ASTP-720 Homework 2

Zach Diermyer

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

1 Problem 1

For this problem I implemented the equations derived in class. Each function in my code takes a mathematical function and a step size, h. The derivative uses a starting x value Then finds the input function's value at that x then at the x one step later. Taking the difference and dividing by the step size yields the derivative. The integral functions all take 2 bounds and sum the function between the bounds. The number of iterations that the integral sums over is determined by dividing the difference between the bounds by the step size. I used the function $f(x) = x^2$ to test all of my numerical calculus functions.

2 Problem 2

The Navarro-Frenk-White density profile uses dark matter to describe how galaxies can have such a large rotational velocity at large radii. Using this density profile, the mass enclosed, $M_{enc}(r)$, is determined by Equation 1 with $V_c(r)$ defined by Equation 2. The plots of $M_{enc}(r)$ with varying V_c and C are shown in figures 1 and 2 respectively. The total masses all came out to between 1x10^8 and 5x10^8 for velocities between 150 and 250 km/s and concentration factors between 10 and 25. The mass in a small shell is the same as dM/dr for my code because I used a step size of one parsec. This made the shells small enough to approximate the derivative. Plots for the shell/derivative are shown in figures 3 and 4.

$$M_{enc}(r) = \frac{rv_c^2(r)}{G} \tag{1}$$

$$v_c(r) = v_{200}\sqrt{\frac{1}{x}\frac{ln(1+cx) - \frac{cx}{1+cx}}{ln(1+c) - \frac{c}{1+c}}} \tag{2}$$

3 Problem 3

Finally I created a matrix class which can do everything asked in the problem description. The matrices can be added, multiplied, and transposed. The trace, determinant, and inverse of any

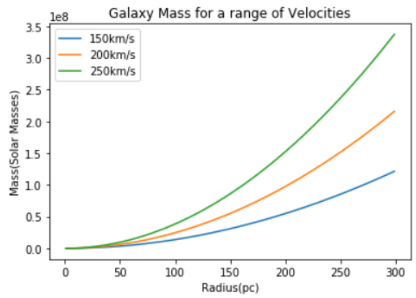

Figure 1

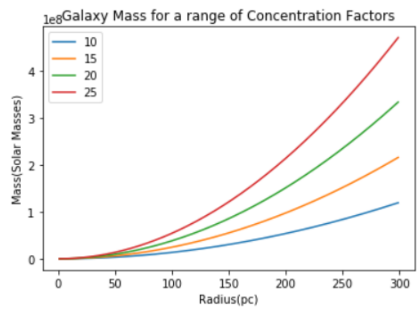

Figure 2

size matrix can also be found. The determinant and inverse functions have helper functions for 2 by 2 matrices. An LU decomposition function is also implemented using a modified version of an algorithm sourced online called the Doolittle Algorithm (link below). The Doolittle Algorithm performs the calculation derived in class.

`https://www.geeksforgeeks.org/doolittle-algorithm-lu-decomposition/`

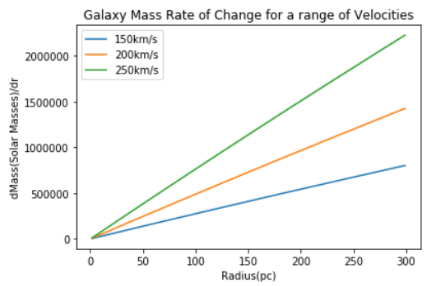

Figure 3

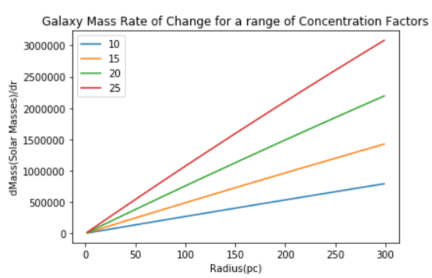

Figure 4