PHYS512_HW4

October 14, 2022

[1]:
```
import numpy as np
import matplotlib.pyplot as plt
import math
```

1 Problem 1

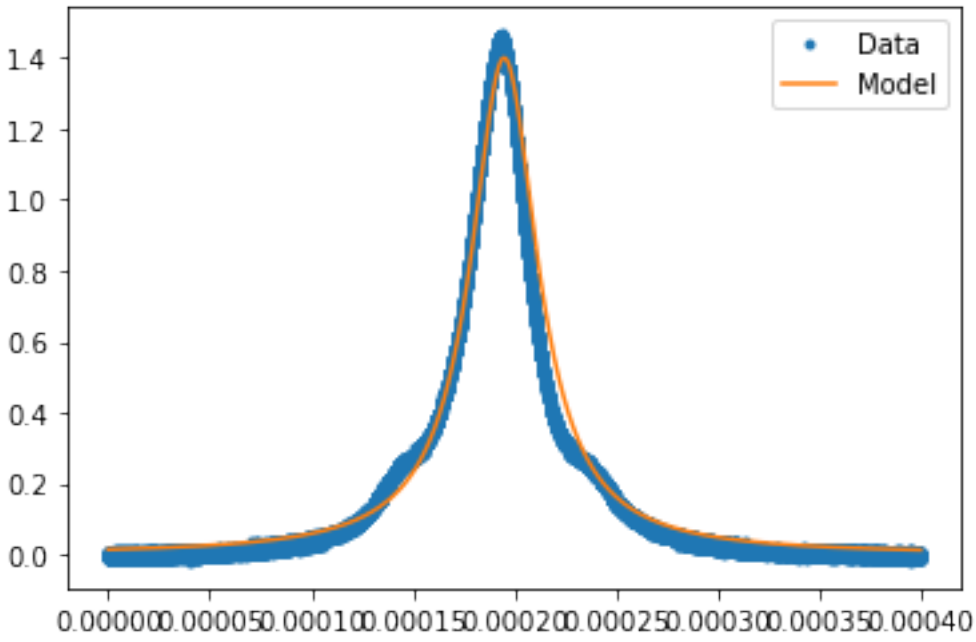
[11]:
```
stuff=np.load('/Users/junalexsugiyama/Desktop/PHYS512/repo/phys512-2022/
 ↪problem_sets/mcmc/sidebands.npz')
t=stuff['time']
d=stuff['signal']
```

1.1 a)

[74]:
```
def calc_lorentz(p,t):
    a = p[0]
    t0 =p[1]
    w = p[2]
    y = a/(1 + (t - t0)**2/w**2)
    #y=p[0]/(p[1]+(t-p[2])**2)
    grad=np.zeros([t.size,p.size])
    #now differentiate w.r.t. all the parameters
    grad[:,0]=1.0/(1 + (t - t0)**2/w**2)
    grad[:,1]=-2*a*(t-t0)/((1+(t - t0)**2/w**2 ) * w**2 )
    grad[:,2]=2*a*w*(t-t0)**2/(w**3 * ( 1+ (t-t0)**2)/w**2)
    return y,grad


x_true,grad=calc_lorentz(p_true,t)

plt.ion()
plt.clf()

plt.plot(t,d,'.', label = 'Data')

p0=np.array([1.4,0.000195,0.00002]) #starting guess, close but not exact
```

```
p=p0.copy()
for j in range(10):
    pred,grad=calc_lorentz(p0,t)
    r=d-pred
    err=(r**2).sum()
    r=np.matrix(r).transpose()
    grad=np.matrix(grad)

    lhs=grad.transpose()*grad
    rhs=grad.transpose()*r
    dp=np.linalg.inv(lhs)*(rhs)
    for jj in range(p.size):
        p[jj]=p[jj]+dp[jj]

plt.plot(t,pred, label = 'Model')
plt.legend()
print('a = ', p[0], '\n',
      't0 = ', p[1], '\n',
    'w = ', p[2], '\n')
```

```
a =  0.8074251575771672
 t0 =  0.00020357019622709648
 w =  -2096944.0164913516
```



1.2 b)

[49]:
```
print(np.sqrt(np.sum((d - pred)**2) / len(pred)))
```

```
0.05295366891412235
```

[ ]:

[ ]:

1.3 c)

[72]:
```
def lorentz(p, t):
    a = p[0]
    t0 =p[1]
    w = p[2]
    y = a/(1 + (t - t0)**2/w**2)
    return y

def func(p, t):
    logdx=np.linspace(-5,-4,len(t) )
    print(t)
    dx=10**logdx
    print(dx)
    params = np.array(p.copy())
    grad=np.zeros([t.size,p.size])
    for i in range(len(p)):
        x0=p[i]

        params[i] = [x0 + dx]
        y1=lorentz(params, t)
        params[i] = [x0 - dx]

        ym=lorentz(params, t)
        d2=(y1-ym)/(2*dx)

        grad[:,i]= d2
    pred = lorentz(p, t)
    return pred, grad

p0=np.array([1.4,0.000195,0.00002])
for j in range(10):
    pred,grad=func(p0,t)
    print(grad)
    r=d-pred
    err=(r**2).sum()
    r=np.matrix(r).transpose()
```

```
    grad=np.matrix(grad)

    lhs=grad.transpose()*grad
    rhs=grad.transpose()*r
    dp=np.linalg.inv(lhs)*(rhs)
    for jj in range(p.size):
        p[jj]=p[jj]+dp[jj]

plt.plot(t,pred, label = 'Model')
```

```
[0.00000e+00 4.00000e-09 8.00000e-09 … 3.99988e-04 3.99992e-04
 3.99996e-04]
[1.00000000e-05 1.00002303e-05 1.00004605e-05 … 9.99953949e-05
 9.99976974e-05 1.00000000e-04]
```

```
      ␣
↪---------------------------------------------------------------------------

       ValueError                                Traceback (most recent call␣
↪last)

       <ipython-input-72-fa27c3c7d3c0> in <module>
        29 p0=np.array([1.4,0.000195,0.00002])
        30 for j in range(10):
   ---> 31     pred,grad=func(p0,t)
        32     print(grad)
        33     r=d-pred


       <ipython-input-72-fa27c3c7d3c0> in func(p, t)
        16         x0=p[i]
        17
   ---> 18         params[i] = [x0 + dx]
        19         y1=lorentz(params, t)
        20         params[i] = [x0 - dx]


       ValueError: setting an array element with a sequence.
```

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