Assignment 3

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EE23B140

1 Code Explanation

Import the relevant libraries

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

Load data from the files given in the form of a numpy array.

Make the variables global so that they can be accessed from everywhere.

Add random noise to the dataset.

```
# Load data
def load_data(filename):
    f = open(filename, "r")

    global x, y
    x, y = [], []

    for line in f:
        l, radiance = line.split(",")
        x.append(l)
        y.append(radiance)

    x = np.array(x, dtype=np.float64)
    y = np.array(y, dtype=np.float64)
    noise = 0.2 * np.random.randn(len(y)) # add noise
    y_noisy = y + noise

    return x, y_noisy
```

Define the function with all parameters

```
# Blackbody radiation function with all parameters
def nlfunc(l, h, c, K, T):
    return (2 * h * c**2 / l**5) / (np.exp((h * c) / (l * K * T)) - 1)
```

Define the initial parameters to help calculate the function and then perform curve fitting using the curve fit function on the datset to determine the parameters from the data

```python
def curve_fitting(x, y_noisy):
    # Constants for the blackbody spectrum
    global h_fixed, c_fixed, K_fixed, T_fixed
    h_fixed = 6.62607015e-34 # Planck's constant (J*s)
    c_fixed = 2.998e8 # Speed of light (m/s)
    K_fixed = 1.380649e-23 # Boltzmann constant (J/K)
    T_fixed = 6000.00 # Temperature(K)
    initial_guess = [
        h_fixed,
        c_fixed,
        K_fixed,
        T_fixed,
    ] # Example initial guess for temperature

    # Fit data to the blackbody spectrum
    params, _ = curve_fit(nlfunc, x, y_noisy, p0=initial_guess)
    return params
```

Plot the function for all 4 data sets and do curve fitting on the same. Print out the values obtained from curve fitting

```python
# Create a figure with a grid of subplots
fig, axes = plt.subplots(2, 2, figsize=(14, 12)) # 2x2 grid, adjust figsize as
    needed

# Dataset filenames and titles
filenames = ["d1.txt", "d2.txt", "d3.txt", "d4.txt"]
titles = ["Dataset 1", "Dataset 2", "Dataset 3", "Dataset 4"]

# Index for subplots
idx = 0

# Process each dataset and plot
for filename in filenames:
    x, y_noisy = load_data(filename)
    params = curve_fitting(x, y)
    h_fit = params[0]
    c_fit = params[1]
    K_fit = params[2]
    T_fit = params[3]

    print(f" h_fit = {h_fit}\n c_fit = {c_fit}\n K_fit = {K_fit}\n T_fit = {T_fit
        }\n")

    # Determine subplot position
    row = idx // 2
    col = idx % 2
    ax = axes[row, col]

    # Sort data for plotting
    sorted_indices = np.argsort(x)
    x_sorted = x[sorted_indices]
    y_noisy_sorted = y_noisy[sorted_indices]

    # Plot the noisy data and fitted curve
    ax.plot(x_sorted, y_noisy_sorted, label="Noisy Data", color="blue")
    x_fit = np.linspace(min(x), max(x), 1000)
```

```
    y_fit = nlfunc(x_fit, *params)
    ax.plot(x_fit, y_fit, color="red", label="Fitted Curve")

    # Set labels, legend, and title for the subplot
    ax.set_xlabel("Wavelength (m)")
    ax.set_ylabel("Spectral Radiance")
    ax.legend()
    ax.set_title(titles[idx])

    # Increment the index for the next subplot
    idx += 1

# Show the plot
plt.show()
```

Create partial functions with only one unknown parameter as it makes curve fitting much more accurate

```
# create partial function with only wavelength and T as parameters
def partialfunc_T(l, T):
    return (2 * h_fixed * c_fixed**2 / l**5) / (
    np.exp((h_fixed * c_fixed) / (l * K_fixed * T)) - 1)

# create partial function with only wavelength and h as parameters
def partialfunc_h(l, h):
    global t_fixed
    t_fixed = 4000.00 # from previous results
    return (2 * h * c_fixed**2 / l**5) / (
        np.exp((h * c_fixed) / (l * K_fixed * t_fixed)) - 1
    )

# create partial function with only wavelength and c as parameters
def partialfunc_c(l, c):
    return (2 * h_fixed * c**2 / l**5) / (
        np.exp((h_fixed * c) / (l * K_fixed * t_fixed)) - 1
    )

# create partial function with only wavelength and K as parameters
def partialfunc_K(l, K):
    return (2 * h_fixed * c_fixed**2 / l**5) / (
        np.exp((h_fixed * c_fixed) / (l * K * t_fixed)) - 1
    )
```

Curve fit the partial functions and print the estimated values of the parameters

```
# calculate the parameters using curve fitting on the partial functions
for filename in filenames:
    x, y_noisy = load_data(filename)
    T_guess = 6000
    T, _ = curve_fit(partialfunc_T, x, y_noisy, p0=T_guess)
    print(f"T_fit = {T[0]}")
    h_guess = 6.63e-34
    h, _ = curve_fit(partialfunc_h, x, y_noisy, p0=h_guess)
    print(f"h_fit = {h[0]}")
    c_guess = 3e8
    c, _ = curve_fit(partialfunc_c, x, y_noisy, p0=c_guess)
    print(f"c_fit = {c[0]}")
    K_guess = 1.4e-23
```

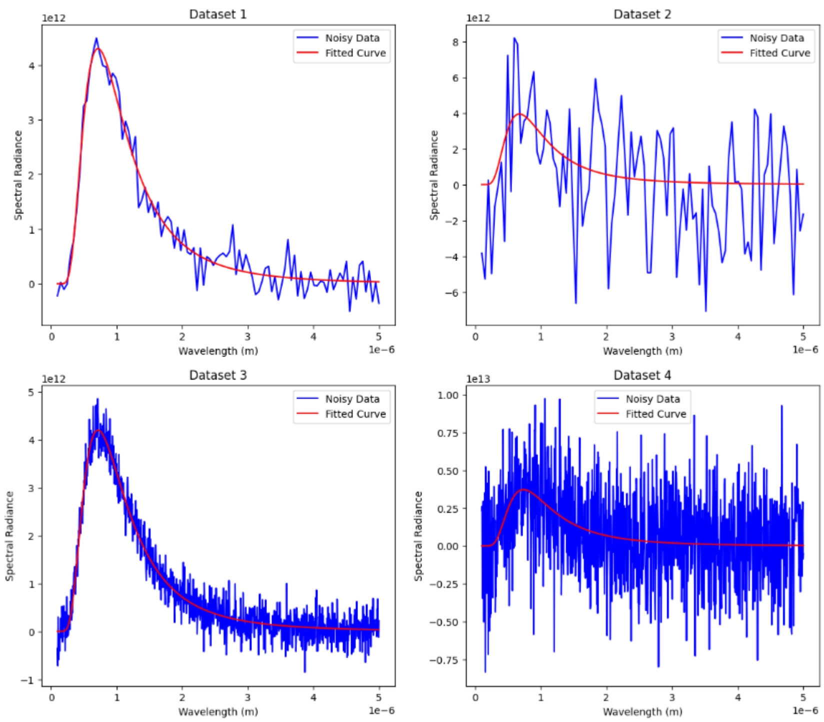
```python
    K, _ = curve_fit(partialfunc_K, x, y_noisy, p0=K_guess)
    print(f"K_fit = {K[0]}\n")
```

2 Findings

```
h_fit = 1.4247732394649525e-33
c_fit = 201685712.87789991
K_fit = 1.5395069738840864e-23
T_fit = 5243.586589803959

h_fit = 3.0578080053070537e-34
c_fit = 354998807.0504989
K_fit = 7.949603478076316e-24
T_fit = 4090.2645712469734

h_fit = 2.3791522669341284e-33
c_fit = 154126310.24502125
K_fit = 1.8861634456305762e-23
T_fit = 5462.967731460856

h_fit = 1.688078364379975e-33
c_fit = 182686752.65530685
K_fit = 2.109509897840237e-23
T_fit = 4012.315331159715
```

These values are pretty inaccurate compared to the real values because we are trying to fit 4 unknown parameters at the same time.

If I experiment and put the initial guess pretty different than the actual values, the curve fitting is just not performed.



The below parameters obtained from the partial functions are much more accurate and consistent.

```
T_fit = 4019.8544785163613
h_fit = 6.584188695947929e-34
c_fit = 297251280.70030266
K_fit = 1.3875020170379547e-23

T_fit = 3956.750872092873
h_fit = 6.687959018225388e-34
c_fit = 300793593.84075284
K_fit = 1.365721192576067e-23

T_fit = 4000.5633732635047
h_fit = 6.622638868387446e-34
c_fit = 299379054.5274586
K_fit = 1.3808434671975695e-23

T_fit = 3904.6881561520354
h_fit = 6.8261842089740425e-34
c_fit = 311349683.09270024
K_fit = 1.347751567100121e-23
```