Wechselstromeigenschaften von RLC-Gliedern

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In [1]:
```python
%matplotlib inline
import matplotlib.pyplot as plt
import numpy as np

#Messwerte aus Tabelle 3: t über f
f = np.array([1,2,3,4,5,6,7,8,9,10])*1e3
fehler_f = f*2e-2

t = np.array([200.00,82.00,44.80,28.00,19.20,13.90,10.40,8.00,6.48,5.16])*1e-6
fehler_t = np.array([7.7,0.14,0.14,0.14,0.14,0.01,0.1,0.1,0.05,0.06])*1e-6

phi = t*f*360
fehler_phi = np.sqrt((fehler_t/t)**2+(fehler_f/f**2))*phi

#Fitfunktion
from scipy import odr

def fit_func(p, x):
    (rc) = p
    return np.arctan(1/(x*rc))*180/np.pi

model = odr.Model(fit_func)

#darzustellende Daten
x = f
y = phi
delta_x = fehler_f
delta_y = fehler_phi

#Startparameter
para0 = [1.0]

data = odr.RealData(x, y, sx=delta_x, sy=delta_y)
odr = odr.ODR(data, model, beta0=para0 )
out = odr.run()

#1-Sigma
popt = out.beta
perr = out.sd_beta

#Sigma-Umgebung
nstd = 16 # um n-Sigma-Umgebung zu zeichnen
popt_top = popt+nstd*perr
popt_bot = popt-nstd*perr

#Plot-Umgebung
x_fit = np.logspace(np.log10(min(x))-0.1, np.log10(max(x))+0.1, 1000)
fit = fit_func(popt, x_fit)
fit_top = fit_func(popt_top, x_fit)
fit_bot = fit_func(popt_bot, x_fit)

#Plot
fig, ax = plt.subplots(1)
plt.errorbar(x, y, yerr=delta_y, xerr=delta_x, lw=1, ecolor='k', fmt='none', capsize=1, label='Messdaten')
plt.title('Diagramm 1: Phasenverlauf ')
plt.grid(True)
plt.xscale('log')
plt.xlabel('Frequenz '+r'${f}$'+' '+r'${[kHz]}$')
plt.ylabel('Phasenverschiebung '+r'${\phi}$' + ' '+r'${[°]}$')
plt.plot(x_fit, fit, 'r', lw=1, label='Fit')
ax.fill_between(x_fit, fit_top, fit_bot, alpha=.25, label=str(nstd)+r'$\sigma$'+'-Umgebung')
plt.legend(loc='best')

#Chi-Quadrat orthogonal
from scipy.stats import chi2

dof = x.size-popt.size
chisquare = np.sum(((fit_func(popt, x)-y)**2)/(delta_y**2+((fit_func(popt, x+delta_x)-fit_func(popt, x-delta_x))/2)**2))
chisquare_red = chisquare/dof
prob = round(1-chi2.cdf(chisquare,dof),2)*100

#Grenzfrequenz
def fit_func_rev(x, p):
    (rc) = p
    return 1/(np.tan(x*np.pi/180)*rc)

phi_g = 45
f_g = fit_func_rev(phi_g, popt)
fehler_f_g = abs(fit_func_rev(phi_g, popt+perr)-fit_func_rev(phi_g, popt-perr))/2

#Output
```

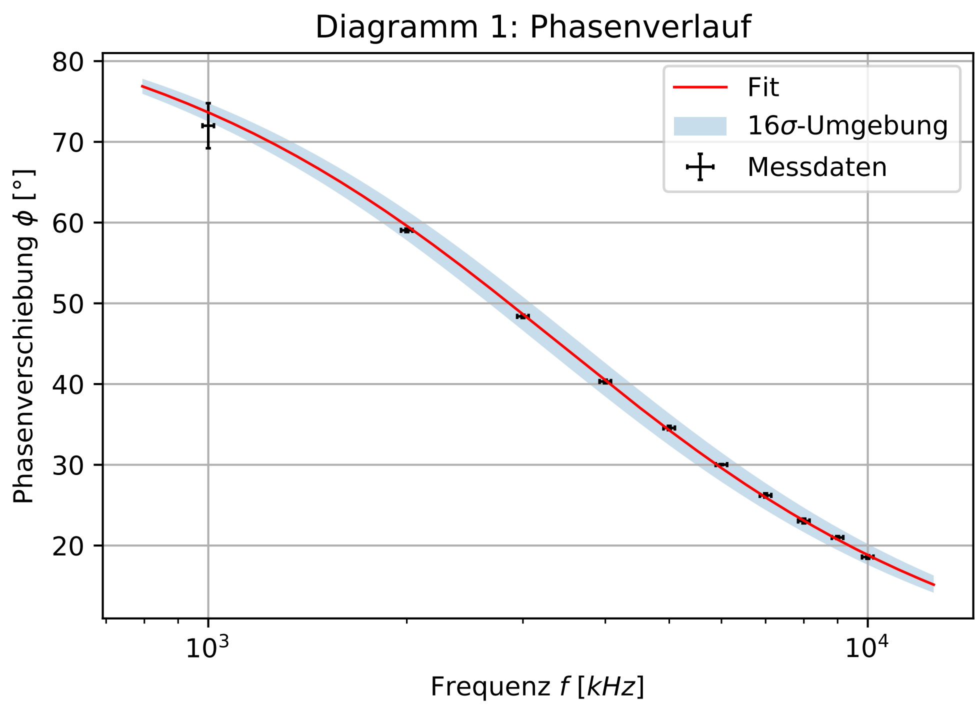
```
        plt.savefig('figures/241_Diagramm1.pdf', format='pdf')

        print('RC [μs] =', popt[0]*1e6, ', Standardfehler =', perr[0]*1e6)
        print('\n')
        print('f_g [kHz] =', f_g[0]*1e-3, ', Standardfehler =', fehler_f_g[0]*1e-3)
        print('\n')
        print('Chi-Quadrat =', chisquare)
        print('Freiheitsgrade =', dof)
        print('Chi-Quadrat reduziert =', chisquare_red)
        print('Wahrscheinlichkeit ein größeres oder gleiches Chi-Quadrat zu erhalten =', prob, '%')
```

```
RC [μs] = 293.3838210408594 , Standardfehler = 1.3486797954803351


f_g [kHz] = 3.4085042469357254 , Standardfehler = 0.01566915974051449


Chi-Quadrat = 3.5289447981851856
Freiheitsgrade = 9
Chi-Quadrat reduziert = 0.3921049775761317
Wahrscheinlichkeit ein größeres oder gleiches Chi-Quadrat zu erhalten = 94.0 %
```




```
In [2]: %matplotlib inline
        import matplotlib.pyplot as plt
        import numpy as np

        #Messwerte aus Tabelle 5: U_max über n
        T = (1.080/4)*1e3

        t = np.array([1,2,3,4,5])*T
        fehler_t = np.array([0.07, 0.07, 0.07, 0.07, 0.07])*1e3

        U_max = np.array([5.200, 2.860, 1.530, 0.690, 0.340])
        fehler_U_max = np.array([0.035, 0.035, 0.014, 0.014, 0.007])

        #Fitfunktion
        from scipy import odr

        def fit_func(p, x):
```

```
        (A, d) = p
        return A*np.exp(-d*x)

    model = odr.Model(fit_func)

    #darzustellende Daten
    x = t
    y = U_max
    delta_x = fehler_t
    delta_y = fehler_U_max

    #Startparameter
    para0 = [10.0, 0.0]

    data = odr.RealData(x, y, sx=delta_x, sy=delta_y)
    odr = odr.ODR(data, model, beta0=para0 )
    out = odr.run()

    #1-Sigma
    popt = out.beta
    perr = out.sd_beta

    #Sigma-Umgebung
    nstd = 2 # um n-Sigma-Umgebung zu zeichnen
    popt_top = popt+nstd*perr
    popt_bot = popt-nstd*perr

    #Wechselspannung
    def AC(p, x):
        (A, d) = p
        return A*np.exp(-d*x)*np.cos((x/T)*2*np.pi)

    #Plot-Umgebung
    x_fit = np.linspace(0, max(x), 1000)
    fit = fit_func(popt, x_fit)
    fit_AC = AC(popt, x_fit)
    fit_top = AC(popt_top, x_fit)
    fit_bot = AC(popt_bot, x_fit)

    #Plot
    fig, ax = plt.subplots(1)
    plt.errorbar(x, y, yerr=delta_y, xerr=delta_x, lw=1, ecolor='k', fmt='none', capsize=1, label='Messdaten')
    plt.title('Diagramm 2: Spannungsverlauf')
    plt.grid(True)
    plt.xlabel('Zeit '+r'${t}$'+' '+r'${[\mu s]}$')
    plt.ylabel('Spannung '+r'${U}$' + ' '+r'${[V]}$')
    plt.plot(x_fit, fit, 'r--', lw=1, label=r'${{\propto}e^{-{\delta}t}}$')
    plt.plot(x_fit, -fit, 'r--', lw=1)
    plt.plot(x_fit, fit_AC, 'r', lw=1, label='Fit')
    ax.fill_between(x_fit, fit_top, fit_bot, alpha=.25, label=str(nstd)+r'$\sigma$'+'-Umgebung')
    plt.legend(loc='best')

    #Chi-Quadrat orthogonal
    from scipy.stats import chi2

    dof = x.size-popt.size
    chisquare = np.sum(((fit_func(popt, x)-y)**2)/(delta_y**2+((fit_func(popt, x+delta_x)-fit_func(popt, x-delta_x))/2)**2))
    chisquare_red = chisquare/dof
    prob = round(1-chi2.cdf(chisquare,dof),2)*100

    #Output
    plt.savefig('figures/241_Diagramm2.pdf', format='pdf')

    print('U_0 [V] =', popt[0], ', Standardfehler =', perr[0])
    print('delta [kHz] =', popt[1]*1e3, ', Standardfehler =', perr[1]*1e3,)
    print('\n')
    print('Chi-Quadrat =', chisquare)
    print('Freiheitsgrade =', dof)
    print('Chi-Quadrat reduziert =', chisquare_red)
    print('Wahrscheinlichkeit ein größeres oder gleiches Chi-Quadrat zu erhalten = {value:.0f}'.format(value=prob), '%')
```

```
U_0 [V] = 11.068419409321136 , Standardfehler = 0.8112838698051997
delta [kHz] = 2.554372698550157 , Standardfehler = 0.08202561048008566


Chi-Quadrat = 0.4649566669495556
Freiheitsgrade = 3
Chi-Quadrat reduziert = 0.15498555564985186
Wahrscheinlichkeit ein größeres oder gleiches Chi-Quadrat zu erhalten = 93 %
```

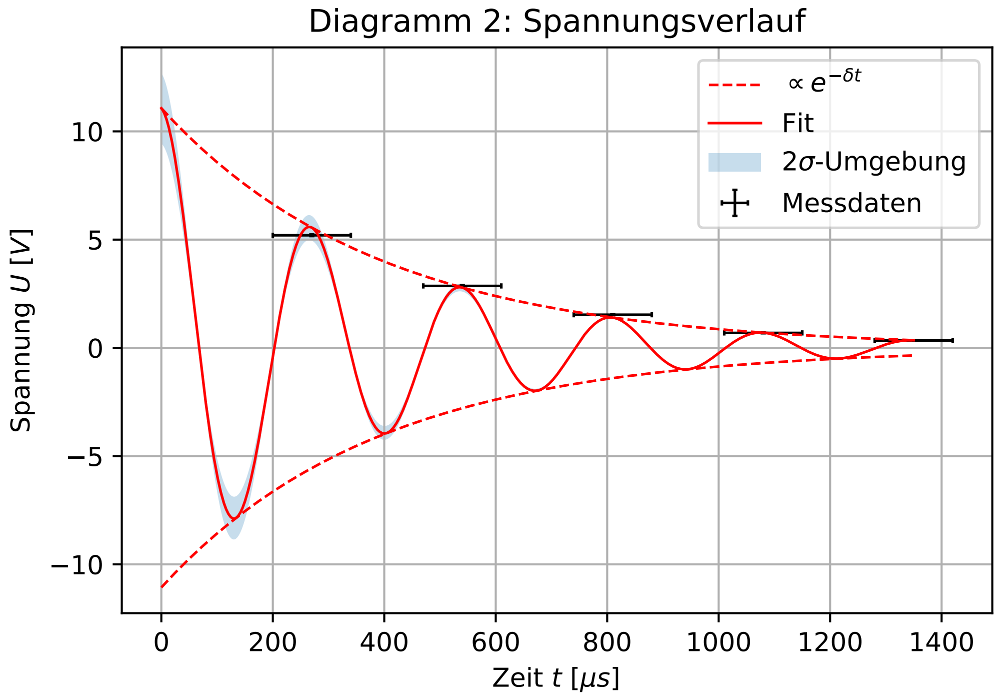


Diagramm 2: Spannungsverlauf
$\propto e^{-\delta t}$
Fit
2σ-Umgebung
Messdaten
Spannung U [V]
Zeit t [μs]
10
5
0
−5
−10
0
200
400
600
800
1000
1200
1400