pylab2

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0.1 PyLab 2

PHY224H1S | 2020 Winter

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31 Jan 2020

[1]:
```
# imports

import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
from scipy.optimize import curve_fit
```

[2]:
```
# defining functions

# linear model
def f(x, a, b):
    return a * x + b

# nonlinear model
def g(x, a, b):
    return b * np.exp(a * x)

# theoretical model
def theoretical(x, a, b):
    return b * np.power(0.5, x / a)
```

[3]:
```
# reading data
_, background = np.loadtxt('RadioactiveDecay_TuesdayOct2_2018_background.txt',␣
 ↪skiprows=2, unpack=True)
sampleid, decay = np.loadtxt('RadioactiveDecay_TuesdayOct2_2018_decay.txt',␣
 ↪skiprows=2, unpack=True)
```

[4]:
```
# adjusting time, subtracting background from measurements

sampleid *= 20
```

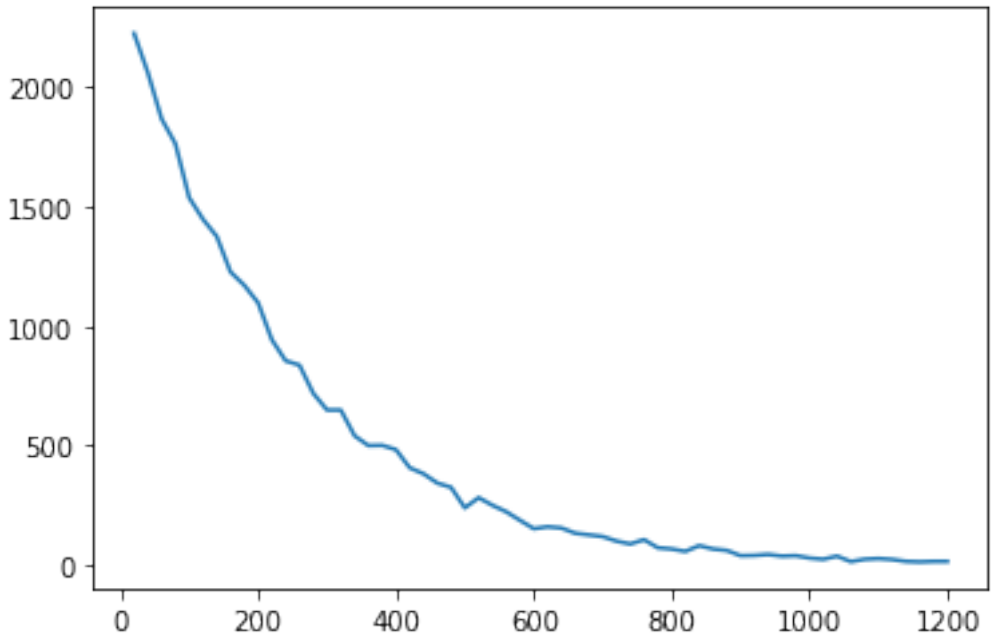
```
clean = decay - background.mean()
```

[5]:
```
# calculating errors

stddev = np.sqrt(decay + background)
err = np.abs(stddev / clean)
```

[6]:
```
# initial plot, sanity check
plt.plot(sampleid, clean)
```

[6]: [<matplotlib.lines.Line2D at 0x126dd85d0>]



[7]:
```
# fit with linear model
popt, pcov = curve_fit(f, sampleid, np.log(clean))
```

[8]:
```
# print parameters and corresponding errors
print(popt)
print(np.sqrt(np.diag(pcov)))
```

```
[-4.39942710e-03  7.82635203e+00]
[5.15796673e-05 3.61818282e-02]
```

[9]:
```
# print half life and corresponding error
print(f'half-life: {1/popt[0] * np.log(0.5)} seconds')
print(f'error: {np.sqrt(np.diag(pcov))[0] / np.square(popt[0])} seconds')
```

```
half-life: 157.55396422235438 seconds
error: 2.6649329344915813 seconds
```

[10]:
```
# fit with nonlinear model
popt2, pcov2 = curve_fit(g, sampleid, clean, p0=(-0.01, 1))
```

```
/usr/local/lib/python3.7/site-packages/ipykernel_launcher.py:9: RuntimeWarning:
overflow encountered in exp
  if __name__ == '__main__':
```

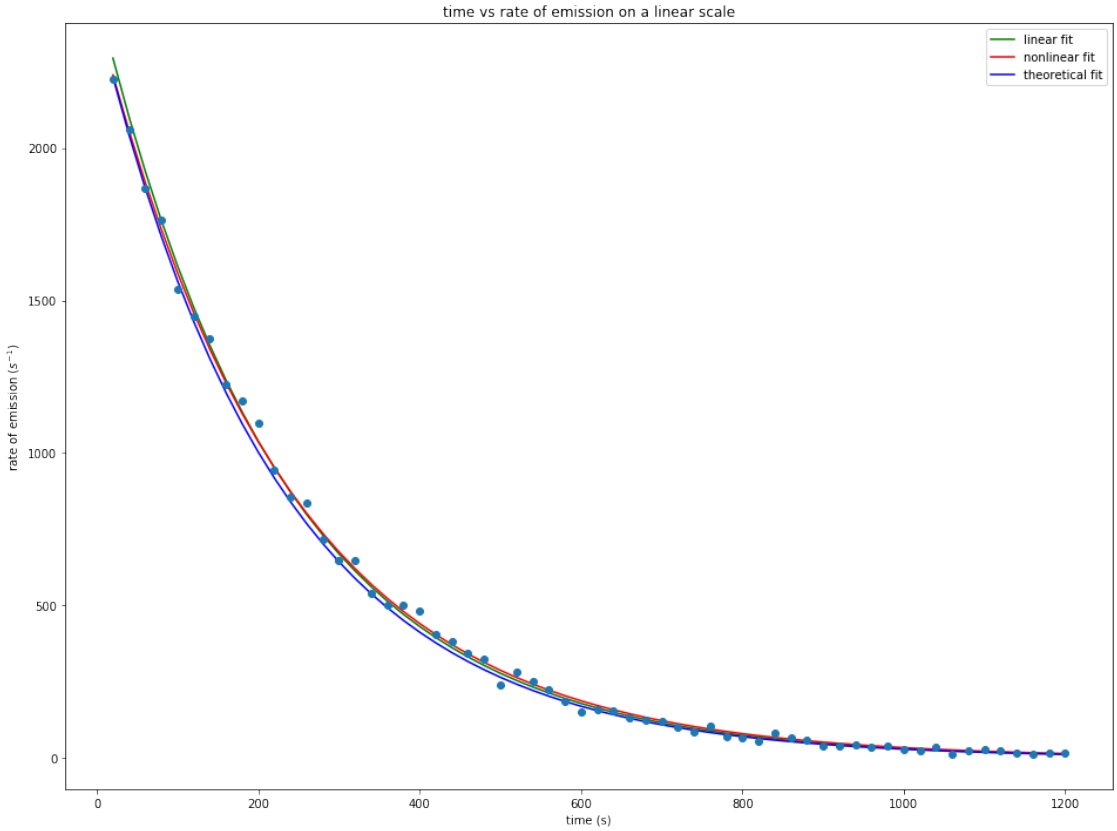
[11]:
```
# printing parameters and corresponding errors
print(popt2)
print(np.sqrt(np.diag(pcov2)))
```

```
[-4.27694055e-03  2.43989747e+03]
[3.16977005e-05 1.33397038e+01]
```

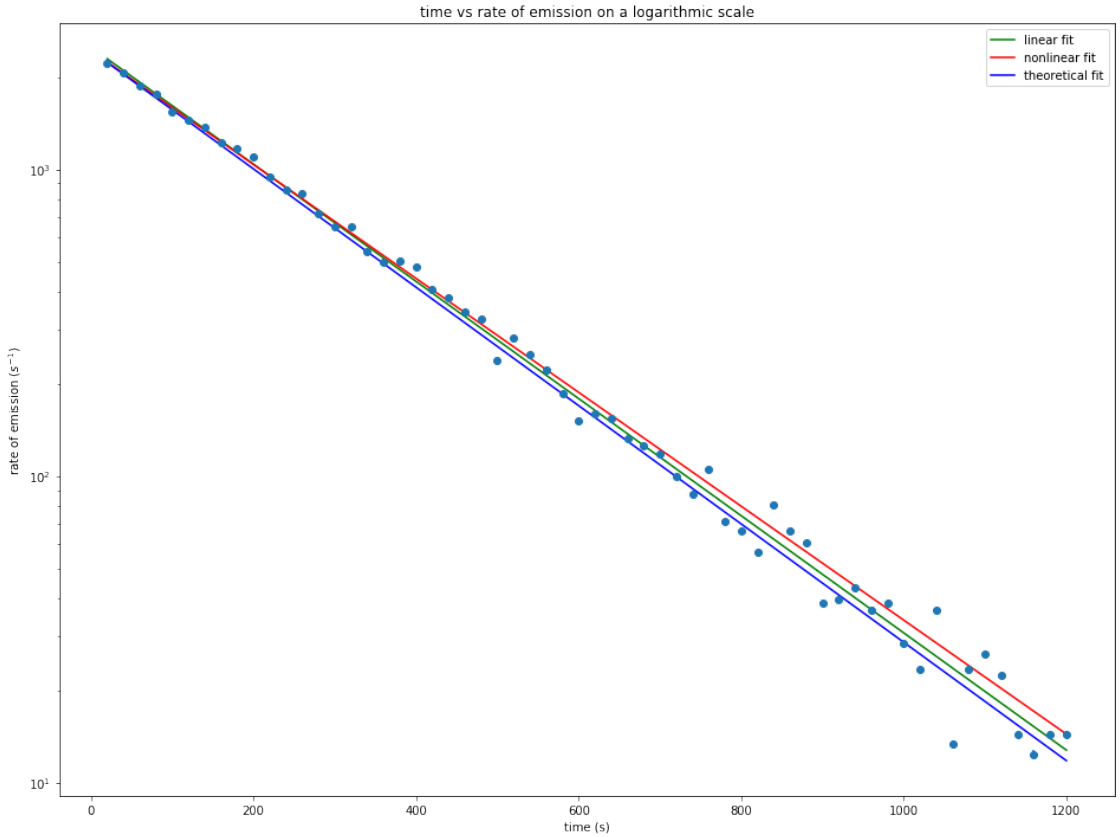
[12]:
```
# print half life and corresponding error
print(f'half-life: {1/popt2[0] * np.log(0.5)} seconds')
print(f'error: {np.sqrt(np.diag(pcov2))[0] / np.square(popt2[0])} seconds')
```

```
half-life: 162.0661245227056 seconds
error: 1.7328514337306509 seconds
```

[13]:
```
# plotting time vs rate on linear scale
plt.figure(figsize=(16, 12))
plt.errorbar(sampleid, clean, err, ls='', marker='o')
plt.plot(sampleid, np.exp(f(sampleid, *popt)), c='g', label='linear fit')
plt.plot(sampleid, g(sampleid, *popt2), c='r', label='nonlinear fit')
plt.plot(sampleid, g(sampleid, 1/156 * np.log(0.5), popt2[1]), c='b',␣
↪label='theoretical fit')
plt.legend()
plt.xlabel('time (s)')
plt.ylabel('rate of emission ($s^{-1}$)')
plt.title('time vs rate of emission on a linear scale')
plt.savefig('pylab2-linear.png')
```



[14]:
```
# same plot as above but on a log scale for the y axis
plt.figure(figsize=(16, 12))
plt.errorbar(sampleid, clean, err, ls='', marker='o')
plt.plot(sampleid, np.exp(f(sampleid, *popt)), c='g', label='linear fit')
plt.plot(sampleid, g(sampleid, *popt2), c='r', label='nonlinear fit')
plt.plot(sampleid, g(sampleid, 1/156 * np.log(0.5), popt2[1]), c='b',␣
 ↪label='theoretical fit')
plt.yscale('log')
plt.legend()
plt.xlabel('time (s)')
plt.ylabel('rate of emission ($s^{-1}$)')
plt.title('time vs rate of emission on a logarithmic scale')
plt.savefig('pylab2-log.png')
```



[15]:
```
# reduced chi squared function
def rcs(pred, target, uncertainty, n_params):
    return np.square((pred - target) / uncertainty).sum() / (pred.size -␣
 ↪n_params)
```

[16]:
```
# print reduced chi squares for models
print(f'reduced chi squared for linear model: {rcs(np.exp(f(sampleid, *popt)),␣
 ↪clean, err, 2)}')
print(f'reduced chi squared for non-linear model: {rcs(g(sampleid, *popt2),␣
 ↪clean, err, 2)}')
```

```
reduced chi squared for linear model: 729121.9026490474
reduced chi squared for non-linear model: 354421.12337128626
```