NO INTERFERENCE FRINGES ABOVE 10^{-6}

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Many authors consider interference fringes as main limiting mechanism for trace molecules detection using Tunable Diode Laser Spectroscopy (TDLS). In [1] strategy of this problem solution was described.

[1] A.Nadezhdinskii, I.Zasavitskii, in “Monitoring of gaseous pollutants by tunable diode lasers”, R.Grisar, H.Preier, G.Schmidtke, G.Restelli (Ed.), Proc. Int. Symposium, Freiburg, FRG 1986, D.Reidel Publ.Com., Dordrecht, 1987, p95-106.

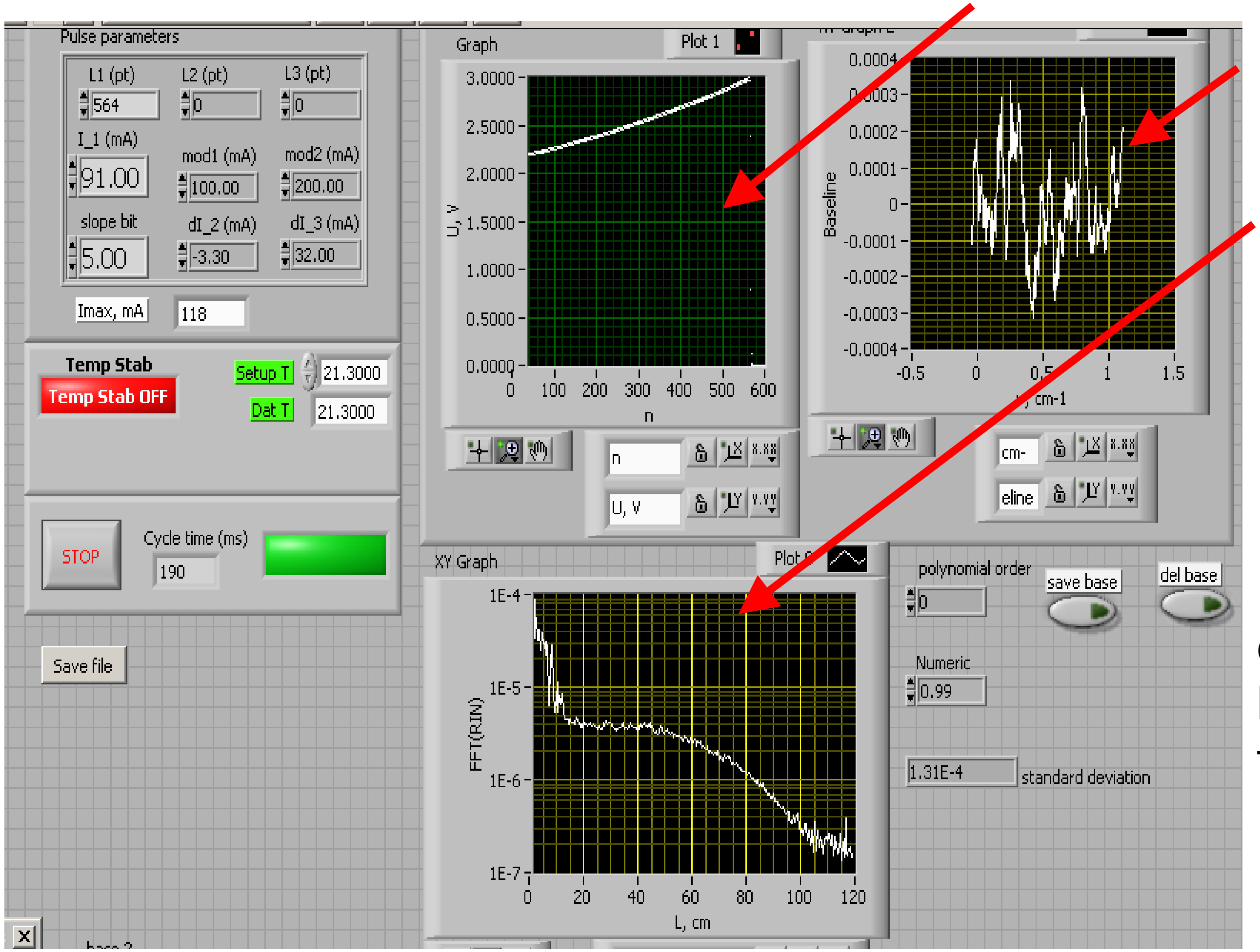
However, many authors continue to speak about interference as main mechanism of TDLS sensitivity limitation. In present paper this strategy together with new software developed is presented.

BaseLine Software

Signal

Baseline,

Baseline FFT, averaged over realizations.



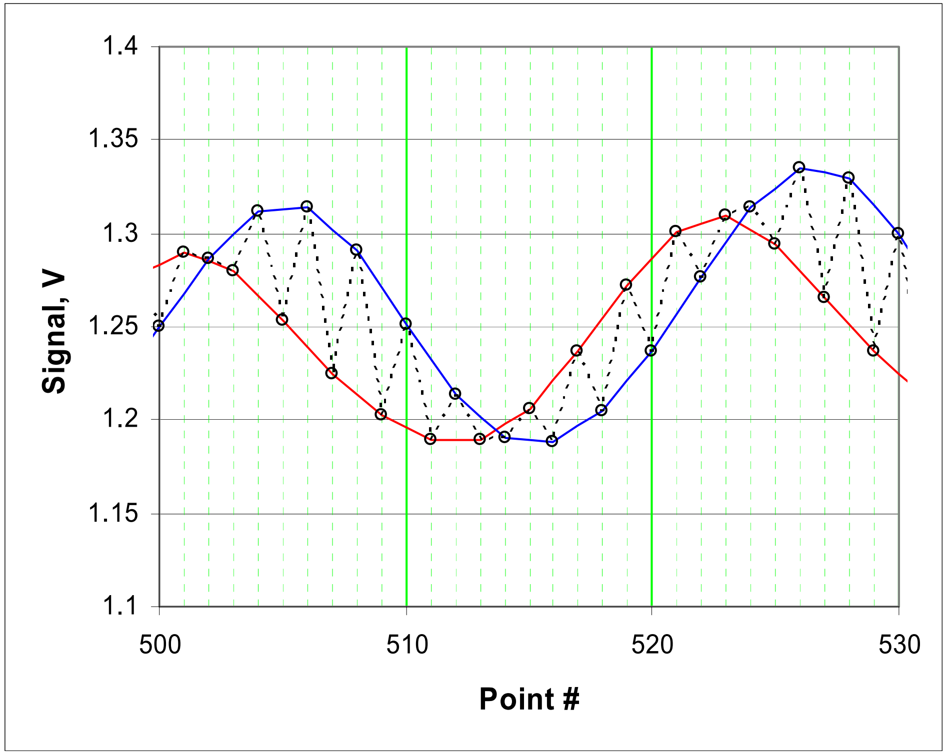
Last software version developed calculates also baseline correlation function.

Calibration:

Horizontal scale is calibrated to give distance between surfaces of reflection - L

Vertical scale gives amplitude of harmonic component

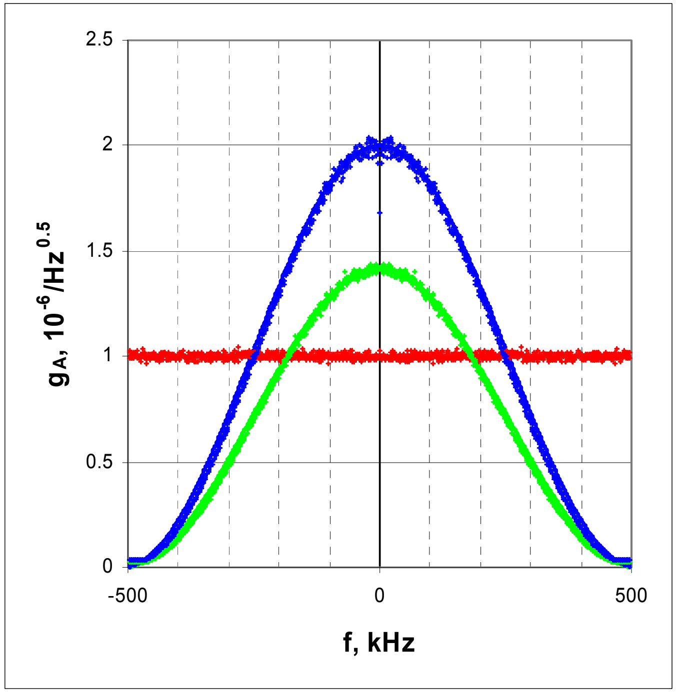
Baseline calculation



$$
\begin{array}{cccc}
 & i-1=2n-1 & i=2n & i+1=2n+1 \\
Even & \frac{1}{2}(S_{i-2}+S_i) & S_i & \frac{1}{2}(S_i+S_{i+2}) \\
Odd & S_{i-1} & \frac{1}{2}(S_{i+1}+S_{i-1}) & S_{i+1}
\end{array}
$$

$$B = \ln[Even - Odd]$$

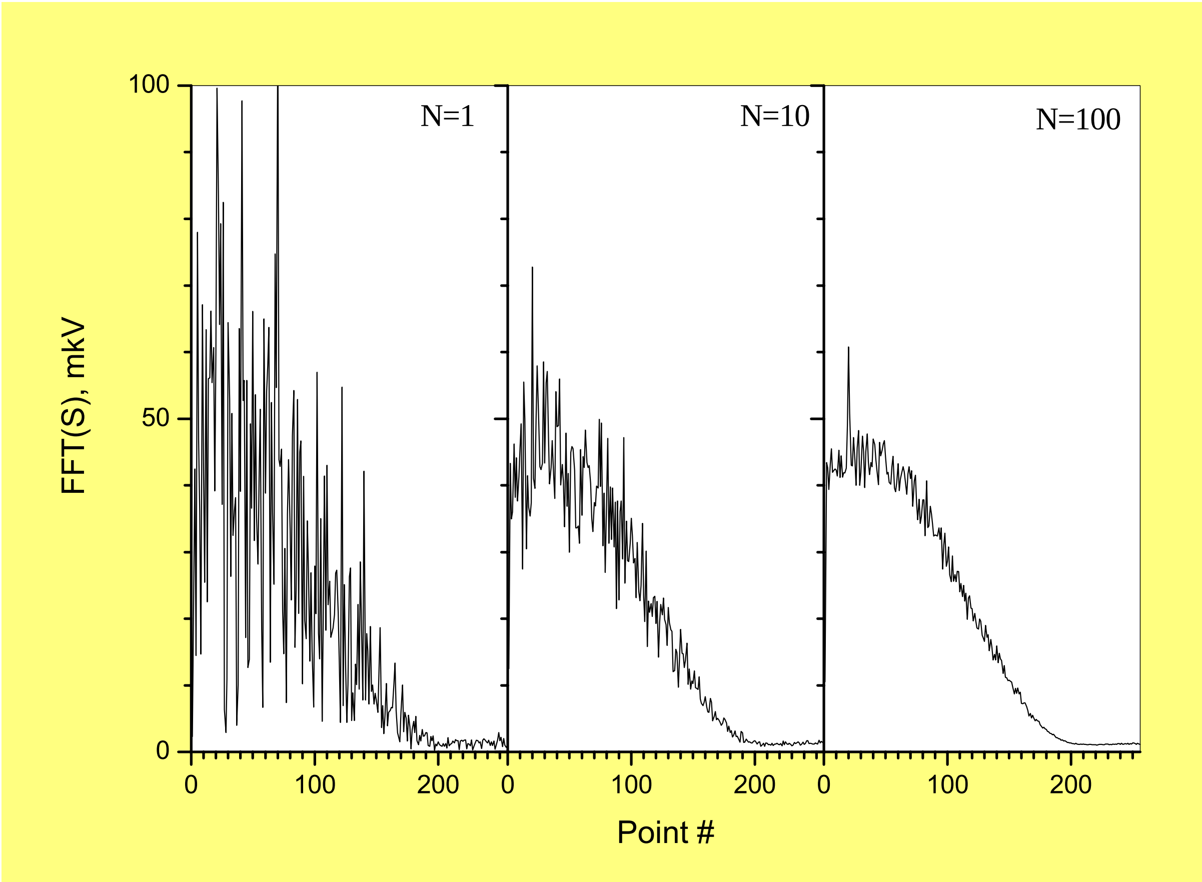
Signal fragment when FP etalon was installed in laser beam



Spectral density of white noise S (red), Even (green), and B (blue)

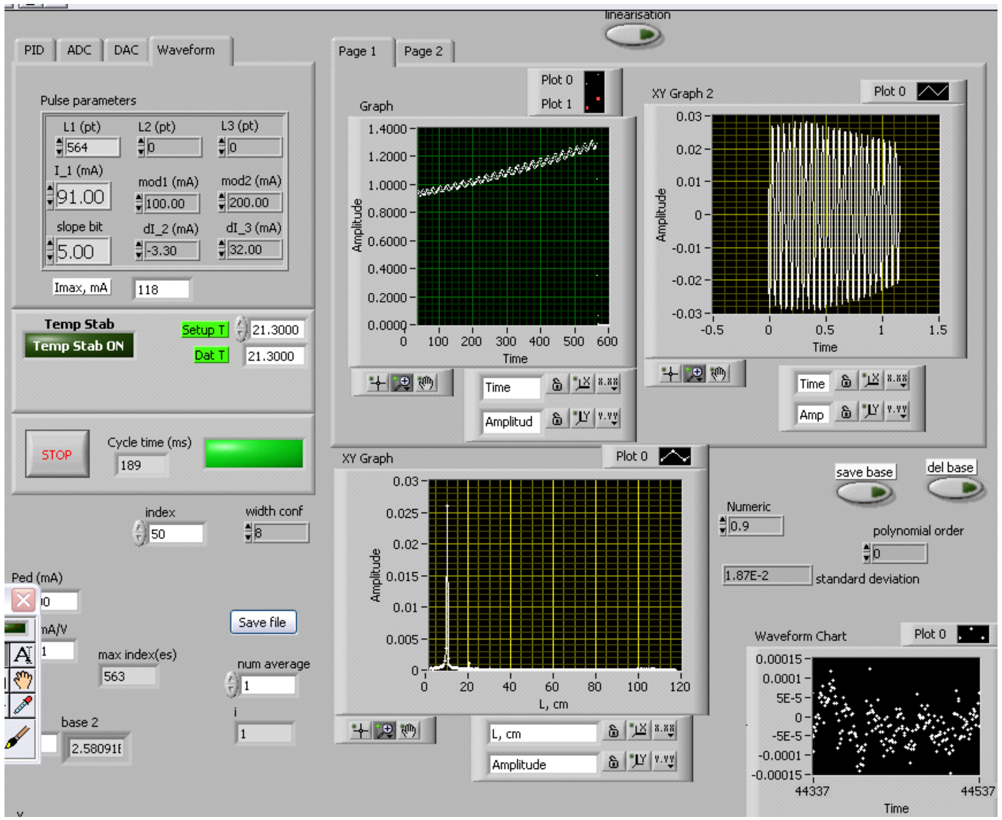
Realizations Averaging

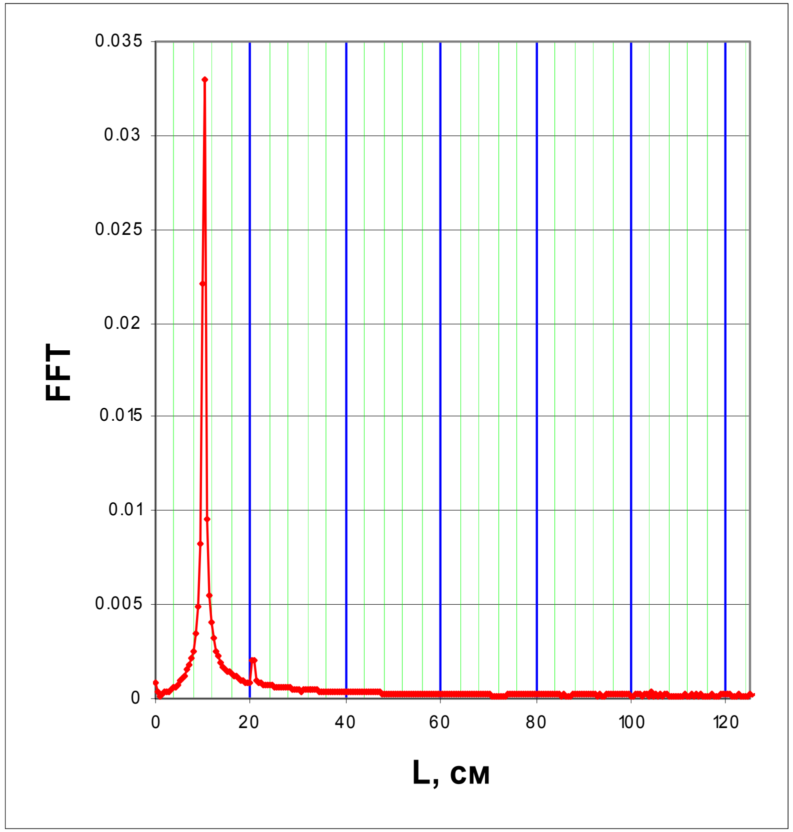
Time and realizations averaging are equivalent for white noise. In TDLS flicker noise and drift play dominant role. For these noise types realizations averaging is preferable.



Spectral density of photo-diode noise when realizations averaging module was used. Cross-talking peak is easily identified for 100 averages.

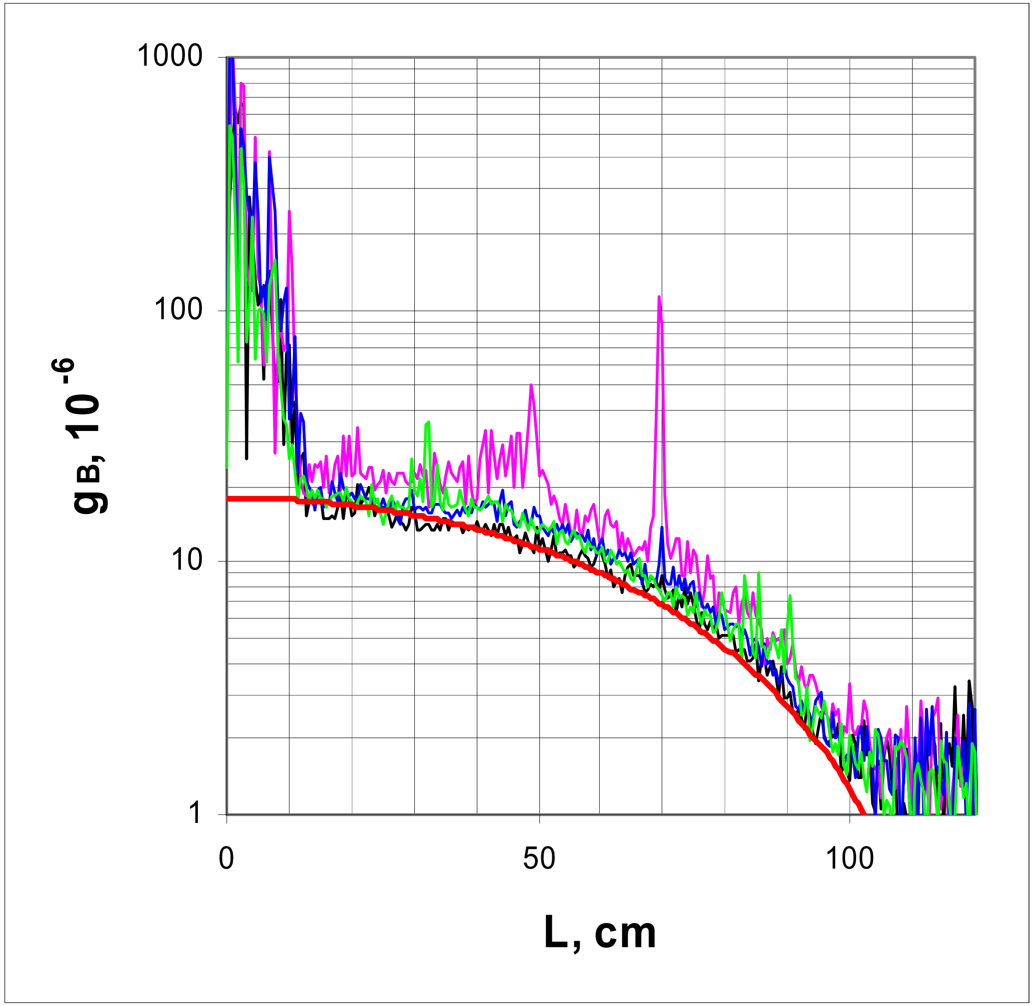
Frequency scale calibration





View of software interface when FP etalon (0.049421 cm^{-1} free spectral range) was installed in laser beam (left). FFT of recorded signal as function of optical distance between surfaces of reflection – L.

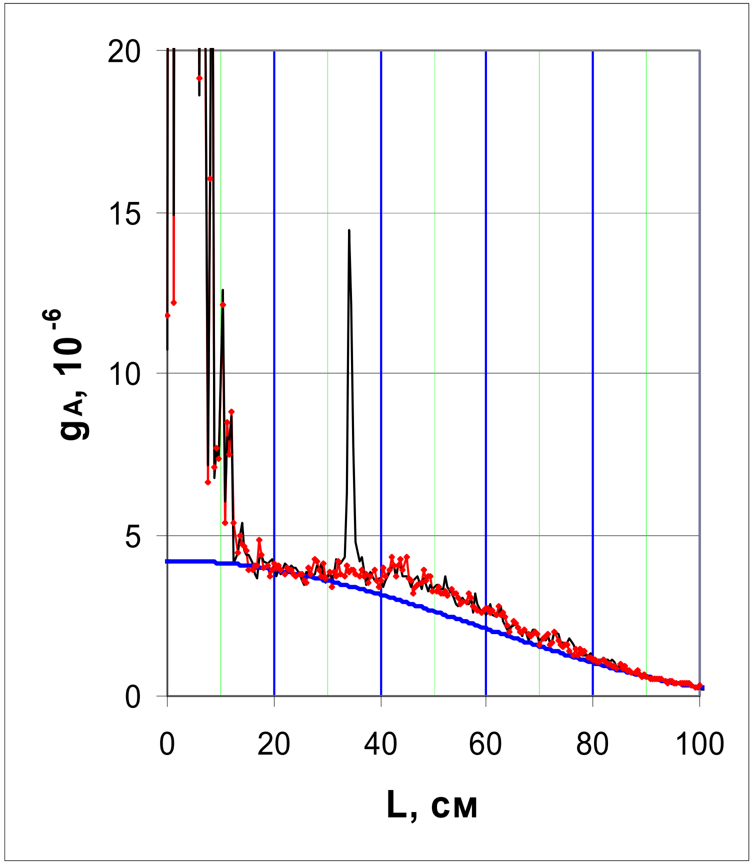
Interference Detection



Examples of baseline FFT for different optical scheme alignments. Red line presents photo diode white noise (photo-current shot noise in this case).

If interference peak is observed, responsible surface can be determined and undesirable reflection can be removed.

Interference for Diffuse Scattering



Experiment explanation :

Blue line – photo-current shot noise.

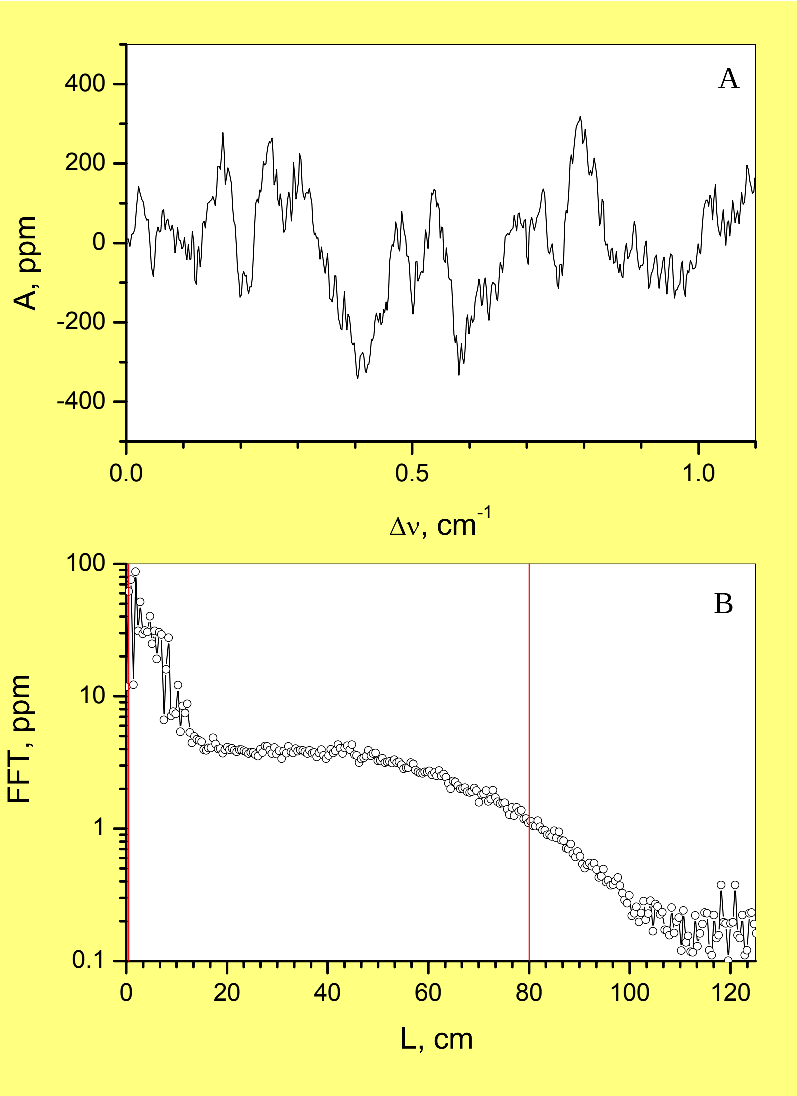
Red line – photo-diode was installed at distance of 75 cm from diode laser and detected small part of laser radiation (no optical elements between DL and PD).

Black line – white paper sheet was installed at 34 cm from DL; diverged laser beam was scattered by paper; small part of scattered light reached DL active area and produced optical feedback resulting in interference peak. One can also see interference of light scattered from environment at distance around 50 cm.

Estimations enable us to make following conclusion:

The most dangerous situation for TDLS: reflected or scattered light will hits DL active area, because this light will be amplified and gain in DL is very high.

Baseline



Experiment explanation:
Photo-diode was installed at distance of 80 cm from diode laser and detected small part of laser radiation (no optical elements between DL and PD). DL module had window at 2 mm from laser. Possible distances of reflection are shown by red vertical lines. All interference effects were reduced below 10^{-6} level.

Baseline (A) and its FFT (B)

Resume: Baseline is determined by DL properties (see separate poster).

Conclusion

1. *2 decades ago proposed strategy to suppress interference and optical feedback in TDLS was considered.*
2. *Software was developed to control interference and optical feedback in real time.*
3. *Baseline is determined by DL properties (see separate poster).*
4. *Using strategy under consideration and software developed interference fringes in our experements were suppressed below* $\mathbf{10^{-6}}$ *level.*