# NMR

October 9, 2023

[1]:

```
import numpy as np
import pandas as pd
import sympy as sm
import matplotlib.pyplot as plt
from scipy.optimize import curve_fit
from matplotlib_inline.backend_inline import set_matplotlib_formats
plt.style.use('seaborn-v0_8')
plt.rcParams |= {
    'text.usetex': True,
    'figure.figsize': (10, 4)
}
set_matplotlib_formats('svg', 'pdf')
```

[2]:

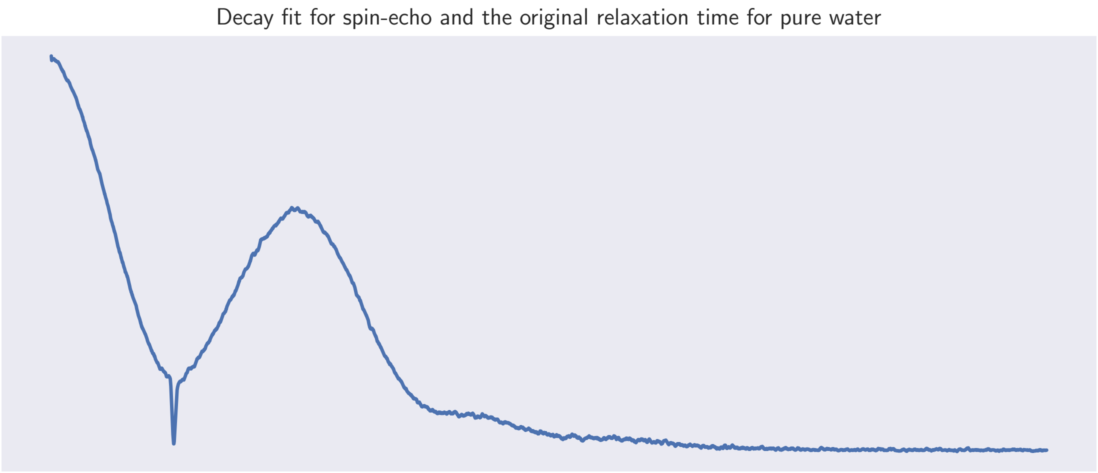
```
def smooth_data(data, window_size):
    return data.rolling(window=window_size, min_periods=1).mean()

# Function for the decay exponential
def decay_func(t, A, k, C):
    return A * np.exp(-k * t) + C

t = sm.symbols('t')
def decay_func_sm(t, A, k, C):
    return A * sm.exp(-k * t) + C
```

[3]:

```
df = pd.read_csv('/Users/ammar-imac/Documents/NMR/tek0004CH1H_OSE.csv')
df = df[19:]
df.columns = ['TIME', 'CH1']
```

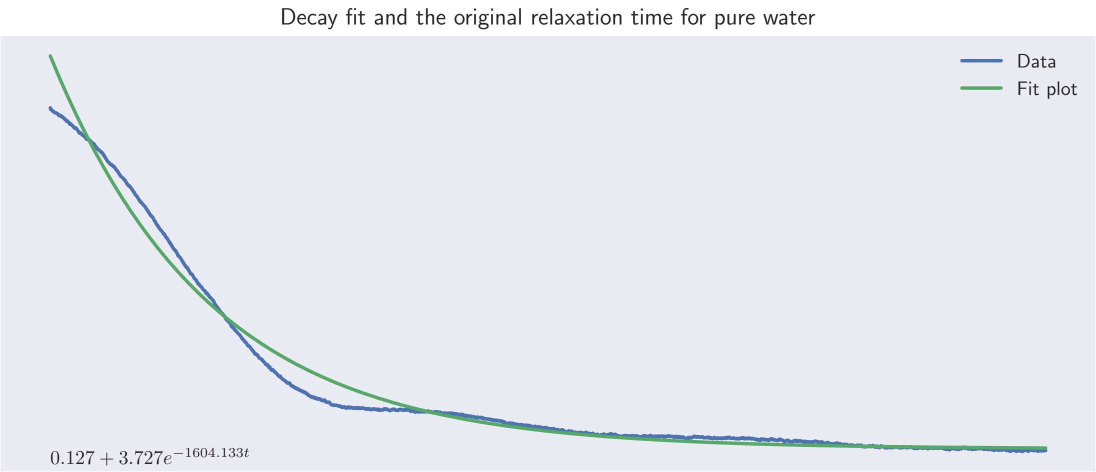
[4]:

```
val = np.argmax(df.CH1)
plt.plot(df.TIME.iloc[val:], smooth_data(df.CH1.iloc[val:], 20))
plt.xticks([])
plt.yticks([])
plt.title("Decay fit for spin-echo and the original relaxation time for pure␣
  ↪water")
plt.show()
```



```
[5]: df = pd.read_csv('/Users/ammar-imac/Downloads/NMR/tek0008ALLLLLLL.csv')
     df = df[19:]
     df.columns = ['TIME', 'CH1']
     val = np.argmax(df.CH1)
     t_data = df.TIME.iloc[val:].astype(float)
     y_data = smooth_data(df.CH1.iloc[val:], 50).astype(float)
     params, covariance = curve_fit(decay_func, t_data, y_data)
```

```
[6]: plt.plot(df.TIME.iloc[val:], smooth_data(df.CH1.iloc[val:], 10), label='Data')
     plt.plot(
         df.TIME.iloc[val:], decay_func(df.TIME.iloc[val:].astype(float), *params),
         label='Fit plot'
     )

     plt.xticks([])
     plt.yticks([])
     plt.text(0, 0, sm.latex(decay_func_sm(t, *[round(val, 3) for val in params]),␣
      ↪mode='inline'))
     plt.title("Decay fit and the original relaxation time for pure water")
     plt.legend()
     plt.show()
```



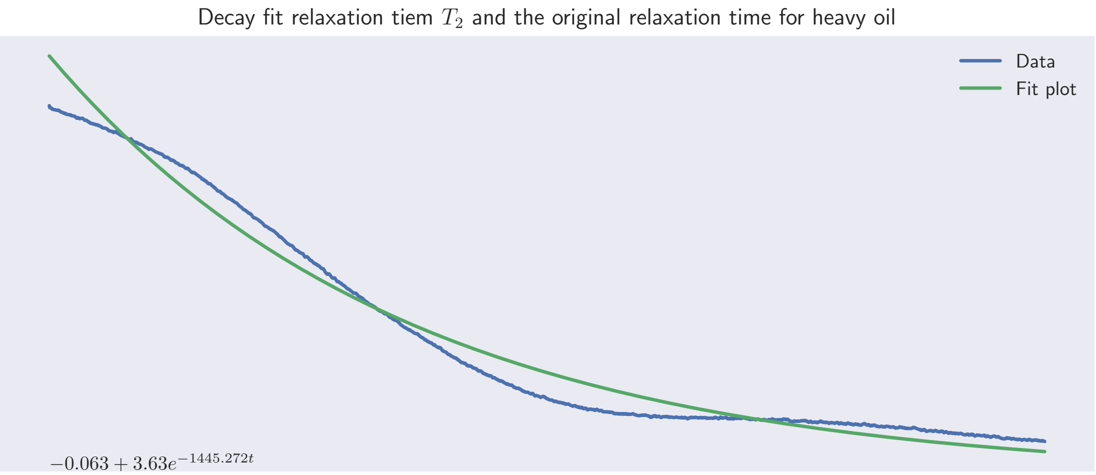
Decay fit and the original relaxation time for pure water

[7]:

```python
df = pd.read_csv('/Users/ammar-imac/Documents/NMR/tek0001CH1.csv')
df = df[19:]
df.columns = ['TIME', 'CH1']
val = np.argmax(df.CH1)
t_data = df.TIME.iloc[val:].astype(float)
y_data = smooth_data(df.CH1.iloc[val:], 50).astype(float)
params, covariance = curve_fit(decay_func, t_data, y_data)
```

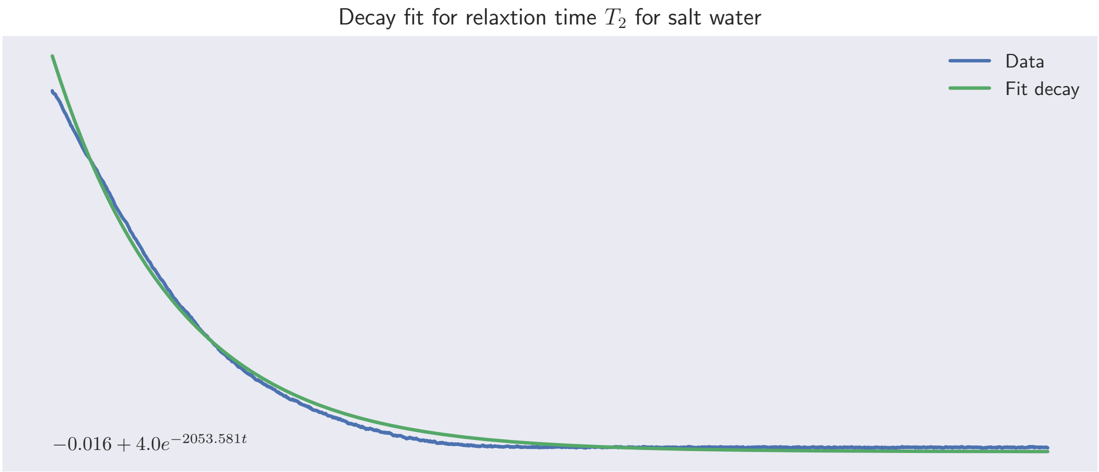
[8]:

```python
val = np.argmax(df.CH1)
plt.plot(df.TIME.iloc[val:], smooth_data(df.CH1.iloc[val:], 10), label='Data')
plt.plot(
    df.TIME.iloc[val:], decay_func(df.TIME.iloc[val:].astype(float), *params),
    label='Fit plot'
)

plt.xticks([])
plt.yticks([])
plt.text(0, 0, sm.latex(decay_func_sm(t, *[round(val, 3) for val in params]), mode='inline'))
plt.title("Decay fit relaxation tiem $T_2$ and the original relaxation time for heavy oil")
plt.legend()
plt.show()
```



[9]:
```
df = pd.read_csv('/Users/ammar-imac/Documents/NMR/tek0009CHWSSS1.csv')
df = df[19:]
df.columns = ['TIME', 'CH1']
# fit plot
val = np.argmax(df.CH1)
t_data = df.TIME.iloc[val:].astype(float)
y_data = smooth_data(df.CH1.iloc[val:], 50).astype(float)
params, covariance = curve_fit(decay_func, t_data, y_data)
```

[10]:
```
val = np.argmax(df.CH1)
plt.plot(df.TIME.iloc[val:], smooth_data(df.CH1.iloc[val:], 10),
        label='Data')
plt.plot(
    df.TIME.iloc[val:], decay_func(df.TIME.iloc[val:].astype(float), *params),
    label='Fit decay'
)

plt.xticks([])
plt.yticks([])
plt.text(0, 0, sm.latex(decay_func_sm(t, *[round(val, 3) for val in params]),␣
  ↪mode='inline'))
plt.title("Decay fit for relaxtion time $T_2$ for salt water")
plt.legend()
plt.show()
```


Decay fit for relaxtion time $T_2$ for salt water
Data
Fit decay
$-0.016 + 4.0e^{-2053.581t}$