back scattering

May 14, 2022

[1]:
```python
# %load ../../setup.py
"""
Packages for plotting and other stuff
version: 1.0
author: Riasat
"""
# %matplotlib widget

# data loading
import pandas as pd

# data maipulation
import pwlf
import numpy as np
from scipy.interpolate import interp1d, UnivariateSpline
from scipy.signal import find_peaks
from scipy import optimize

# plotting tools
import matplotlib.pyplot as plt

# extra tweaks
import warnings

warnings.filterwarnings("ignore")

# plot tweaks
plt.style.use("seaborn-poster")
pd.options.display.max_columns = None
pd.options.display.float_format = "{:.5f}".format

# function for extrapolation
def extrapolate1d(x, y):
    f = interp1d(x, y, kind="linear", fill_value="extrapolate")
    a = np.arange(0, x[len(x) - 1], 0.001)
    b = f(a)
    return a, b
```

```python
# function for interpolation
def interpolate1d(x, y):
    f = interp1d(x, y, kind="linear", fill_value="extrapolate")
    a = np.arange(x[0], x[len(x) - 1], 0.001)
    b = f(a)
    return a, b


# function for interpolation
def interpolate2d(x, y):
    f = interp1d(x, y, kind="quadratic", fill_value="extrapolate")
    a = np.arange(x[0], x[len(x) - 1], 0.001)
    b = f(a)
    return a, b


# function for interpolation
def interpolate3d(x, y):
    f = interp1d(x, y, kind="cubic", fill_value="extrapolate")
    a = np.arange(x[0], x[len(x) - 1], 0.001)
    b = f(a)
    return a, b


# funciton for polynomial fitting
def polfit(a, b, c):
    z = np.polyfit(a, b, c)
    f = np.poly1d(z)

    x = np.arange(a[0], a[len(a) - 1], 0.001)
    y = f(x)
    return x, y


# function for picewise linear fit
def picewise_linear_fit(x, y, segments):
    my_pwlf = pwlf.PiecewiseLinFit(x, y)  # fit my data
    res = my_pwlf.fit(segments)  # fit the data for n line segments
    # slopes = myPWLF.calc_slopes()  # calculate slopes

    # predict for the determined points
    xHat = np.linspace(min(x), max(x), num=10000)
    yHat = my_pwlf.predict(xHat)

    # calculate statistics
```

```
    # p = myPWLF.p_values(method="non-linear", step_size=1e-4)  # p-values
    # se = myPWLF.se  # standard errors
    return xHat, yHat


# curve fit
def cur_fit(x, y):
    func = lambda t, a, c, d: a * np.log(t + c) + d
    popt, pcov = optimize.curve_fit(func, x, y)  # type: ignore
    xx = np.arange(x[0], x[len(x) - 1], 0.001)
    yy = func(xx, *popt)
    return xx, yy
```

1 Datas

[2]:
```
# plateau datas
data_plateau = pd.read_excel("data.xlsx", sheet_name="plateau")
pl_voltage = data_plateau["p_voltage"]
pl_counts = data_plateau["p_counts"]

# al backscattrer
data_al = pd.read_excel("data.xlsx", sheet_name='al_back')
al_thick = data_al['al_thick']
al_0 = data_al['al_0']
al_counts = data_al['al_counts']

# cu backscattrer
data_cu = pd.read_excel("data.xlsx", sheet_name='cu_back')
cu_thick = data_cu['cu_thick']
cu_0 = data_cu['cu_0']
cu_counts = data_cu['cu_counts']

# ag backscattrer
data_ag = pd.read_excel("data.xlsx", sheet_name='ag_back')
ag_thick = data_ag['ag_thick']
ag_0 = data_ag['ag_0']
ag_counts = data_ag['ag_counts']
```

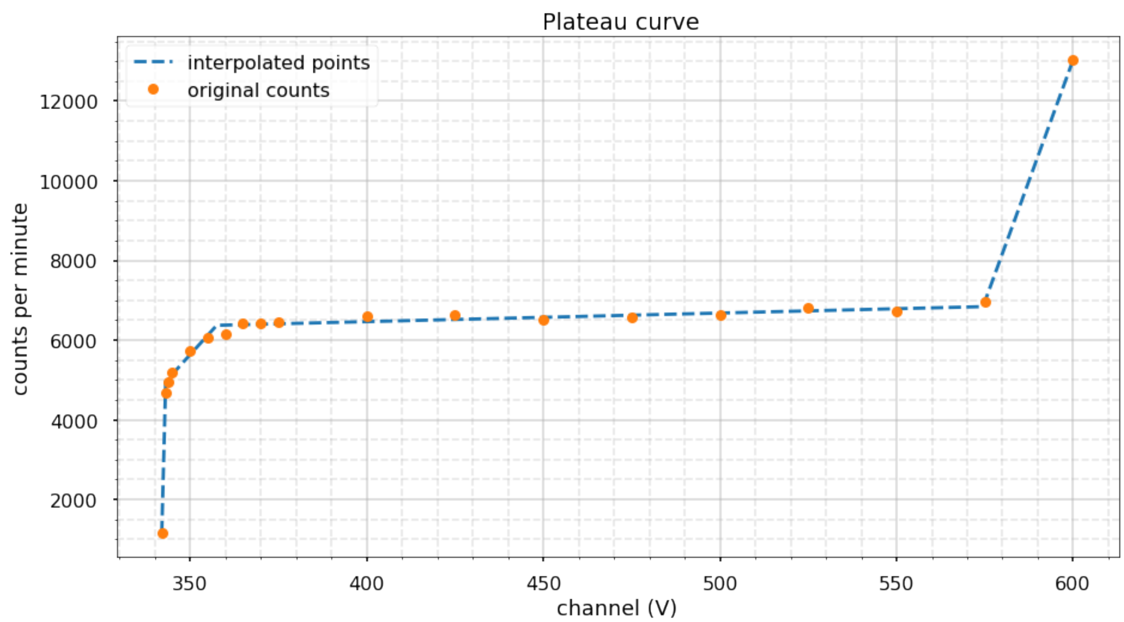
2 Functions

[3]:
```
# function for interpolation
def interpolate(x, y):
    f = interp1d(x, y, kind="cubic", fill_value="extrapolate")
    a = np.arange(x[0], x[len(x) - 1], 0.001)
    b = f(a)
```

```
    return a, b
```

3 Plateau

[4]:
```
# %matplotlib widget
voltage_interpolated_pl, counts_interpolated_pl =␣
 ↪picewise_linear_fit(pl_voltage, pl_counts, 4)

plt.style.use("seaborn-poster")
plt.figure(figsize=(15, 8))
plt.title(f" Plateau curve")
plt.xlabel("channel (V)")
plt.ylabel("counts per minute")
plt.plot(voltage_interpolated_pl, counts_interpolated_pl, "--",␣
 ↪label="interpolated points")
plt.plot(pl_voltage, pl_counts, "o", markersize=9, label="original counts")
plt.legend(loc="upper left")
plt.grid(alpha=0.5, which="major")
plt.minorticks_on()
plt.grid(alpha=0.3, which="minor", ls="--")
plt.show()
```



I choosed the operating voltage at 400 V

4 Backscattering factor

[5]:
```
element_name = ["Aluminium", "Copper", "Silver"]
```

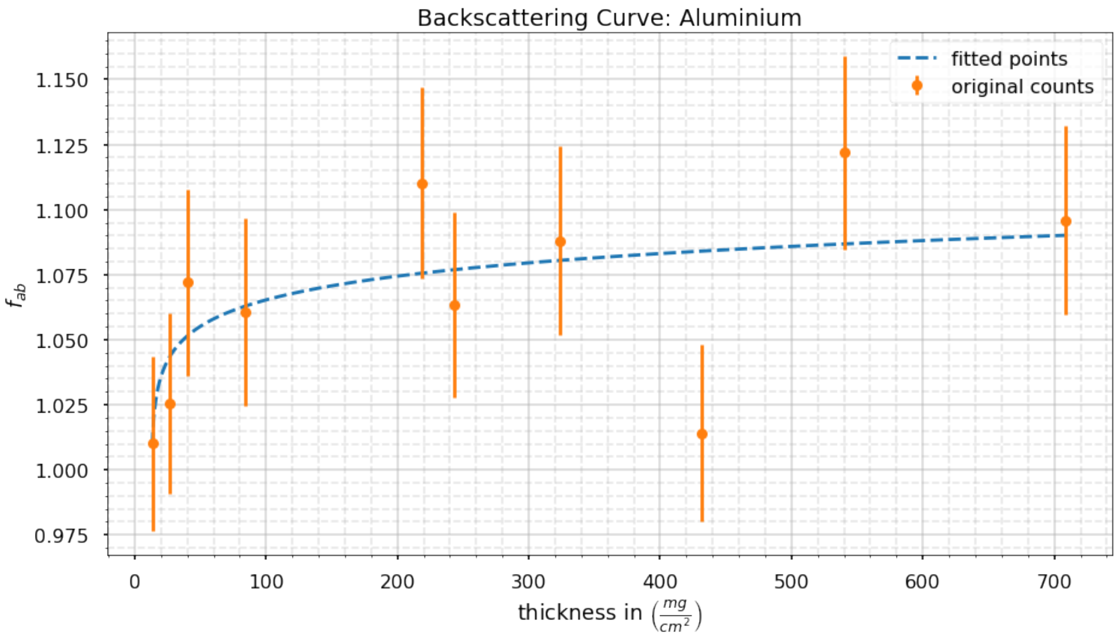
4.1 Aluminium

[6]:
```
f_al = al_counts/al_0
del_f_al = f_al*np.sqrt(1/al_0 + 1/al_counts)
print(f"{f_al}, {del_f_al}")
```

```
0    1.01006
1    1.02546
2    1.07200
3    1.06055
4    1.11021
5    1.06351
6    1.08796
7    1.01414
8    1.12189
9    1.09592
dtype: float64, 0    0.03368
1    0.03467
2    0.03577
3    0.03584
4    0.03677
5    0.03560
6    0.03626
7    0.03399
8    0.03708
9    0.03632
dtype: float64
```

[7]:
```
# plotting the curves
# plt.style.use("seaborn-poster")
plt.figure(figsize=(15, 8))

plt.title(f"Backscattering Curve: {element_name[0]}")
plt.xlabel(r"thickness in $\left(\frac{mg}{cm^2}\right)$")
plt.ylabel(r"$f_{ab}$")

pxal, pyal = cur_fit(al_thick, f_al)
plt.plot(pxal, pyal, "--", label="fitted points")
plt.errorbar(al_thick, f_al, yerr=del_f_al, fmt="o", markersize=9,␣
  ↪label="original counts")

plt.legend(loc="upper right")
plt.grid(alpha=0.5, which="major")
```

```
plt.minorticks_on()
plt.grid(alpha=0.3, which="minor", ls="--")

plt.show()
```



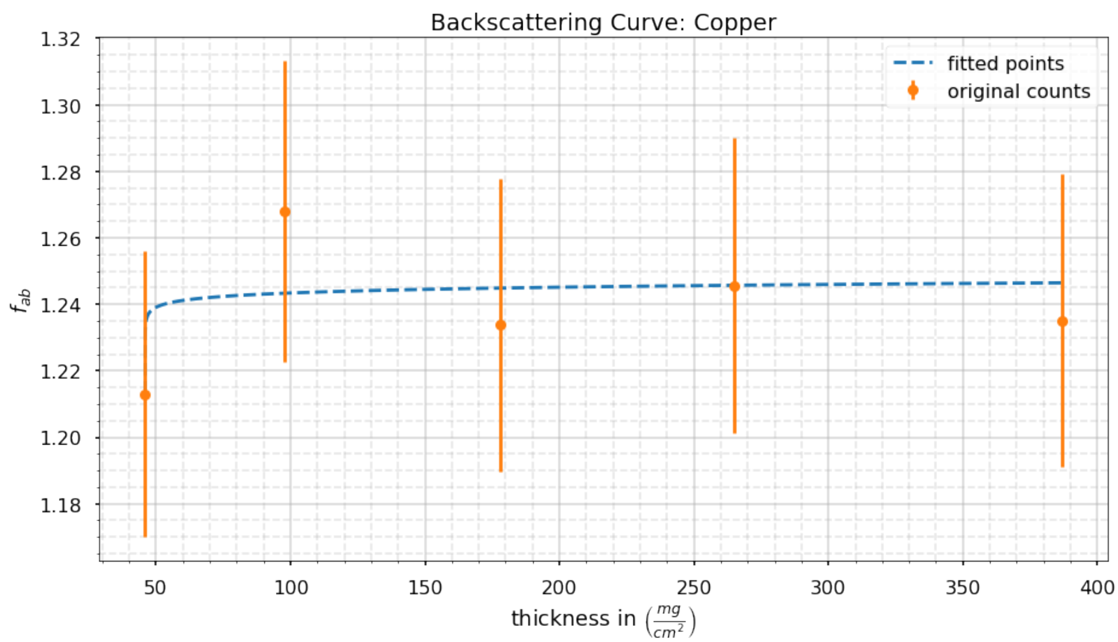
4.2 Copper

[8]:
```
f_cu = cu_counts/cu_0
del_f_cu = f_cu*np.sqrt(1/cu_0 + 1/cu_counts)
# cu_thick_interpolate, f_cu_interpolate = polfit(cu_thick,f_cu, 4)
print(f"{f_cu}, {del_f_cu}")
```

```
0    1.21291
1    1.26791
2    1.23385
3    1.24561
4    1.23505
dtype: float64, 0    0.04294
1    0.04539
2    0.04399
3    0.04430
4    0.04407
dtype: float64
```

[9]:
```
# plotting the curves
# plt.style.use("seaborn-poster")
```

```
plt.figure(figsize=(15, 8))

plt.title(f"Backscattering Curve: {element_name[1]}")
plt.xlabel(r"thickness in $\left(\frac{mg}{cm^2}\right)$")
plt.ylabel(r"$f_{ab}$")

pxcu, pycu = cur_fit(cu_thick, f_cu)
plt.plot(pxcu, pycu, "--", label="fitted points")
plt.errorbar(cu_thick, f_cu, yerr=del_f_cu, fmt="o", markersize=9,␣
 ↪label="original counts")

plt.legend(loc="upper right")
plt.grid(alpha=0.5, which="major")
plt.minorticks_on()
plt.grid(alpha=0.3, which="minor", ls="--")

plt.show()
```



4.3 Silver

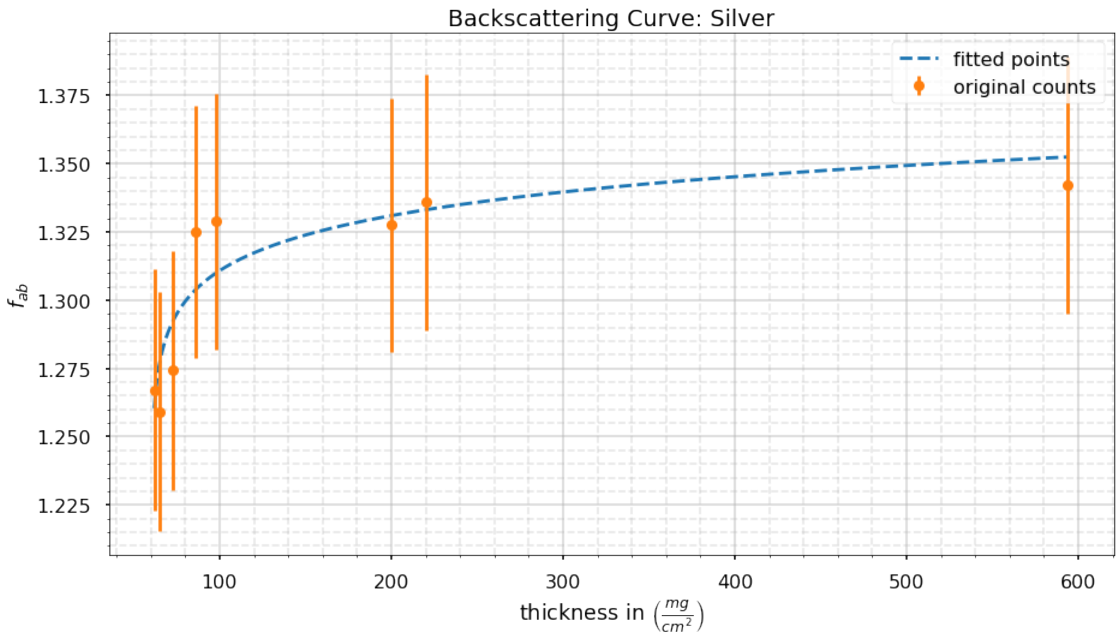
[10]:
```
f_ag = ag_counts/ag_0
del_f_ag = f_ag*np.sqrt(1/ag_0 + 1/ag_counts)
print(f"{f_ag}, {del_f_ag}")
```

```
0    1.26703
1    1.25911
```

```
2    1.27435
3    1.32500
4    1.32883
5    1.32748
6    1.33591
7    1.34225
dtype: float64, 0    0.04423
1    0.04381
2    0.04383
3    0.04625
4    0.04693
5    0.04660
6    0.04683
7    0.04705
dtype: float64
```

[11]:

```
# plotting the curves
# plt.style.use("seaborn-poster")
plt.figure(figsize=(15, 8))

plt.title(f"Backscattering Curve: {element_name[2]}")
plt.xlabel(r"thickness in $\left(\frac{mg}{cm^2}\right)$")
plt.ylabel(r"$f_{ab}$")

pxag, pyag = cur_fit(ag_thick,  f_ag)
plt.plot(pxag, pyag, "--", label="fitted points")
plt.errorbar(ag_thick, f_ag, yerr=del_f_ag, fmt="o", markersize=9,␣
 ↪label="original counts")

plt.legend(loc="upper right")
plt.grid(alpha=0.5, which="major")
plt.minorticks_on()
plt.grid(alpha=0.3, which="minor", ls="--")

plt.show()
```


Backscattering Curve: Silver
fitted points
original counts
1.375
1.350
1.325
1.300
1.275
1.250
1.225
f_{ab}
100
200
300
400
500
600
thickness in $\left(\frac{mg}{cm^2}\right)$