Analysis of Thin Film Transmittance

Last revised: 2013-06-10

Determination of the thickness and the optical constants of a thin film on a transparent substrate from the transmission spectrum based on the method and formulae by R. Swanepoel [J. Phys. E 16 (1983), 1214-1222].

The following requirements are necessary:

1. **The film is assumed to be homogeneous and of uniform thickness.**
2. **The substrate is transparent and thick (no interference).**
3. **For the envelope method, the spectrum must expose a sufficent number of interference minima and maxima for approximation of the envelopes.**

Folder containing the data files: DataFolder := "data"

Helper functions

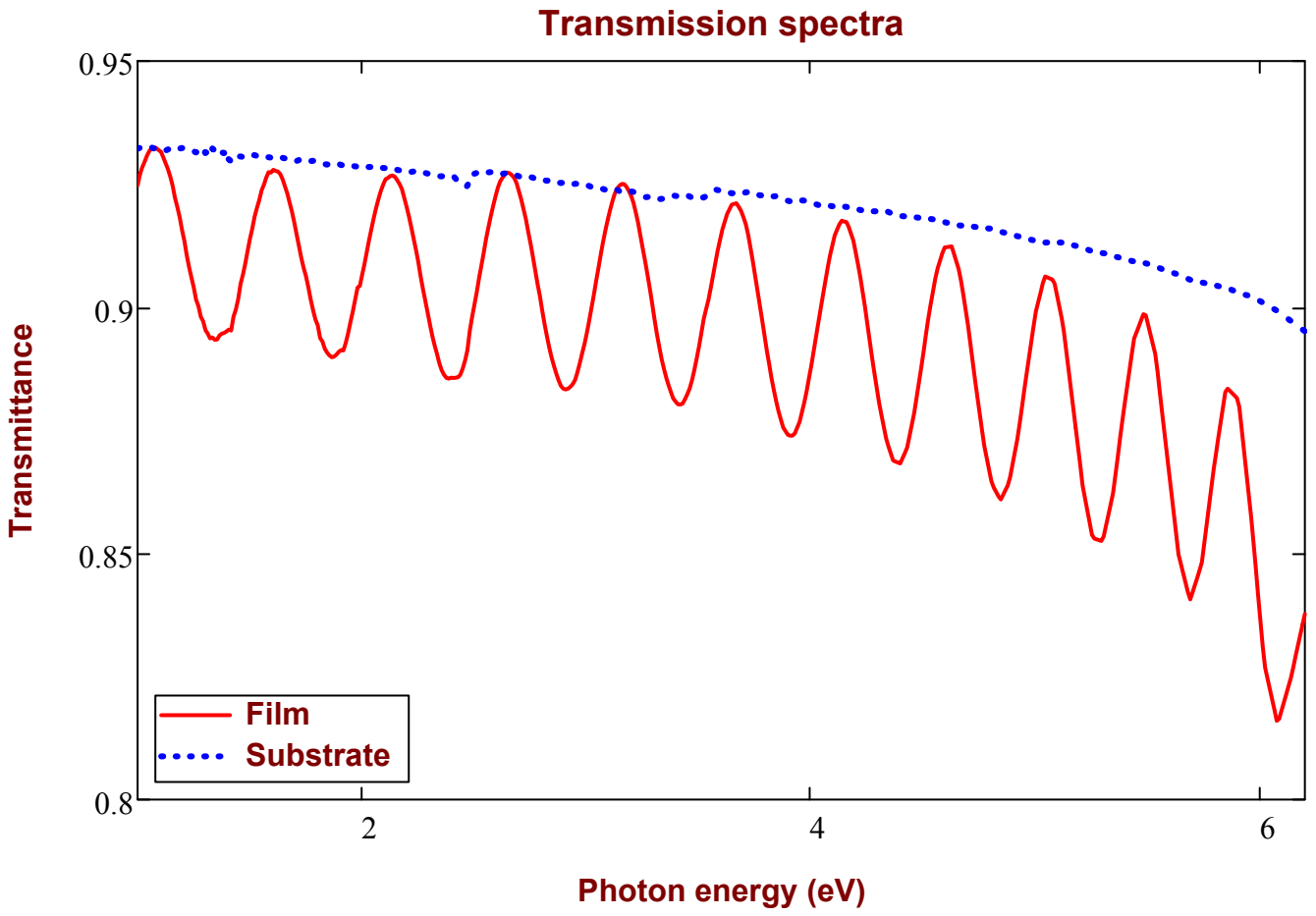
========== Experimental data ==========

$$\begin{pmatrix} \text{Substrate} \\ \text{Film} \end{pmatrix} := \begin{pmatrix} \text{"substrate.dat"} \\ \text{"film.dat"} \end{pmatrix}$$

$$\text{Settings} := \begin{pmatrix} \text{PERCENT} & \text{TRUE} \\ \text{UNIT} & \text{"nm"} \\ \text{MIN} & 1 \\ \text{POINTS} & 500 \end{pmatrix}$$

Click here for help

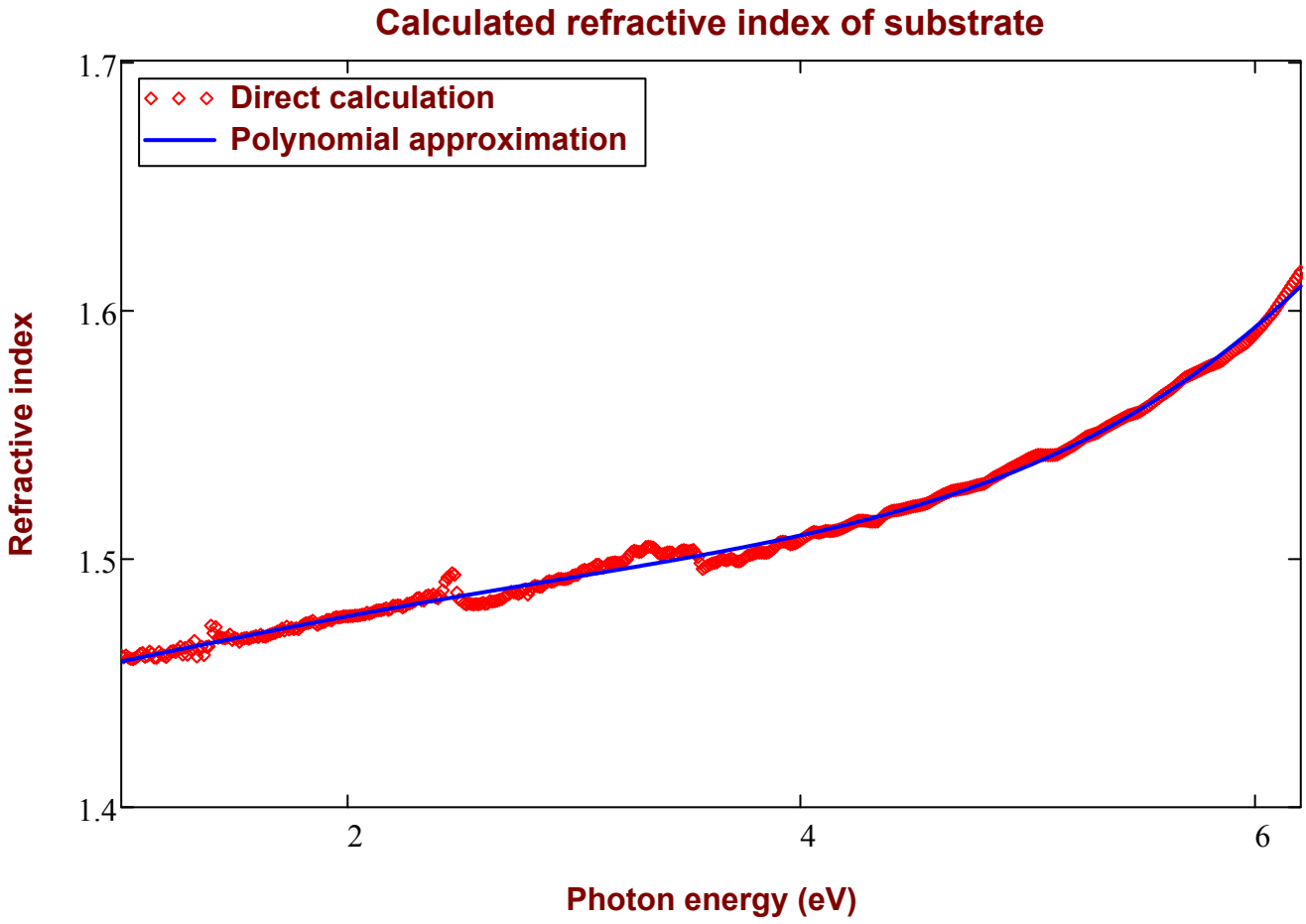
Processing



======= Refractive index of substrate =======

To get rid of the noise, a polynomial is used to model the experimental dispersion of substrate. Enter the order of the polynomial: Order := 4

Processing

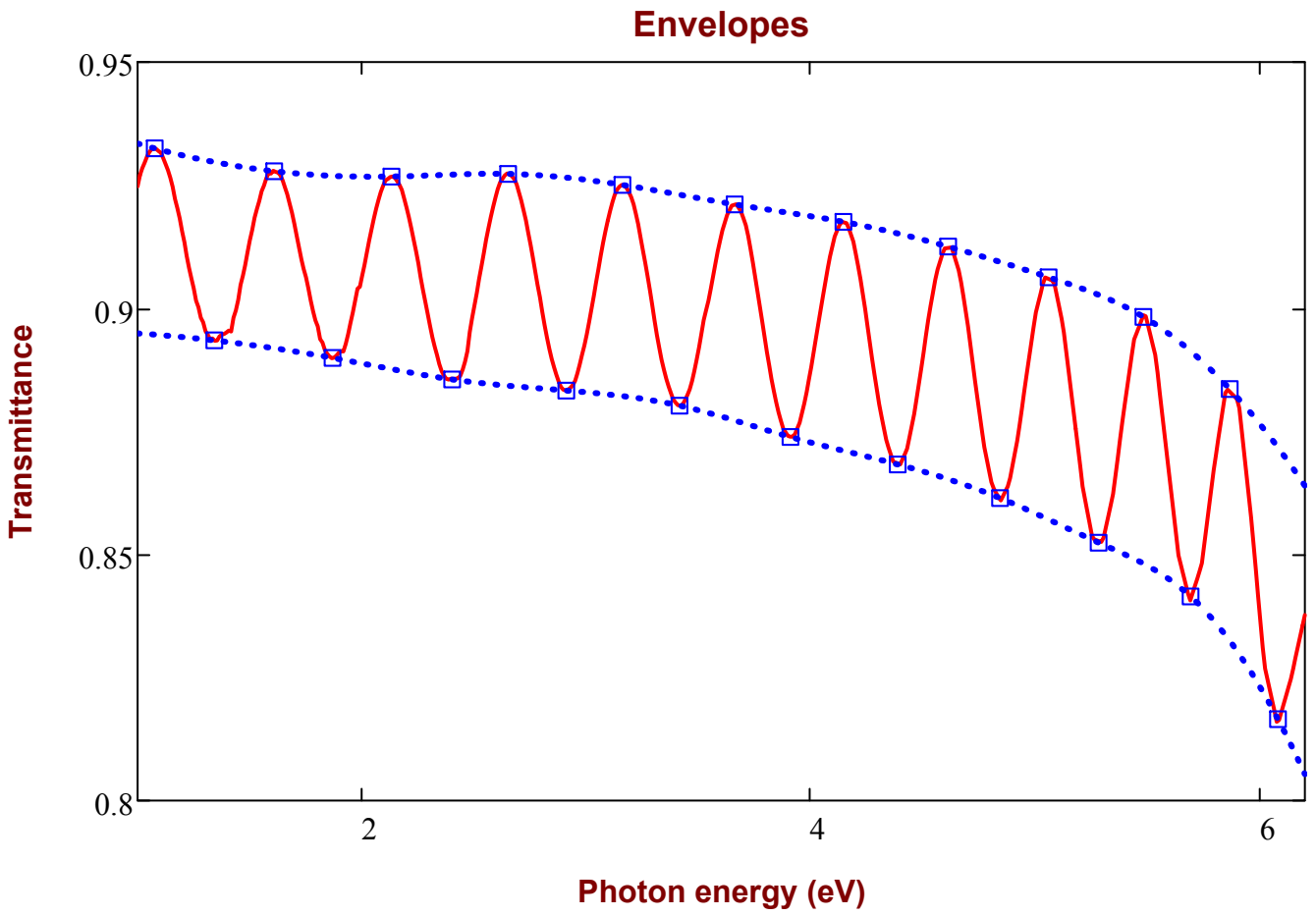


========== Envelopes ==========

$$\text{Settings} := \begin{pmatrix} \text{INTERP} & \text{PSPLINE} \\ \text{POINTS} & 7 \\ \text{SEP} & 0.2 \end{pmatrix}$$

Click here for help

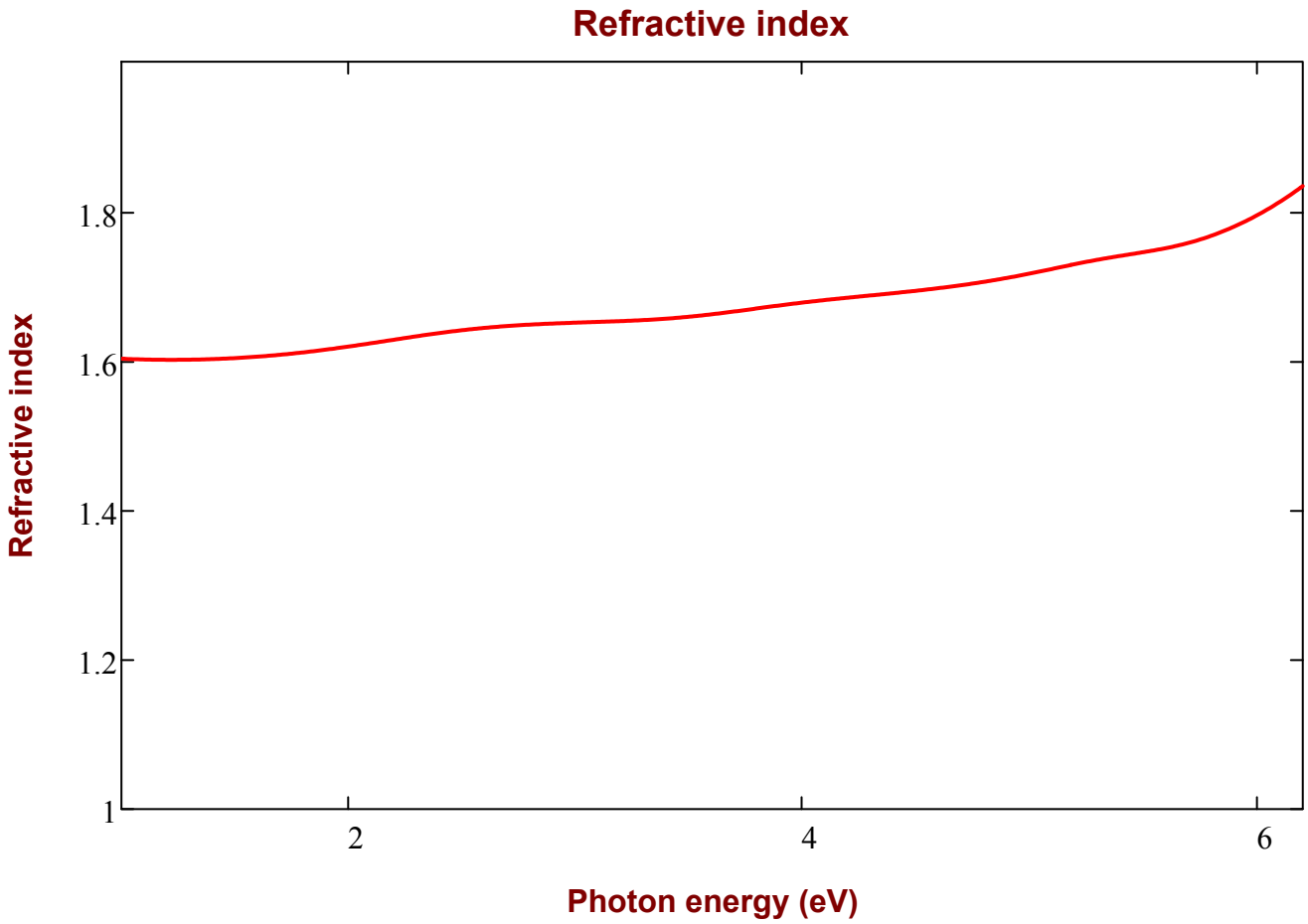
Processing



Reference wavelength $\lambda_{ref} := 550$

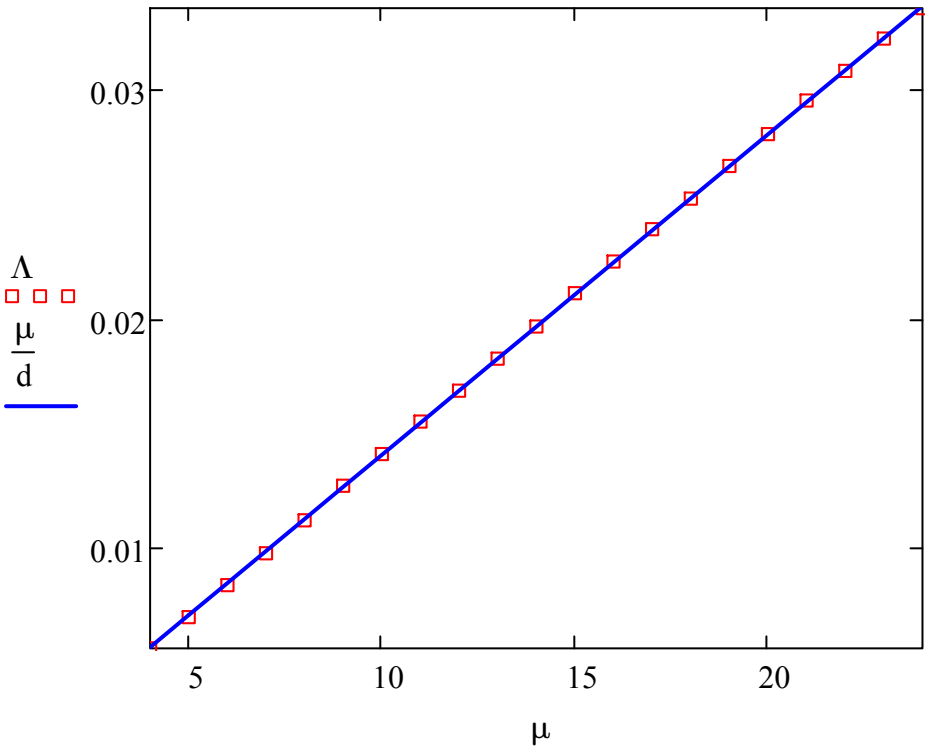
Processing

Refractive index at reference wavelength $n_{ref} = 1.631$



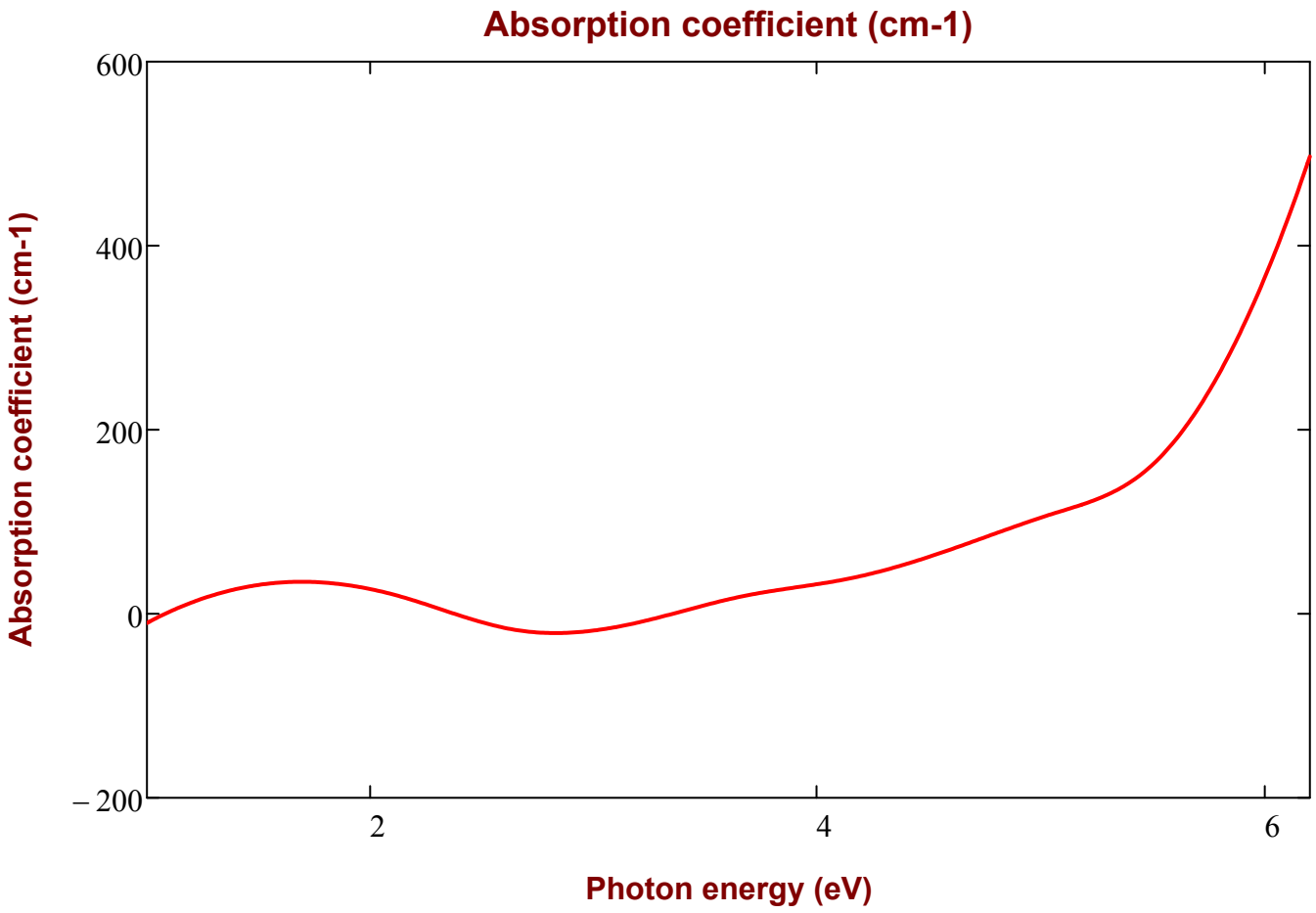
Remove points which diverge from the linear fit.
Number of points to remove from beginning and end: RemovePoints := (0 1)

Processing



Calculated thickness
d = 712.6

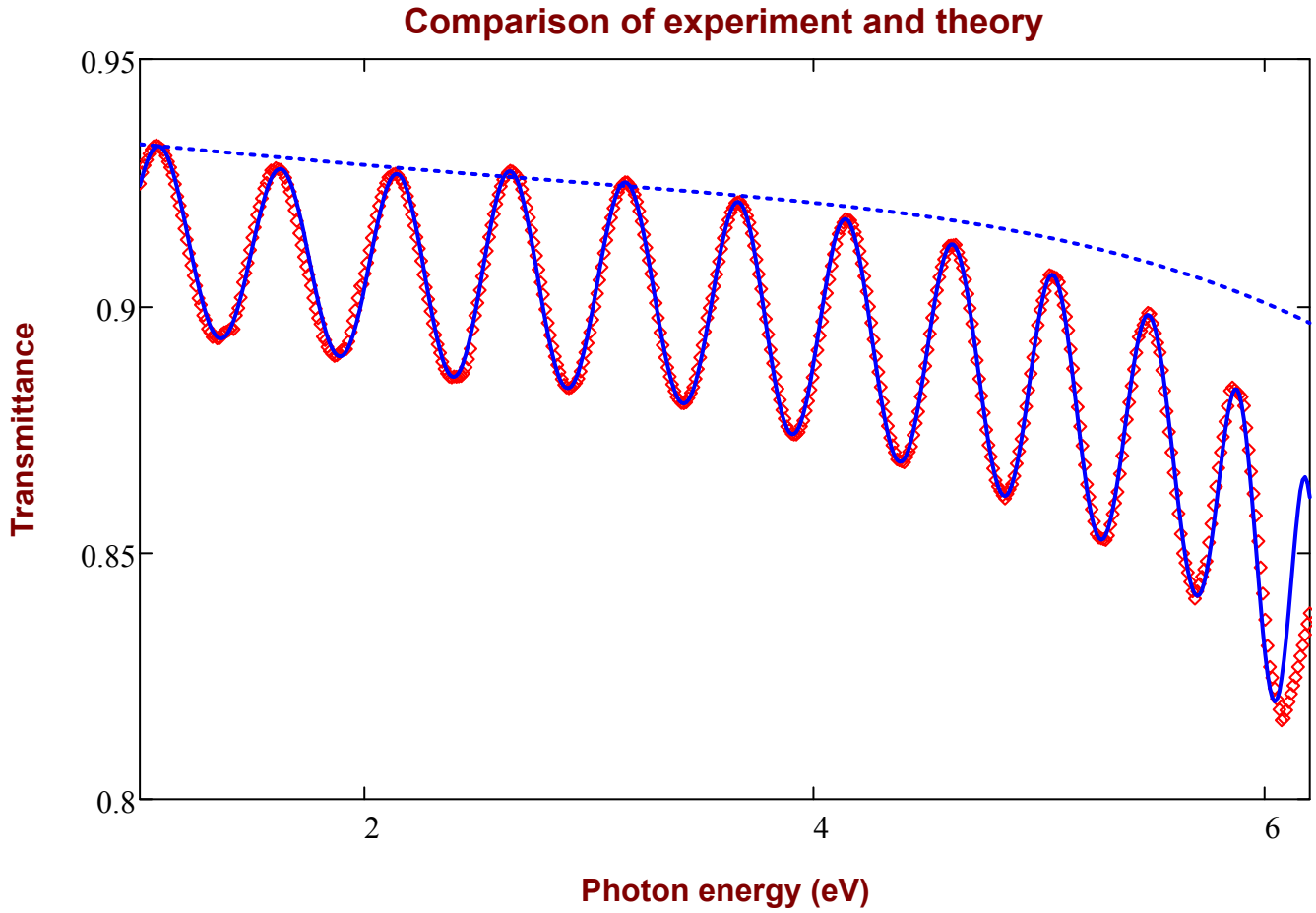
Processing


Absorption coefficient (cm-1)
600
400
200
0
– 200
Absorption coefficient (cm-1)
2
4
6
Photon energy (eV)

===== Modeling of transmission spectrum =====

Processing

Figure-of-merit FOM = 0.498·%



Processing

Spectral dependences were written to the file DataFile = "data\film.swanep.curves"

Order of data: E λ T T_s n α T_{model} T_{smodel}

Report was written to the file ReportFile = "data\film.swanep.report"

========== Least-squares fitting ==========

Initialize

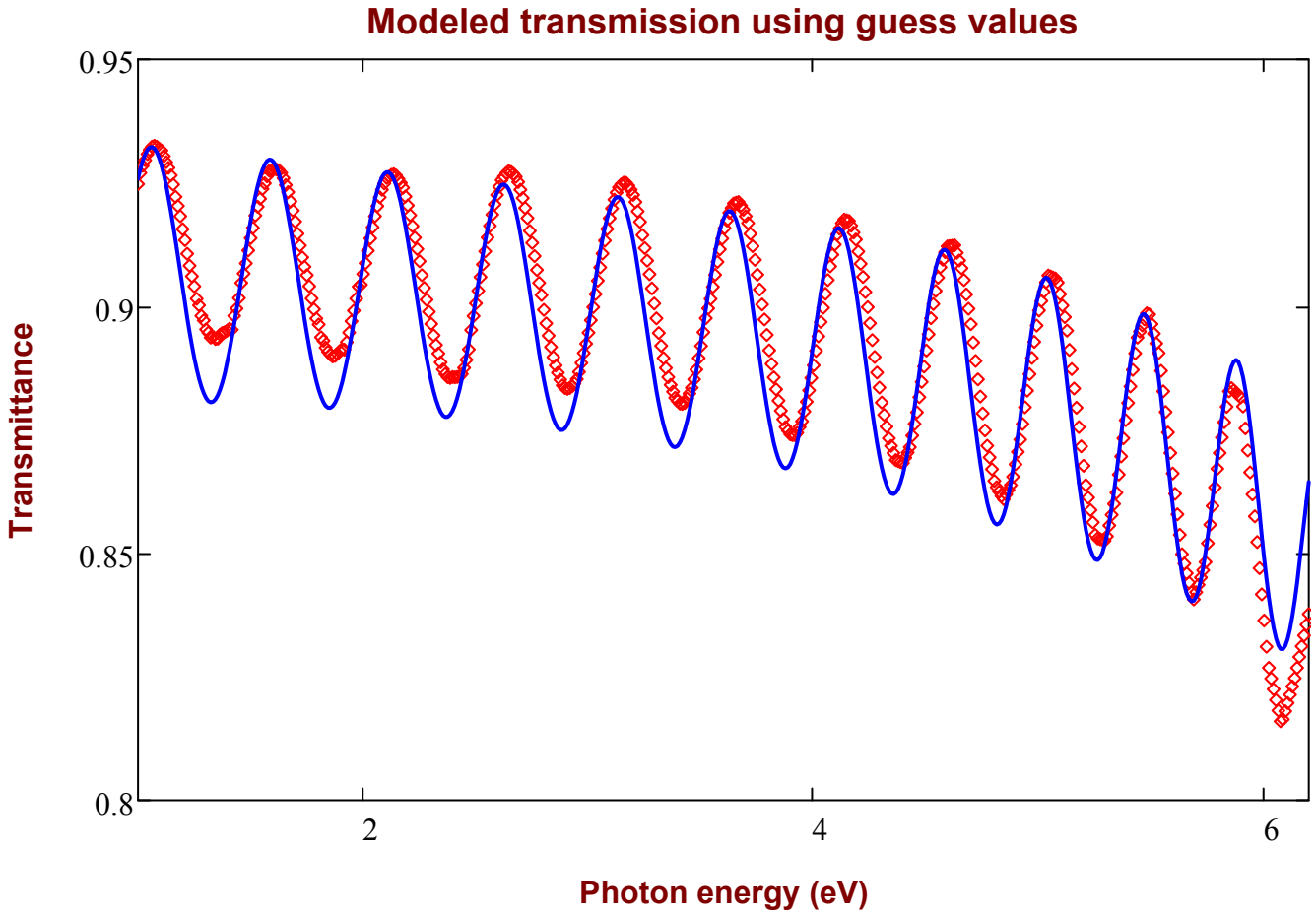
Dispersion model and guess values of all fitting parameters (incl. film thickness "d", its variability "delta" and film coverage "cover"):

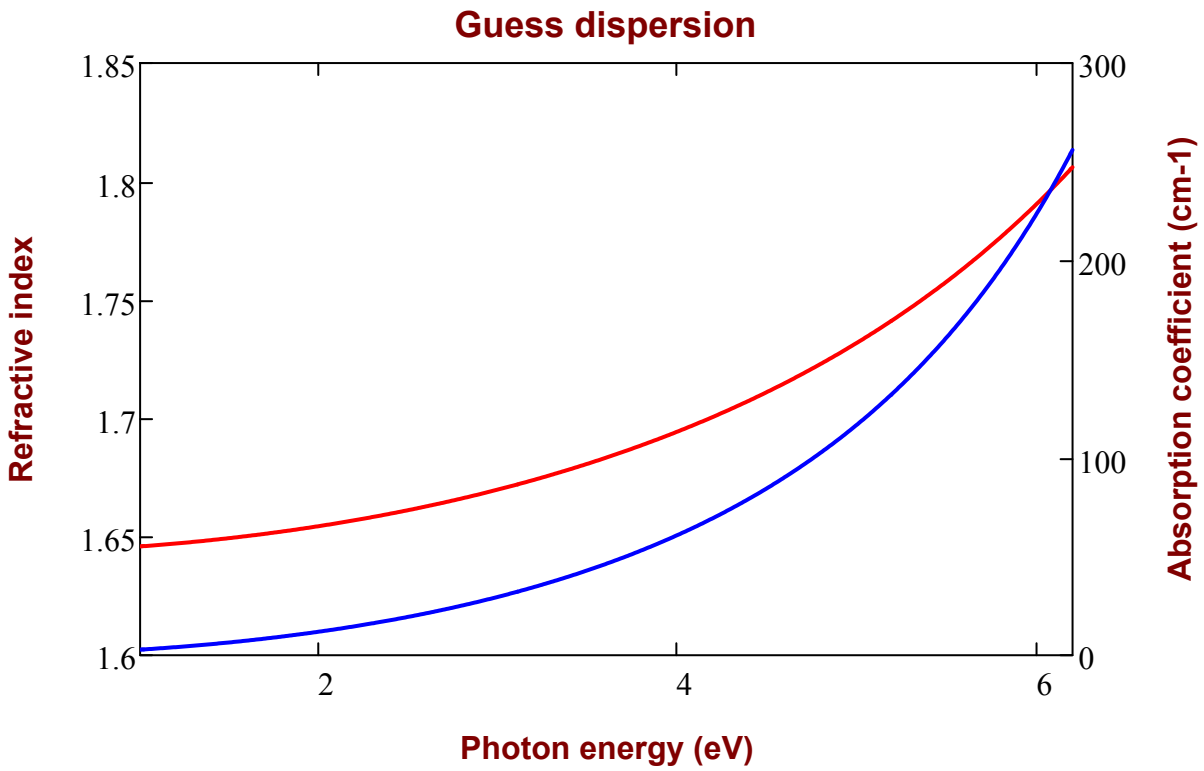
$$(\text{Dispersion Parameters}) := \left[\text{LORENTZ} \begin{pmatrix} \text{"eps}(\infty)\text{"} & 1.8 \\ \text{"A"} & 0.9 \\ \text{"E0"} & 10 \\ \text{"C"} & 0.01 \\ \text{"d"} & 710 \end{pmatrix}\right]$$

Click here for help

Processing

Figure-of-merit $\text{FOM} = 0.925 \cdot \%$




Guess dispersion
Refractive index
Absorption coefficient (cm-1)
Photon energy (eV)
1.85
1.8
1.75
1.7
1.65
1.6
300
200
100
0
2
4
6

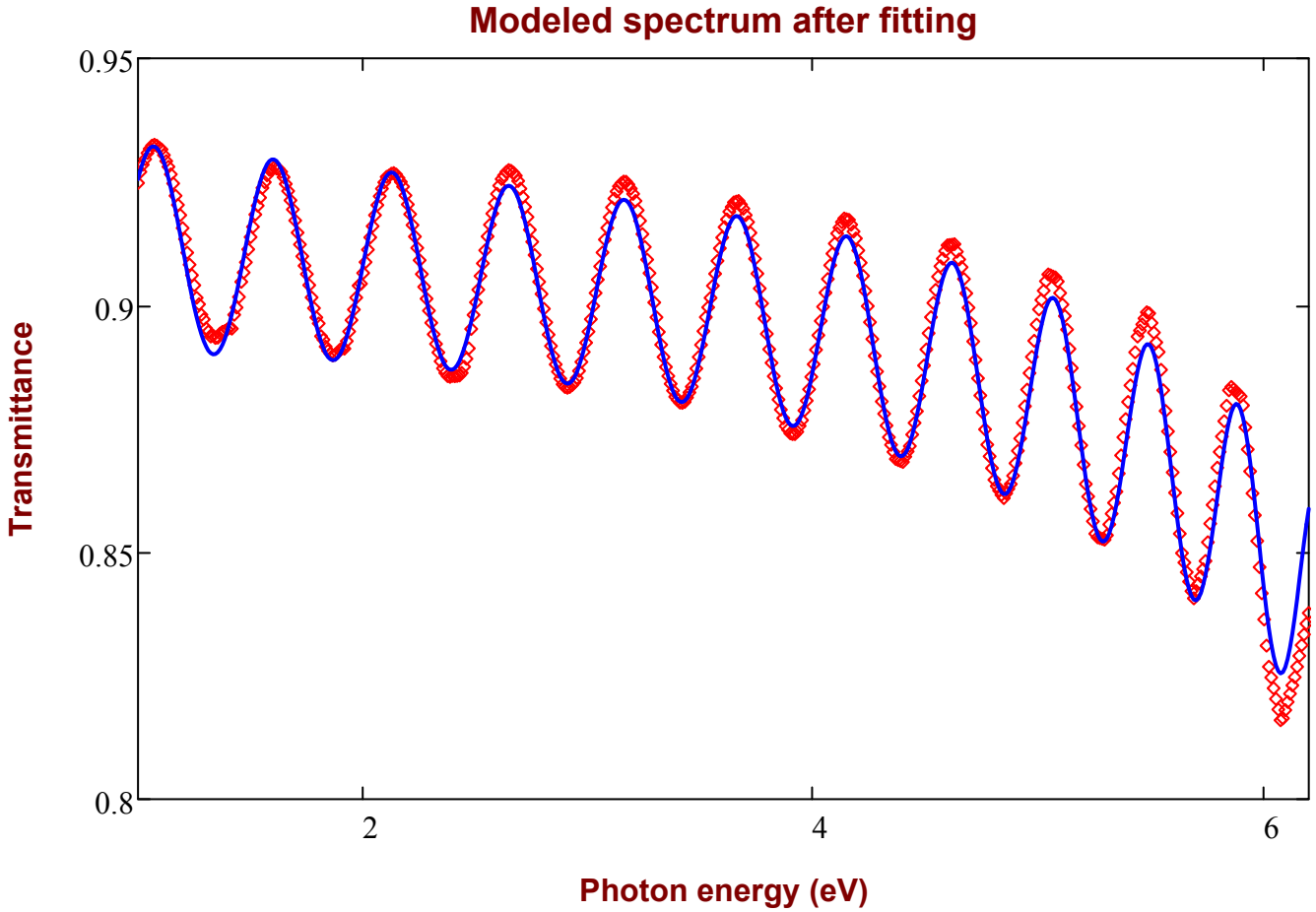
Processing

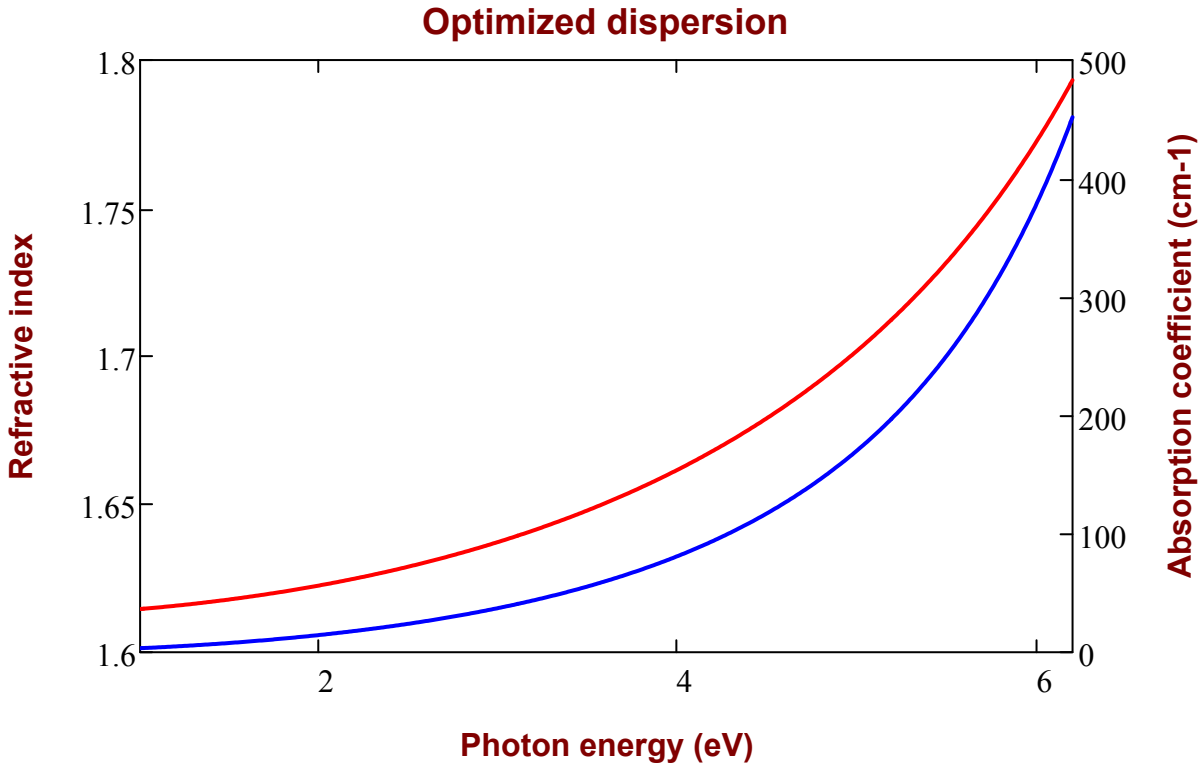
Optimized parameter values (copy-paste as new guess values to repeat optimization):

$$\text{Optimized} = \begin{pmatrix} \text{"eps}(\infty)\text{"} & 1.97753 \\ \text{"A"} & 0.6212 \\ \text{"E0"} & 8.78211 \\ \text{"C"} & 0.013 \\ \text{"d"} & 717.54467 \end{pmatrix}$$

Refractive index at reference wavelength $n_{ref} = 1.626$

Figure-of-merit $\text{FOM} = 0.389 \cdot \%$





Processing

Spectral dependences were written to the file DataFile = "data\film.leastsq.curves"

Order of data: E λ T T_s n α T_{model} T_{smodel}

Report was written to the file ReportFile = "data\film.leastsq.report"

========== End of Program ==========