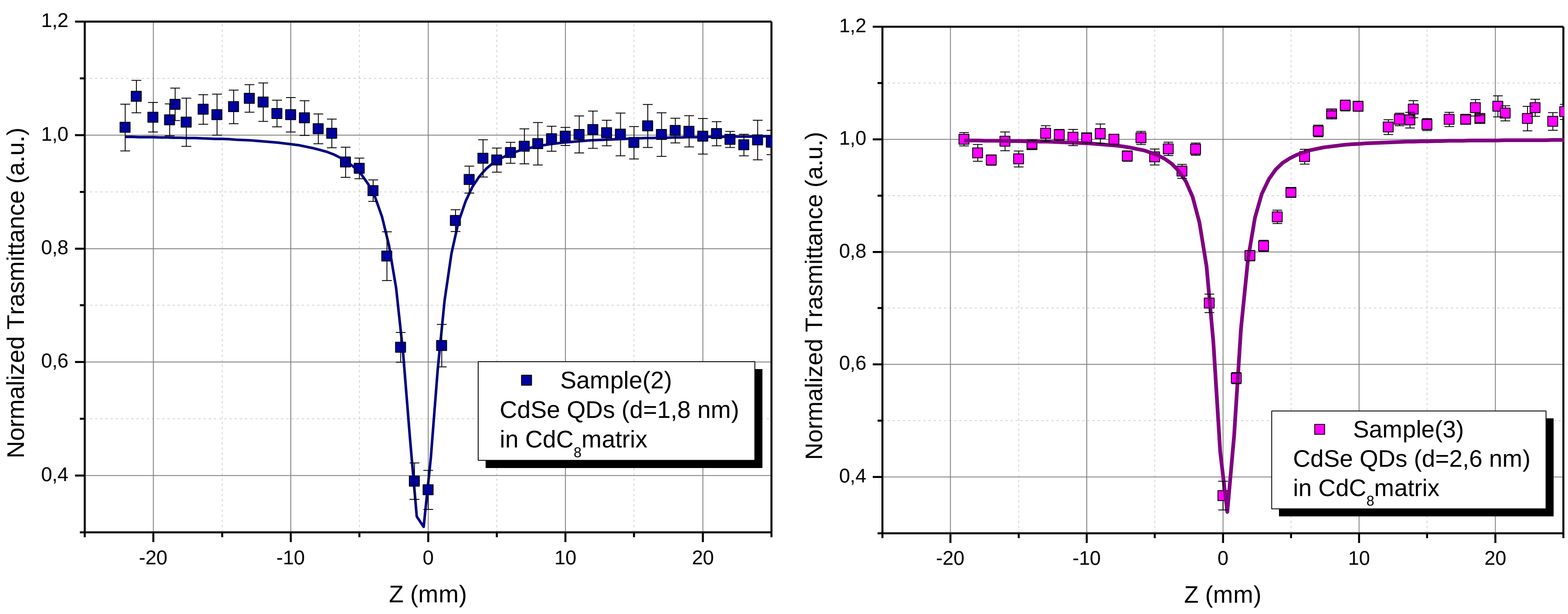


Figure 3. Typical normalized transmittance dependence on the sample position for nanocomposite: cadmium sulfide QDs in the cadmium caprilate matrix for different size of nanocrystals. The solid curve corresponds to the PhLM fitting.

Model of Photoinduced Lens

$$F_m = a_m w^m, \; m = 1, 2, 3\ldots$$

The normalized transmittance is given by

$$T = 1 - \frac{4x}{(1+x^2)^2}\left(\frac{z_0}{2F_m}\right) + \frac{4}{(1+x^2)^3}\left(\frac{z_0}{2F_m}\right)^2,$$

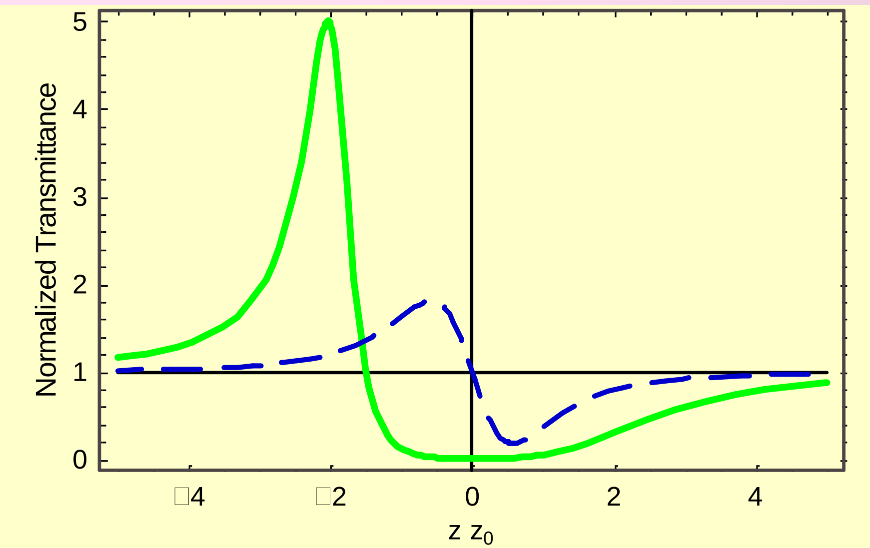
$$x = z/z_0; \quad z_0 = \pi\omega_0^2/\lambda; \qquad (1)$$

$$L_{eff} = \frac{1-e^{-\alpha_0 L}}{\alpha_0}, \quad I_0 = \frac{2P}{\pi\omega_0^2} \qquad (2)$$

I_0 on-axis irradiance at focus (z=0)

α_0 linear absorption coefficient.

L sample length,



The nonlinear phase shift: $\Delta\Phi_{om} = \frac{z_0}{2F_{0m}};$ (3)

The nonlinear refractive index:

$$n_2 = \frac{\Delta\Phi_0}{kI_0L_{eff}} \qquad (4)$$

Sheik-Bahae Formalism

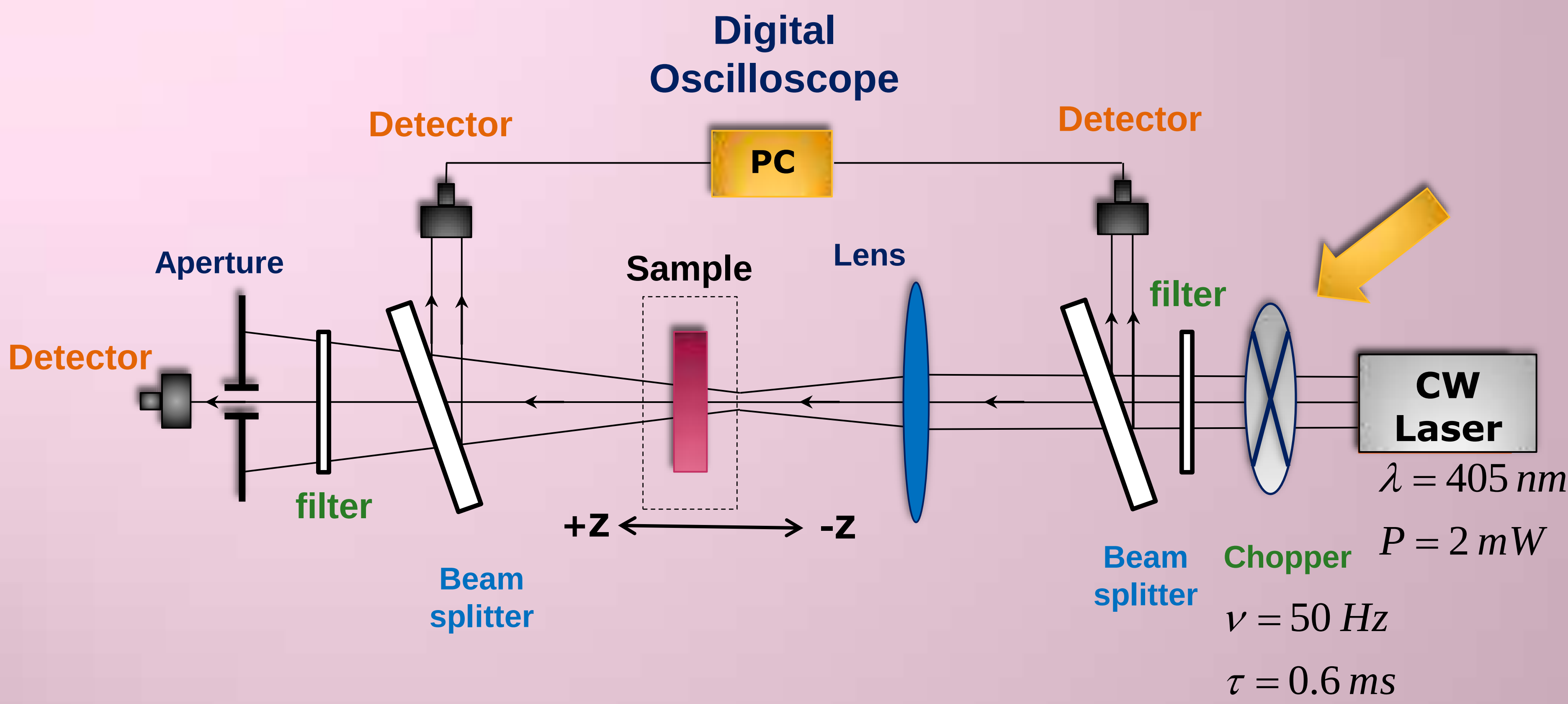
$$\Delta T = T(z) - 1; \quad \Delta T(z) \approx -\frac{q_0}{2\sqrt{2}}\frac{1}{[1+z^2/z_0^2]}$$

$q_0 < 1$

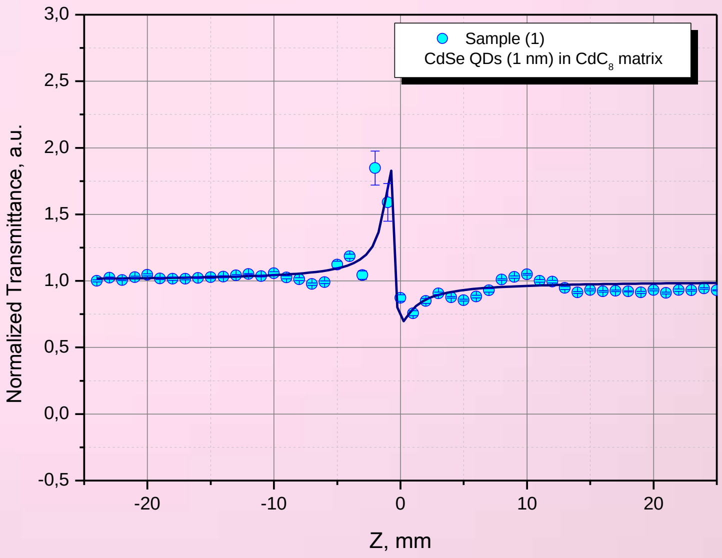
The nonlinear absorption coefficient:

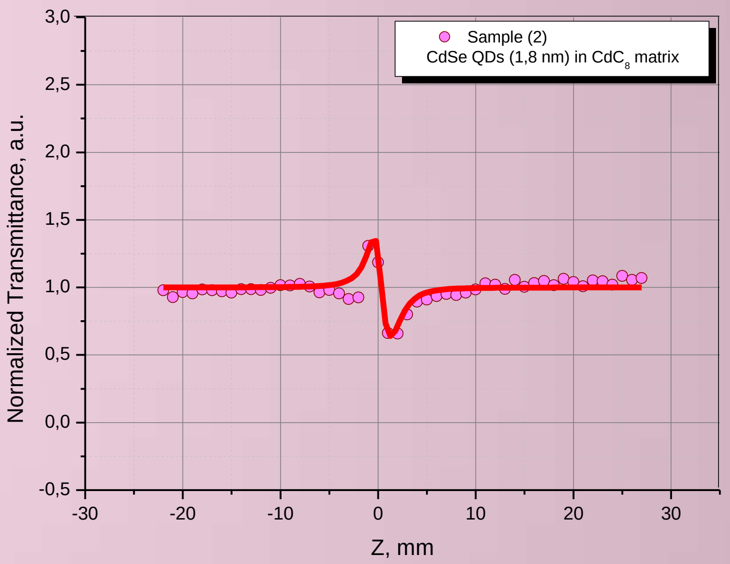
$$\beta = \frac{q_0}{I_0L_{eff}} \qquad (5)$$

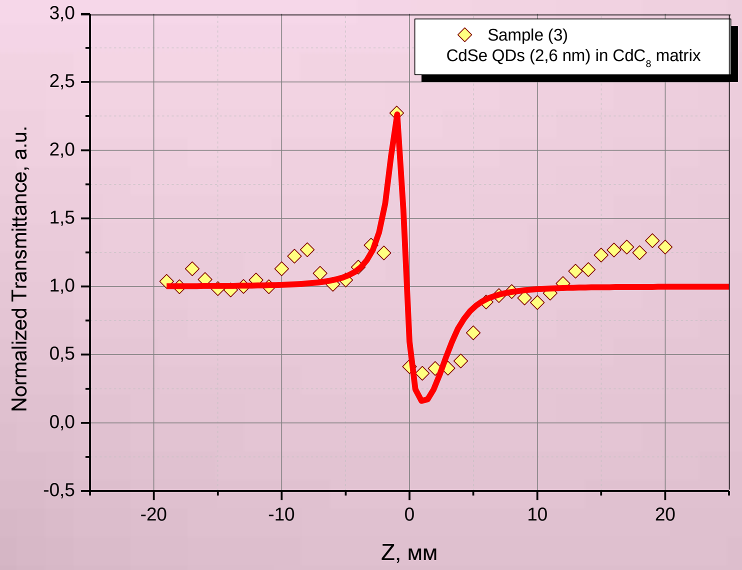
Z – scan Set up for Optical Nonlinearity Measurements

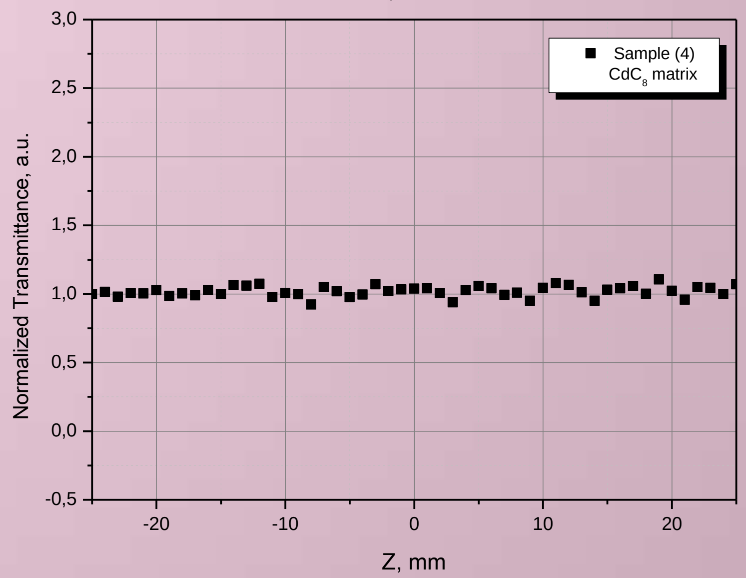


Z-scan results for CdC_8 with CdS (close z-scan)









Z-scan results for nanocomposites: CdSe nanocrystals in CdC_8 matrix (close z-scan)

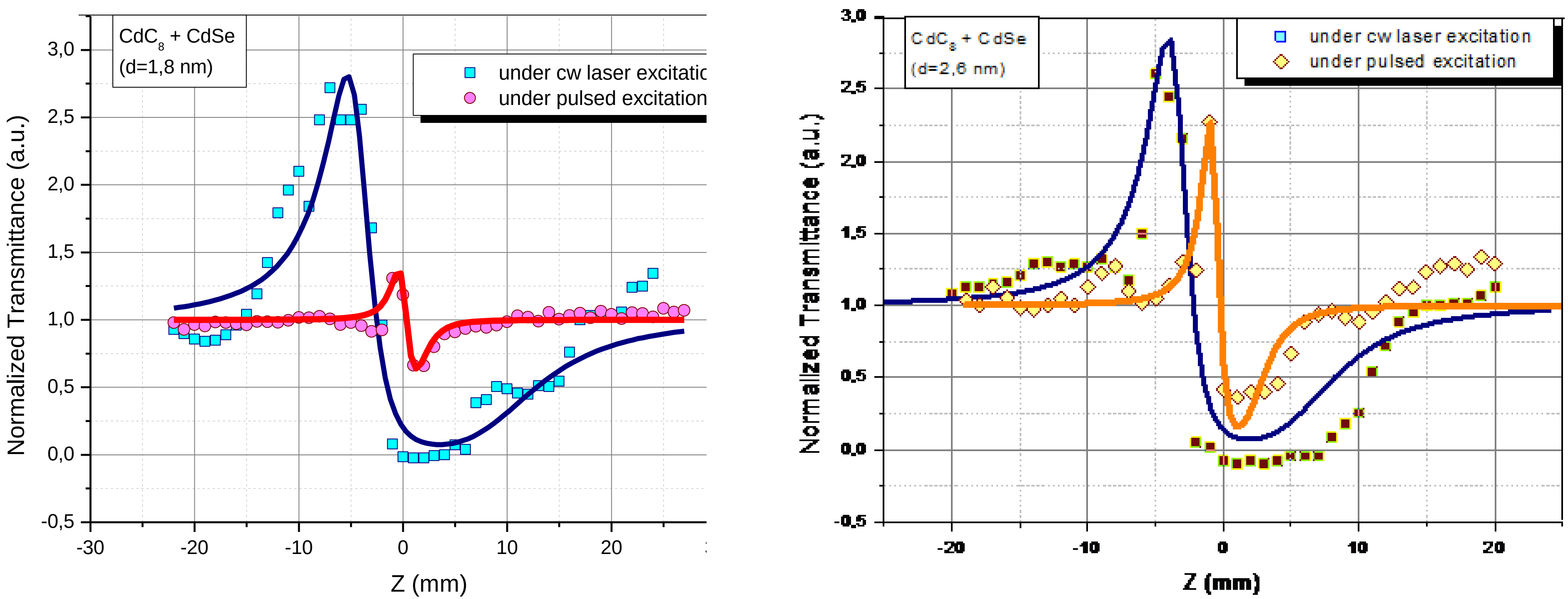


Figure 4. Typical normalized transmittance dependence on the sample position for nanocomposite: cadmium sulfide QDs in the cadmium caprilate matrix for different size of nanocrystals. The solid curve corresponds to the PhLM fitting.

Z-scan results for CdSe (open z-scan)

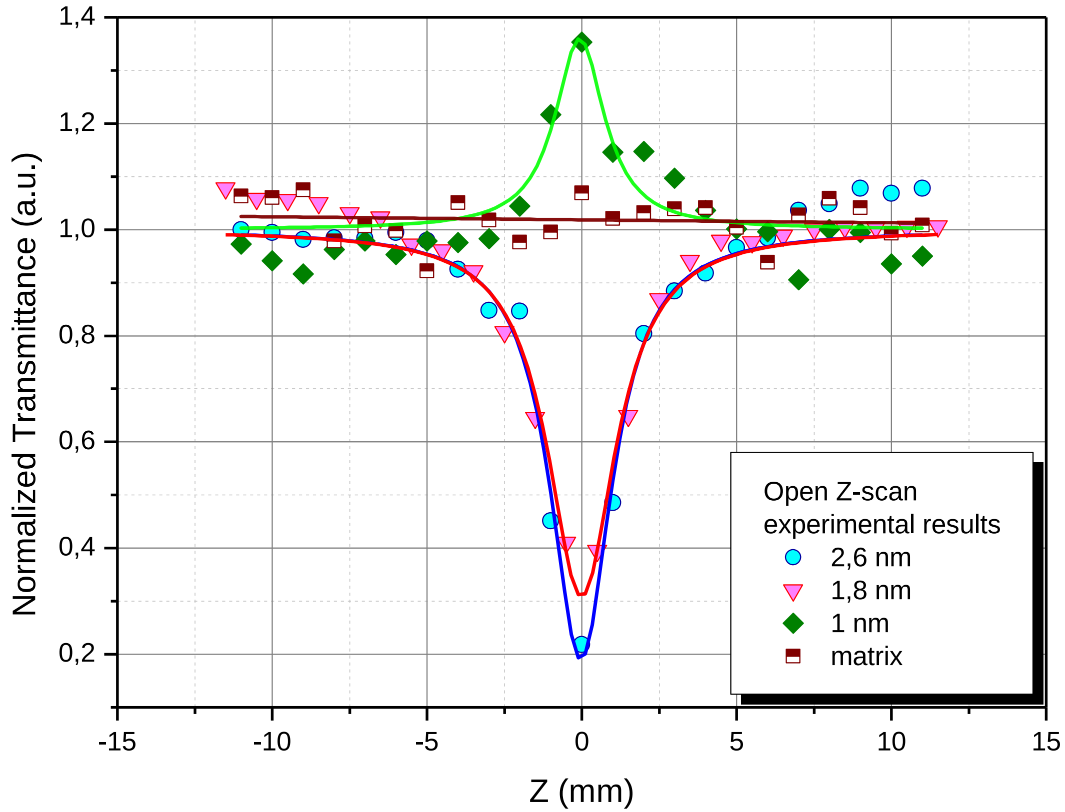


Figure 5. Typical normalized transmittance dependence on the sample position for nanocomposite: cadmium sulfide QDs in the cadmium caprilate matrix.

Conclusions

- Nonlinear properties of nanocomposites connected with CdSe QD's presence.
- Applying chopper allows to reduce the delocalization of refractive index distribution.
- Large values of nonlinear refraction coefficient open perspectives of application in nonlinear optics and photonics.

THANK YOU FOR YOUR ATTENTION !

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