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2D transmission profile of light through highly scattering media

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Theory

continuous wave

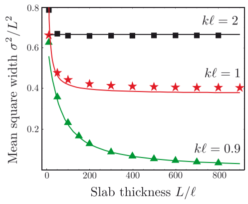


Figure 1: Mean square width of the spatial resolved stationary transmission profile [2].

pulsed wave

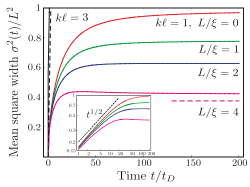
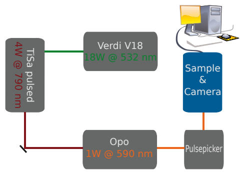


Figure 2: Mean square width of the spatial resolved time dependent transmission profile [2].

Analytically, it was shown that the mean square width σ^2 of the transmission profile of a focused monochromatic beam through disordered media is [2]:

	kl^*	σ^2
diffusion	$kl^* \gg 1$	$\frac{2}{3}L^2 - \mathcal{O}((l^*)^2)$
mobility edge	$kl^* = 1$	$\frac{3}{8}L^2 + \mathcal{O}(Lz_c)$
localisation	$kl^* < 1$	$2L\xi + \mathcal{O}(\xi^2)$

Experimental setup



Setup

- 250 fs pulses @ 590 nm
- Pulsepicker contrast up to 500 : 1
- 16 bit camera, 512×512 pixel
- Minimum gatingtime 1 ns
- 250 ps time resolution

Samples

Sample	d (nm)	Disp. (%)	kl^*
R104	311	10	3.5-4
R700	230	22	2.5
R902	279	38	4.3

Data evaluation

The measured 2D transmission profile is fitted with a 2D gaussian. The mean square width is averaged to σ^2 and evaluated.

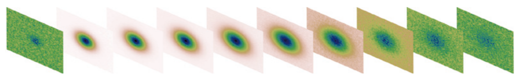


Figure 3: 2D transmission profile of R700 in time. Starting at 3.75 ns going in 2 ns steps to 21.75 ns, see fig. 4.

Results

Time resolved transmission profile

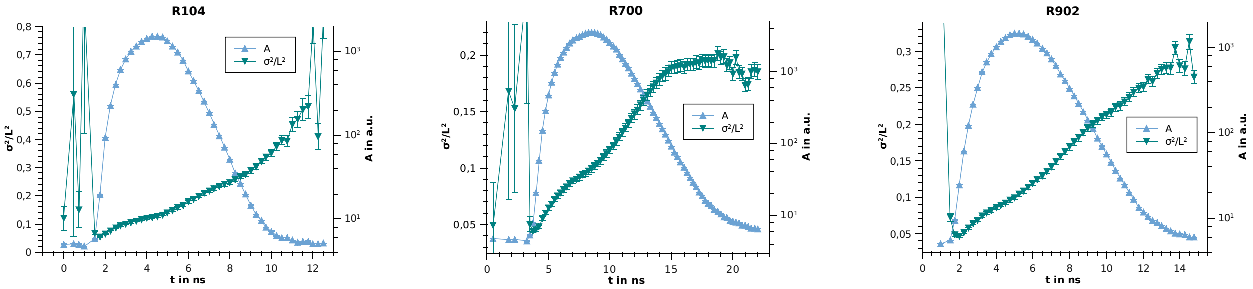


Figure 4: $\frac{\sigma^2}{L^2}$ measured time dependent for three different samples. Obviously there is plateau for the R700 sample. For the R104 sample no plateau was measured. The pulse disappeared in noise before the theoretically value for diffusive media of $\frac{\sigma^2}{L^2} = \frac{2}{3}$ could be reached. R902 indicates a plateau at $\frac{\sigma^2}{L^2} = 0.28$, but the intensity is very low and the afterpulse appears around 15.5 ns. From theory it is expected that the plateau shows up at $\frac{\sigma^2}{L^2} = 2\frac{\xi}{L}$. For R700 the $L = 1.01$ mm thick sample the diffusion constant is $D = 13\frac{\text{m}^2}{\text{s}}$, the absorption time $\tau_{\text{abs}} = 1.7$ ns and the localisation time $\tau_{\text{loc}} = 4.9$ ns. The plateau should be at $\frac{\sigma^2}{L^2} = 0.5$, but is located at $\frac{\sigma^2}{L^2} = 0.193$.

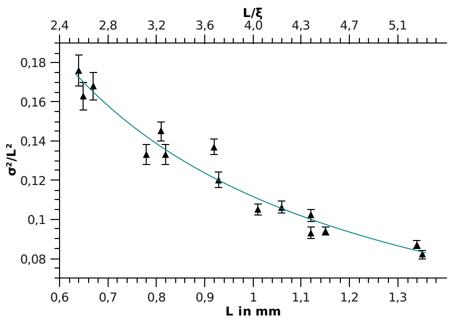


Figure 5: Measurement of $\frac{\sigma^2}{L^2}$ with R700 in static transmission with $\xi = 0.252$ mm. The fit results of $\frac{\sigma^2}{L^2} = A \cdot L^a$ are: $A = 0.117$ mm ± 0.002mm and $a = -0.976 \pm 0.060$.

The fit parameter A is equal to λ. With $\frac{1}{\lambda} = \frac{1}{\xi} + \frac{1}{l_a}$, $\xi = 0.252$ mm and $l_a = 0.149$ mm, it is $\lambda = 0.094$ mm, which is very close to A. The exponent a should scale with $a = -1$, because it should be $\frac{\sigma^2}{L^2} \propto \frac{1}{Ll_a}$, which is clearly shown.

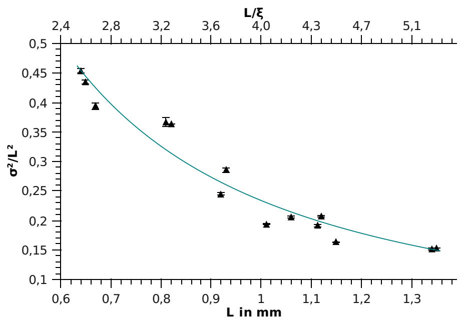


Figure 6: Time resolved measurement of the plateau (see fig. 4) of $\frac{\sigma^2}{L^2}$ in transmission with R700 and $\xi = 0.252$ mm. The results of a fit with $\frac{\sigma^2}{L^2} = A \cdot L^a$ are: $A = 0.237 \pm 0.008$ and $a = -1.491 \pm 0.112$.

The fitted exponent of $a = -1.491 \pm 0.112$ does not match the expected value of $a = -1$. It is not obvious why the exponent should be approximately $-\frac{3}{2}$.

References

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