Shiv Patel Hw 2 02/25/23

1. [30 Points] Write a least-squares fitting code that implements the Levenberg-Marquardt algorithm

   In order to assess the compatibility of the Levenberg-Marquardt algorithm with Equations 1 and 2 (listed below), I utilized Professor Cindy Gullis's code, "LSF-Levenberg-Marquardt_HW2.py," as a basis for my own code. Through coding and debugging with assistance from Nathan Crostello, Killian Gremling, and Kadri Nazim, the TA, my code, "main.py," was able to successfully complete the necessary computations to output the corresponding diagrams. I provided titles and labels to Figures 1 and 2, respectively, as 'Lorentzian Fit' and 'Gaussian Fit'.

2. [45 points] Use the above least-squares fitting code to fit the data hw2 fitting.dat on CANVAS with two functions: a Lorentzian as in Equation (1), and a Gaussian as in Equation (2).

$$\phi(\nu) = \frac{1}{\pi}\frac{\alpha_L}{(\nu-\nu_0)^2+{\alpha_L}^2} \tag{1}$$

$$\phi(\nu) = \frac{1}{\alpha_D}\sqrt{\frac{\ln 2}{\pi}}e^{\frac{-(\ln 2)(\nu-\nu_0)^2}{{\alpha_D}^2}} \tag{2}$$

   Altering my code to correctly read the text in the data file “hw2_fitting.dat’, I used the codes above to calculate the output, calculated variables are:

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Lorentzian fit using the scipy function:
   nu_0 = 46.27051561064118 +/- 0.025449421967938896,
   lorentzian_alpha = 7.543889804343346 +/- 0.02782791908001512
Gaussian fit using the scipy function:
   nu_0 = 44.953870844906994 +/- 0.04602327463033775$,
   gaussian_alpha = 15.026772497231136 +/- 0.03345242382758067
Lorentzian fit using our levenMarq function:
   nu_0 = 46.27051561064118 +/- 0.025449421967938896,
   lorentzian_alpha = 7.543889804343346 +/- 0.02782791908001512
Gaussian fit using our levenMarq function:
   nu_0 = 44.953870844906994 +/- 0.04602327463033775,
   gaussian_alpha = 15.026772497231136 +/- 0.03345242382758067
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   Where ν_0 = nu_0, α_L = Lorentzian_alpha and α_D = Gaussian_alpha

3. [25 points] Plot the data and fitting curves, be sure to include the error-bars of the data. Which function fits the data better and why?

   Upon conducting a thorough analysis of Figures 1 and 2 using the modified code in main.py' and using 'hw2_fitting.dat' as inputted data, it is evident that the Lorentzian and Gaussian Fits are of high quality in terms of data fitting. From a visual standpoint, it is observed that Figure 2 displays an almost identical resemblance between the plot points and the fit, while Figure 1 exhibits a lower peak with slight differences in the shape when compared to the fit. This suggests that the Gaussian Fit provides a closer approximation of the data. Furthermore, the Gaussian Fit falls within the range of error bars for the majority of data points, whereas the Lorentzian Fit does not. This indicates that the gaussian fit is a more dependable tool for precise data analysis and interpretation.