Transient response, low-Q

In[45]:=
```
SetDirectory[
 "/home/ybadal/Documents/Coursework/2_Smore_Year/2_Winter_2018/Ph 6/Lab 1"]
```

In[124]:=
```
LoadFile["transient_response_low_q.dat"]
```

In[125]:=
```
With[{x = SetXRange[ LinearDataPlot[], Log -> False,
     Label -> "Set the X values for the range you wish to keep." ]},
 Print[x];

 XRangeKeep[Sequence @@ x]
]
```

```
{0.07, 1.635}

n= 1956

544 points removed.
```

In[127]:=
```
FitData[
  (* The expression defining the function *) A Sin[2 Pi fo t - ϕ Degree] Exp[-t / τ] + c,
 (* The symbol for the variable in the expression *) t,
 (* A list of the parameters in the function to fit *) {A, fo , ϕ, τ , c },
 (* A list of starting values for the parameters *) {0.05, 15.3, 10, 0.2, 0 }
]
```

n = 1956

p = 5

$f[t] = c + A\, e^{-\frac{t}{\tau}} \mathrm{Sin}[2\, fo\, \pi\, t - {}^{\circ}\, \phi]$

Fit of (x,y) (unweighted):

A	=	0.0776126	±	0.0000102029
fo	=	15.5638	±	0.000069428
ϕ	=	17.3716	±	0.00771594
τ	=	0.359143	±	0.000055592
c	=	0.00460317	±	1.18338×10^{-6}

Std. Deviation = 0.0000522996

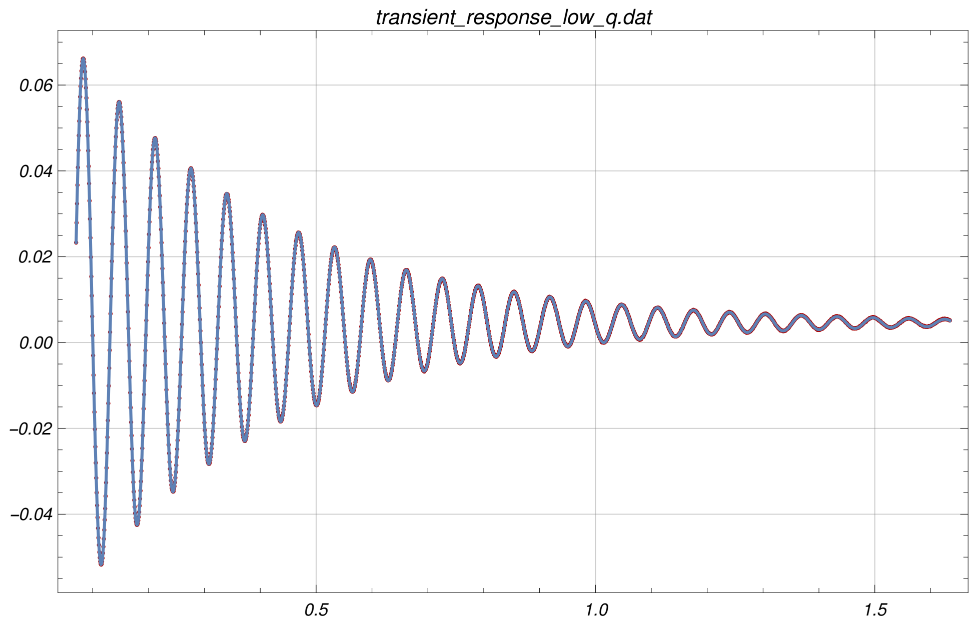
Fit of (x,y±σ_y):

A	=	0.0776037	±	6.89908×10^{-6}
fo	=	15.5638	±	0.0000456056
ϕ	=	17.3703	±	0.00539098
τ	=	0.359198	±	0.0000358152
c	=	0.0046033	±	7.62552×10^{-7}

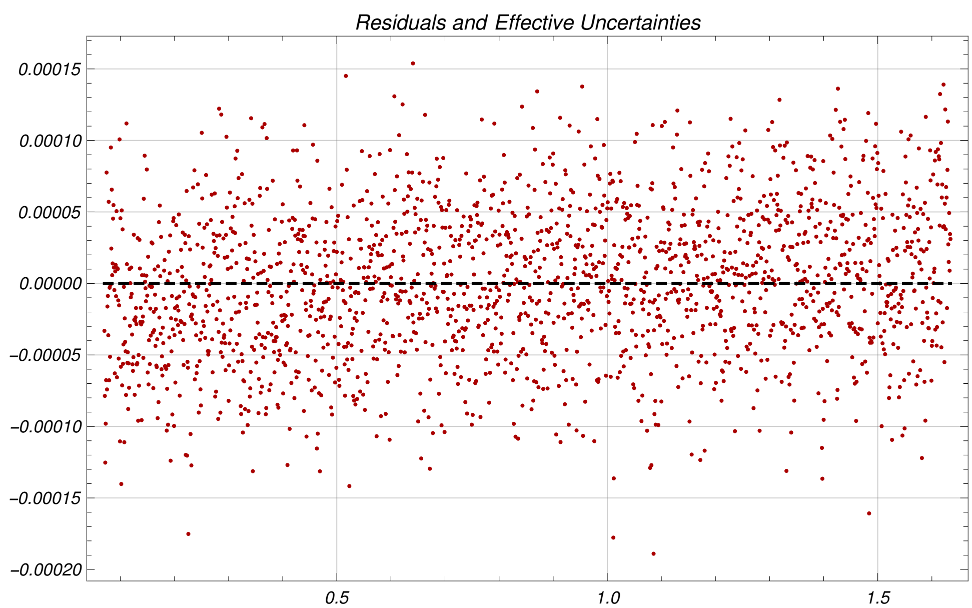
$\frac{\chi^2}{n - p} = 2.28273$

Out[127]= $\{A \to 0.0776037,\ fo \to 15.5638,\ \phi \to 17.3703,\ \tau \to 0.359198,\ c \to 0.0046033\}$

In[128]:= `LinearDifferencePlot[Joined → False]`



Out[128]=



$f[t] = c + A\, e^{-\frac{t}{\tau}} \mathrm{Sin}[2\, fo\, \pi\, t - {}^{\circ}\, \phi]$

A	=	0.0776037	±	6.89908×10^{-6}
fo	=	15.5638	±	0.0000456056
ϕ	=	17.3703	±	0.00539098
τ	=	0.359198	±	0.0000358152
c	=	0.0046033	±	7.62552×10^{-7}

$\frac{\chi^2}{n-p} = 2.28273$

Transient response, high-Q

In[134]:=
```
LoadFile["transient_response_high_q.dat"]
```

In[135]:=
```
With[{x = SetXRange[ LinearDataPlot[], Log -> False,
    Label -> "Set the X values for the range you wish to keep." ]},
 Print[x];

 XRangeKeep[Sequence @@ x]
]
```

{0.23, 7.625}

n= 1849

651 points removed.

In[136]:=
```
FitData[
  (* The expression defining the function *) A Sin[2 Pi fo t - ϕ Degree] Exp[-t / τ] + c,
 (* The symbol for the variable in the expression *) t,
 (* A list of the parameters in the function to fit *) {A, fo , ϕ, τ , c },
 (* A list of starting values for the parameters *) {0.05, 15.3, 10, 2, 0 }
]
```

n = 1849

p = 5

$f[t] = c + A e^{-\frac{t}{\tau}} \mathrm{Sin}[2\, fo\, \pi\, t - {}^{\circ}\, \phi]$

Fit of (x,y) (unweighted):

A	=	0.0764707	±	6.28735×10^{-6}
fo	=	15.5711	±	6.08294×10^{-6}
ϕ	=	17.5708	±	0.00472394
τ	=	2.99424	±	0.00034224
c	=	0.00478254	±	1.16451×10^{-6}

Std. Deviation = 0.0000500729

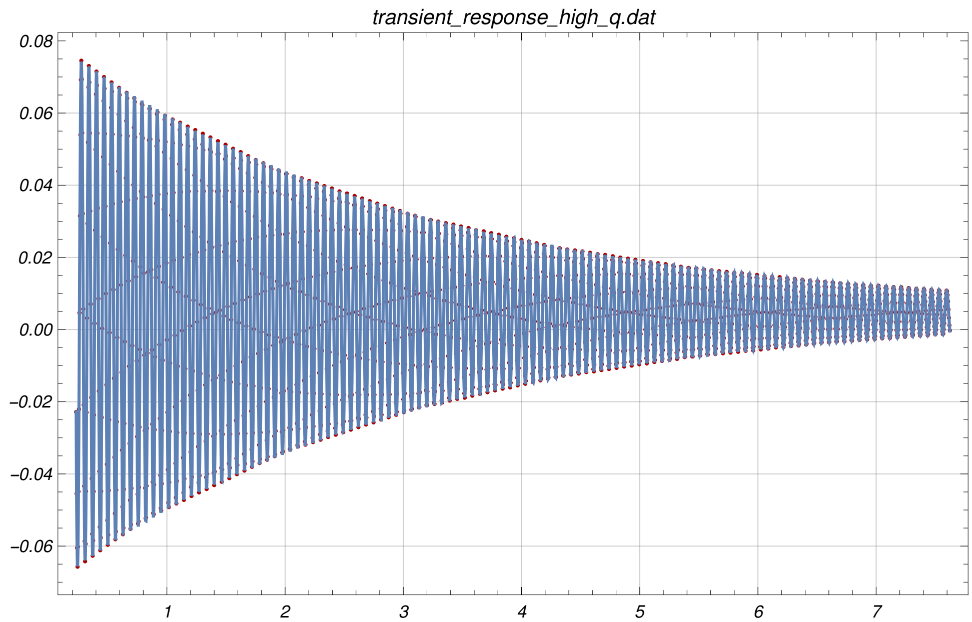
Fit of (x,y±σ_y):

A	=	0.0764802	±	5.60405×10^{-6}
fo	=	15.5711	±	4.64279×10^{-6}
ϕ	=	17.5691	±	0.00386199
τ	=	2.99395	±	0.000272138
c	=	0.00478175	±	8.79915×10^{-7}

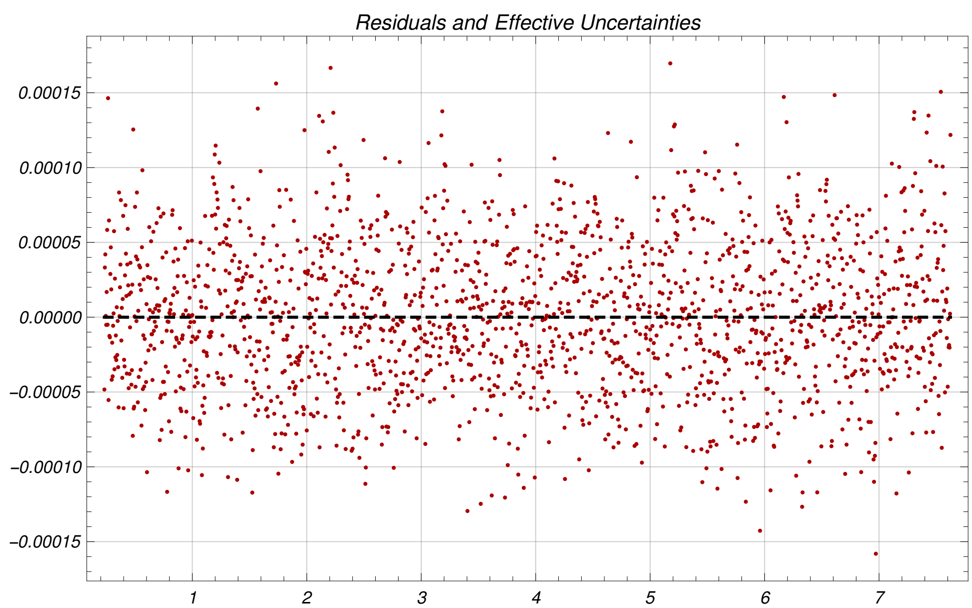
$\frac{\chi^2}{n-p} = 1.51638$

Out[136]= $\{A \to 0.0764802,\ fo \to 15.5711,\ \phi \to 17.5691,\ \tau \to 2.99395,\ c \to 0.00478175\}$

In[137]:= `LinearDifferencePlot[Joined → False]`



Out[137]=



$$f[t] = c + A e^{-\frac{t}{\tau}} \text{Sin}[2\,fo\,\pi\,t - {}^\circ\,\phi]$$

A	=	0.0764802	±	5.60405×10^{-6}
fo	=	15.5711	±	4.64279×10^{-6}
ϕ	=	17.5691	±	0.00386199
τ	=	2.99395	±	0.000272138
c	=	0.00478175	±	8.79915×10^{-7}

$$\frac{\chi^2}{n-p} = 1.51638$$

Analysis

We observe that the transient ring-down qualitatively looks like a decaying sinusoid, as expected. The randomly distributed residuals over a decaying sinusoid fit show that the period of the oscillation is constant.

For the low-Q case, we can calculate:

In[217]:=
```
ω0 = 97922.2;
q = 17.593;
ωT = ω0 Sqrt[1 - 1/(4 * q^2)]
```

Out[219]= 97882.6

In[211]:=
```
% / (2 * Pi)
```

Out[211]= 15578.5

This corresponds to a frequency of 15578 Hz. The frequency found using the fit parameters is 15564 Hz, which closely agrees. For the high-Q case, we calculate:

In[221]:=
```
ω0 = 97907.99;
q = 141.58;
ωT = ω0 Sqrt[1 - 1/(4 * q^2)]
```

Out[223]= 97907.4

In[215]:=
```
% / (2 * Pi)
```

Out[215]= 15582.4

This corresponds to a frequency of 155582 Hz. The frequency found using the fit parameters is 155571 Hz, which also agrees.

We can also calculate a predicted value for τ for the low-Q case as follows:

In[220]:=
```
τ = 2 * q / ω0
```

Out[220]= 0.000359326

This agrees closely with the 0.00035920 s decay time found using the fit. Similarly, for the high-q case:

In[224]:=
```
τ = 2 * q / ω0
```

Out[224]= 0.0028921

This closely agrees with the 0.002993 s decay time found using the fit.