

```

In[1]:= Clear[ω]

In[2]:= Off[NIntegrate::inumr];

In[70]:= (* Parameter *)

cLA := 5.11*10^(-3)
kB := 8.617*10^(-5)
hbar := 0.658
γ := 1 / (5000)
ρ := 5.37 / (1.602*10^(-7))
D1 := -4.8
D2 := -14.6
l1 := 3.19
l2 := 5.8

In[79]:= (* Dispersionsrelation *)

ωBose[q_] := cLA q

(* Bose-Einstein-Verteilung *)

n[q_, T_] := 1 / (Exp[hbar ωBose[q] / (kB T)] - 1)

(* Kopplungselement *)

g[q_] := Sqrt[q / (2 hbar ρ cLA)] (D1 Exp[-q^2 l1^2 / 4] - D2 Exp[-q^2 l2^2 / 4])

(*****
*** Aufgabe 22(b) ***
*****)

(* Polarisation *)

p[ω_, T_] := Ω[ω] / (- I γ - ω - 1 / (2 π^2) NIntegrate[ (g[q])^2 q^2
  ((n[q, T] + 1) / (-I γ + ωBose[q] - ω) + n[q, T] / (-I γ - ωBose[q] - ω)), {q, 0, 2}])

In[83]:= pFree[ω_] := Ω[ω] / (- I γ - ω) (* zum Vergleich: System ohne Phononen *)

(* Absorption *)

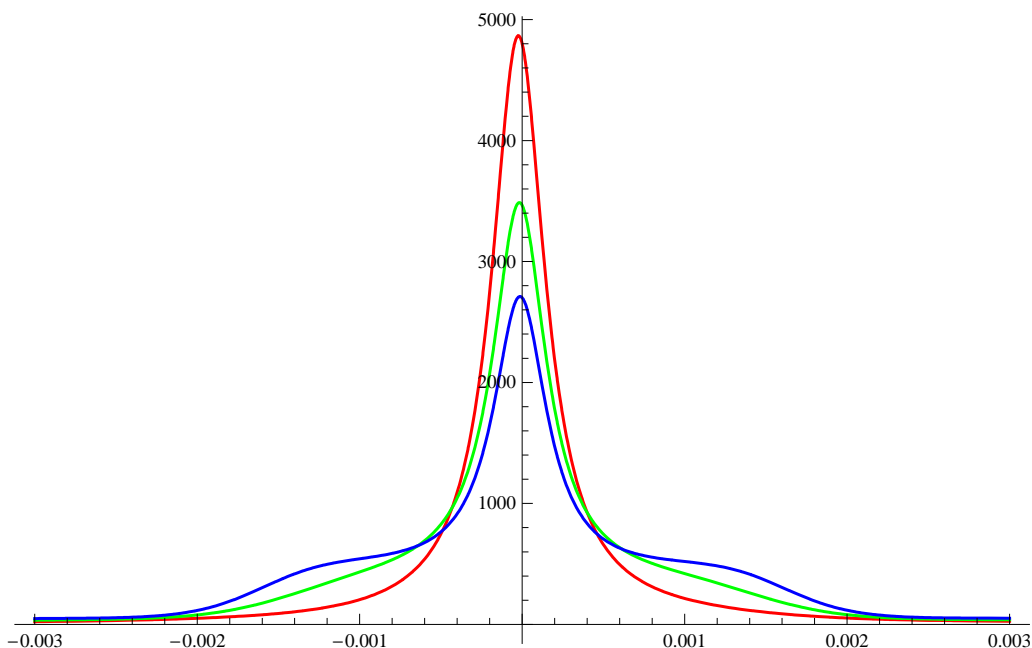
α[ω_, T_] := p[ω, T] / Ω[ω]
αFree[ω_] := pFree[ω] / Ω[ω]

(*** Absorption für T = 4K, 77K, 150K ***

Plot[{Im[α[ω, 4]], Im[α[ω, 77]], Im[α[ω, 150]]},
  {ω, -0.003, 0.003}, PlotRange -> All, PlotStyle ->
  {{Red, Thickness[0.003]}, {Green, Thickness[0.003]}, {Blue, Thickness[0.003]}}]

```

Out[86]=

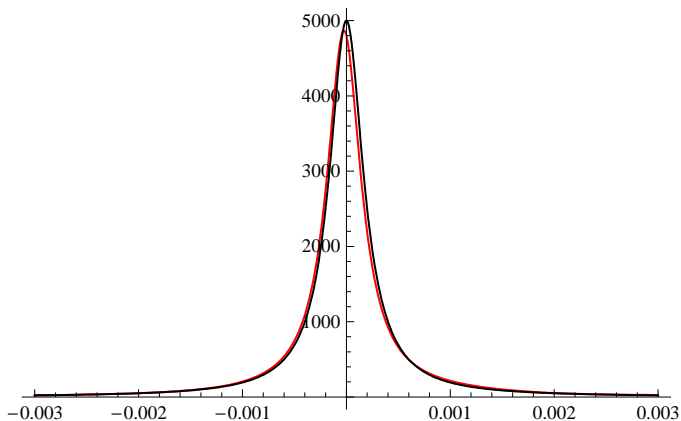


(***** Vergleich mit freiem System *****)

(* T = 4K *)

```
Plot[{Im[α[ω, 4]], Im[αFree[ω]]}, {ω, -0.003, 0.003}, PlotRange → All,
PlotStyle -> {{Red, Thickness[0.003]}, {Black, Thickness[0.003]}}
```

Out[51]=

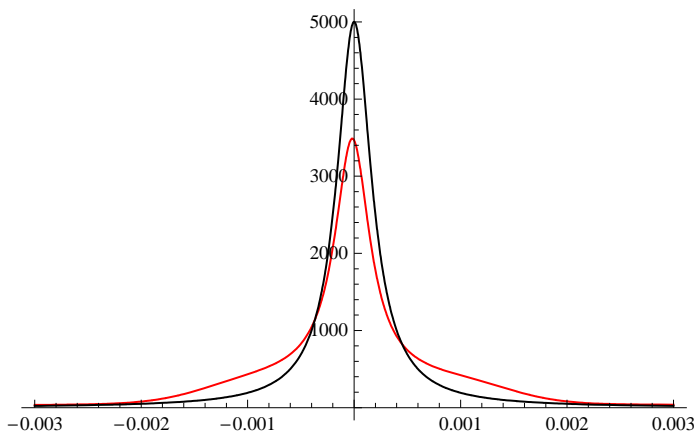


In[68]=

(* T = 77K *)

```
Plot[{Im[α[ω, 77]], Im[αFree[ω]]}, {ω, -0.003, 0.003}, PlotRange → All,
PlotStyle -> {{Red, Thickness[0.003]}, {Black, Thickness[0.003]}}
```

Out[68]=

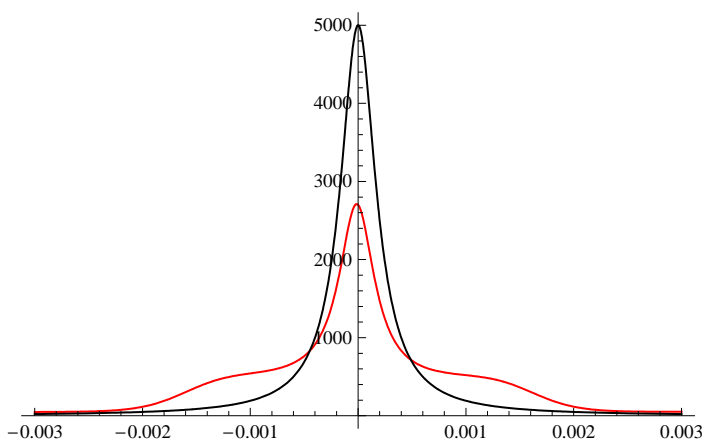


In[69]=

(* T = 150K *)

```
Plot[{Im[α[ω, 150]], Im[αFree[ω]]}, {ω, -0.003, 0.003}, PlotRange → All,
PlotStyle -> {{Red, Thickness[0.003]}, {Black, Thickness[0.003]}}
```

Out[69]=



```
(*****  
(** Aufgabe 22(c) **)  
(***)
```

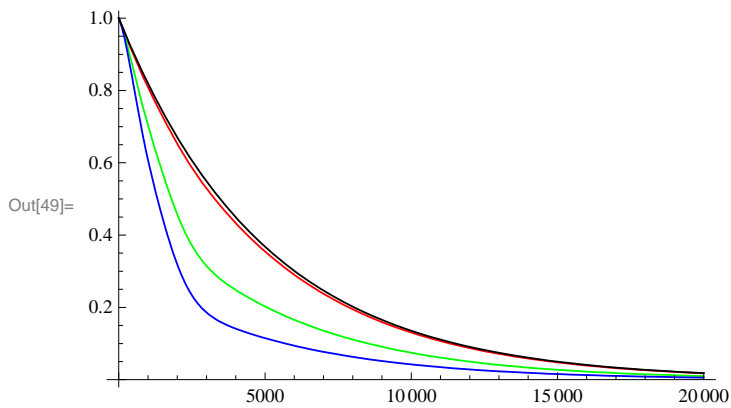
```
(* Polarisation *)
```

```
pIBM[t_, T_] := Exp[1 / (2 π^2) NIntegrate[ (g[q] / ωBose[q])^2 q^2  
  ((n[q, T] + 1) (Exp[-I ωBose[q] t] - 1) + n[q, T] (Exp[I ωBose[q] t] - 1) + I ωBose[q] t),  
  {q, 0, 2}]] Exp[-γ t] HeavisideTheta[t]
```

```
pIBMFree[t_] := Exp[-γ t] (* zum Vergleich: System ohne Phononen *)
```

```
(** Polarisation für T = 4K, 77K, 150K, freies Spektrum **)
```

```
Plot[{Abs[pIBM[t, 4]], Abs[pIBM[t, 77]], Abs[pIBM[t, 150]], Abs[pIBMFree[t]]},  
  {t, 0, 20000}, PlotStyle -> {{Red, Thickness[0.003]},  
  {Green, Thickness[0.003]}, {Blue, Thickness[0.003]}, {Black, Thickness[0.003]}}
```



```
(* Fourier-Transformation *)
```

```
pIBMFT[ω_, T_] := NIntegrate[pIBM[t, T] Exp[I ω t], {t, 0, 20000}]
```

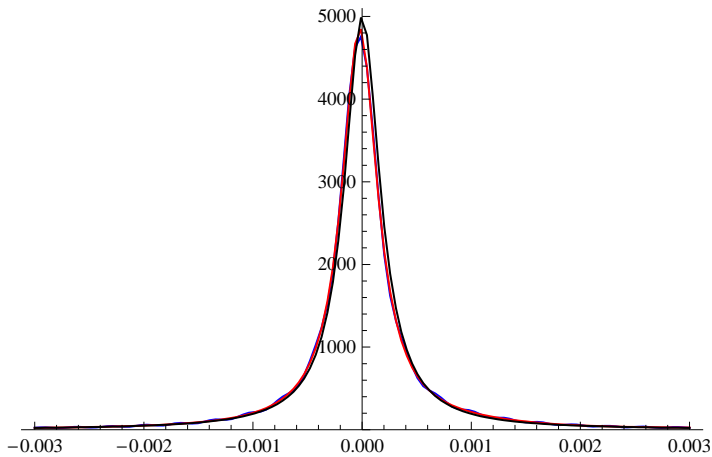
```
pIBMFreeFT[ω_] := NIntegrate[pIBMFree[t] Exp[I ω t], {t, 0, 50000}]
```

(** Absorption: IBM, Störungstheorie, freies Spektrum **)

(* Absorption für T = 4K *)

```
Plot[{Re[pIBMFT[ $\omega$ , 4]], Im[ $\alpha$ [ $\omega$ , 4]], Im[ $\alpha$ Free[ $\omega$ ]], { $\omega$ , -0.003, 0.003},
PlotPoints -> 30, MaxRecursion -> 2, PlotRange -> {0, 5100}, PlotStyle ->
{{Blue, Thickness[0.003]}, {Red, Thickness[0.003]}, {Black, Thickness[0.003]}}
```

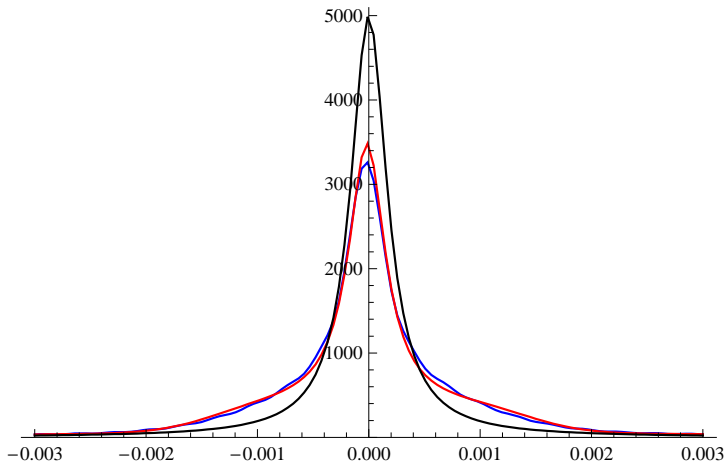
Out[58]=



(* Absorption für T = 77K *)

```
Plot[{Re[pIBMFT[ $\omega$ , 77]], Im[ $\alpha$ [ $\omega$ , 77]], Im[ $\alpha$ Free[ $\omega$ ]], { $\omega$ , -0.003, 0.003},
PlotPoints -> 30, MaxRecursion -> 2, PlotRange -> {0, 5100}, PlotStyle ->
{{Blue, Thickness[0.003]}, {Red, Thickness[0.003]}, {Black, Thickness[0.003]}}
```

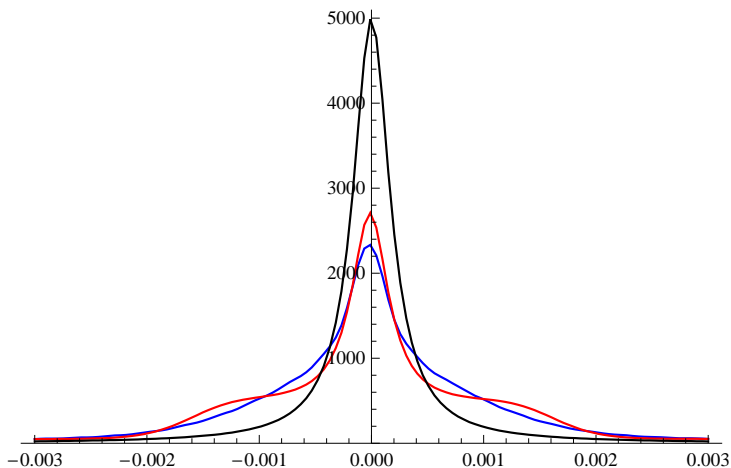
Out[59]=



(* Absorption für T = 150K *)

```
Plot[{Re[pIBMFT[ $\omega$ , 150]], Im[ $\alpha$ [ $\omega$ , 150]], Im[ $\alpha$ Free[ $\omega$ ]], { $\omega$ , -0.003, 0.003},
PlotPoints -> 30, MaxRecursion -> 2, PlotRange -> {0, 5100}, PlotStyle ->
{{Blue, Thickness[0.003]}, {Red, Thickness[0.003]}, {Black, Thickness[0.003]}}
```

Out[60]=

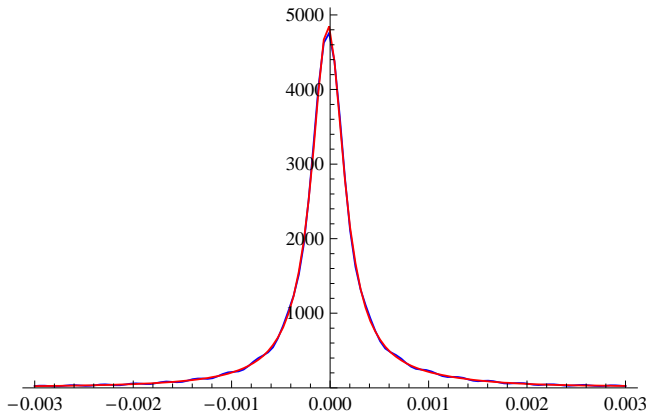


(***** Vergleich IBM, Störungstheorie *****)

(* Absorption für T = 4K *)

```
Plot[{Re[pIBMFT[ $\omega$ , 4]], Im[ $\alpha$ [ $\omega$ , 4]]}, { $\omega$ , -0.003, 0.003}, PlotPoints -> 30, MaxRecursion -> 2,
PlotRange -> {0, 5100}, PlotStyle -> {{Blue, Thickness[0.003]}, {Red, Thickness[0.003]}}
```

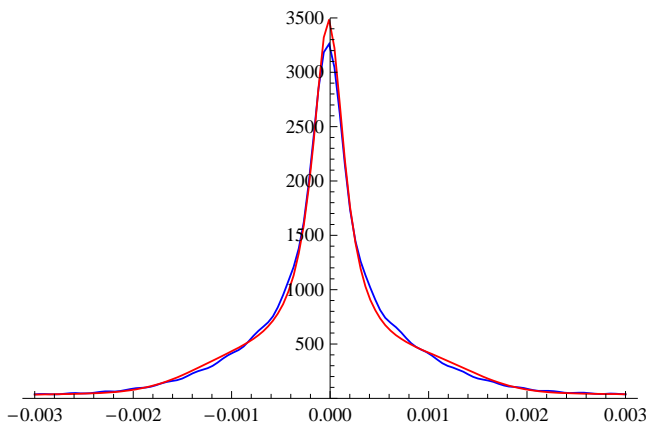
Out[61]=



(* Absorption für T = 77K *)

```
Plot[{Re[pIBMFT[ $\omega$ , 77]], Im[ $\alpha$ [ $\omega$ , 77]]}, { $\omega$ , -0.003, 0.003},
PlotPoints -> 30, MaxRecursion -> 2, PlotRange -> {0, 3500},
PlotStyle -> {{Blue, Thickness[0.003]}, {Red, Thickness[0.003]}}
```

Out[62]=



(* Absorption für T = 150K *)

```
Plot[{Re[pIBMFT[ $\omega$ , 150]], Im[ $\alpha$ [ $\omega$ , 150]]}, { $\omega$ , -0.003, 0.003},
PlotPoints -> 30, MaxRecursion -> 2, PlotRange -> {0, 2800},
PlotStyle -> {{Blue, Thickness[0.003]}, {Red, Thickness[0.003]}}
```

Out[63]=

