ASTP-720 Homework 1

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Github Link: `https://github.com/zrd7527/ASTP720.git`

1 Problem 1

Using the methods described in class, I created a function for all 3 of the root finding algorithms in a Jupyter Notebook cell. The initial guesses and intervals for each are coded into each function. I chose to use the equation which was also used in class, $f(x) = \sqrt{45}$, to test all of my root finding functions. Finally in my main function there are requests for user inputs for entering a threshold value, what the desired threshold value is, printing the number of iterations, and choosing what method to use to find the root of the equation.

2 Problem 2

For this section I used slightly modified versions of the root finding algorithms from problem 1 to find the root of the pseudo-isothermal sphere lens equation. This equation and its derivative can be seen in equation 1 and 2 respectively. I ran each method using threshold values between 0.001 and 0.01 and appended the number of iterations for each method at each threshold value to separate arrays. As can be seen in figure 1, the bisection method had the most iterations at small threshold values whereas the secant method had the least iterations.

$$N_e(x) = N_0[1 + (x/r_c)^2]^{-1/2} \tag{1}$$

$$\frac{d}{dx}N_e(x) = -\frac{N_0 x}{r_c^2[1 + (x/r_c)^2]^{3/2}} \tag{2}$$

3 Problem 3

In this part I used equation 11 in the homework, the Gaussian plasma lens equation, to solve for x using a known range of x' values. I chose to use the secant method because it seemed to be very accurate and the fastest. The threshold value I gave was 0.001 and I found the root of the equation from $x' = 0$ to $x' = 20$ so the x-axis increases in 1/10 AU increments. The ray tracing paths that my code produced can be seen in figure 2 and equation 11 from the homework is equation 3 in this paper.

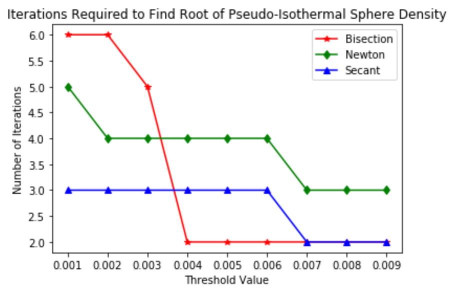

Figure 1

$$x' = x[1 + \frac{\lambda^2 r_e N_0 D}{\pi a^2} e^{-(x/a)^2}] \tag{3}$$

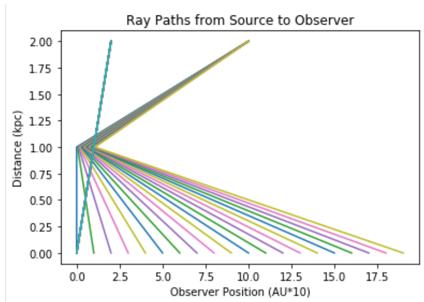

Figure 2

4 Problem 4

This problem was to repeat problem 3 but using the pseudo-isothermal sphere equation, given in equation 1. I used the secant method again and ran my code for a range of r_c values between 1 and 6, making the x-axis increase by 1/5 AU increments. The ray tracing path produced this time can be seen in figure 3.

5 Problem 5

This problem required making an interpolator function. I used the equation derived in class for linear interpolation with 2 initial data points. These data points are the inputs to the function and the output is the y value at the input x value, x_p.

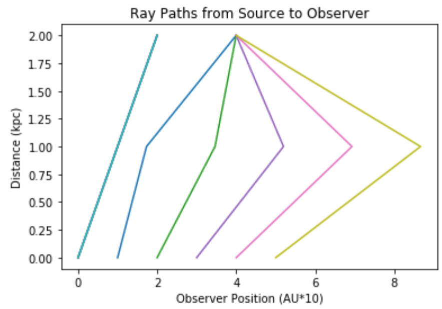

Figure 3

6 Problem 6

In this problem I read the data from the given text file and input all data points through my linear interpolator from problem 5. The x_p value was the midpoint of each pair of x values in the data file. I plotted both the points from the text file and the interpolated y values as can be seen in figure 4. The interpolator appears to work perfectly.

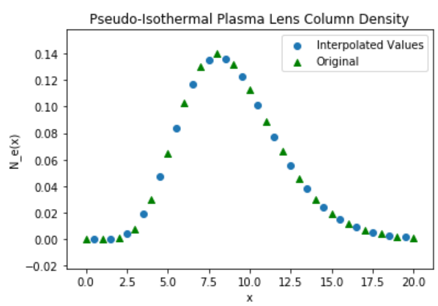

Figure 4