Pre-class assignment #12

PHY-905-005
Computational Astrophysics and Astrostatistics
Spring 2023

This assignment is due the evening of Tuesday Mar. 13, 2023. Turn in all materials via GitHub.

Reading:

1. Chapter 9 of Mike Zingale's Computational Hydrodynamics Tutorial (PDF in the last pre-class assignment)
2. Section 9.2 of *Computational Physics*, by Newman.

Your assignment:

1. After reading the assigned sections from Newman and Zingale's notes, list at least three questions or points of confusion that you have in the file `ANSWERS.md`.
2. Implement one of the relaxation methods described in Section 9.3 of Zingale's notes to solve the 2D Poisson equation for an $N \times N$ grid of user-specified size, which can also accept an arbitrary density distribution in the grid. Make sure to appropriately include boundary conditions, which adds two cells in each dimension. Write the code in a modular way – have a function that generates the grid, one that sets the density field in a user-specified way, one that implements the boundary conditions, one that does the iteration, and one that measures the residual error (as defined by Equation 9.38 of Zingale). Test to make sure that your solver is working correctly by inserting a single point-mass at the center (i.e., density in a single cell), and plot the residual, L_2, and L_∞ norms as a function of iteration (measure L_2 and L_∞ vs. the analytic solution for a point mass).

Handing it in: Include your code, your plots, and your answers to the questions about (in the file `ANSWERS.md`) in your assignment.