ME 388F Homework 4

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See my GitHub repository s25me388f_hansen for my discrete ordinates, P_2, and Monte Carlo simulation. I've also committed all plots used in the below discussion.

I will note that my results in this section may be underresolved in space.

1 More Output

1.1 Infinite Homogeneous Constant Source

(A) We solve the infinite homogeneous problem for $\Sigma_s = 0.9999$ and calculate the new moments as described in the homework to find moments shown in Figure 1 for S_{64}.

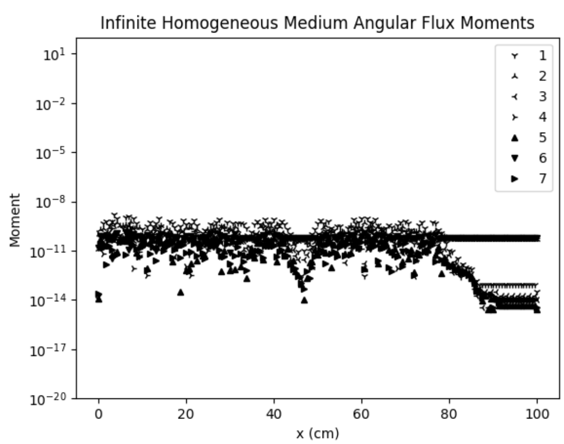
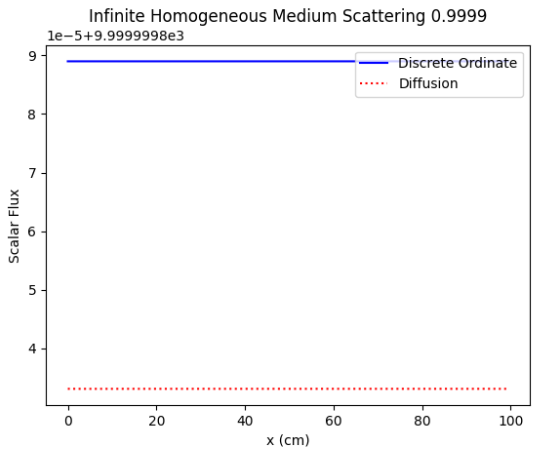


Figure 1: First through seventh order moments of the angular flux as calculated by a S_{64} discrete ordinates approximation. We see that all moments are small, although not quite at machine precision, which indicates that our method succeeded in finding a flat solution.

(B) Both the discrete ordinates and diffusion solutions are flat and have a correct value as shown in Figure **??**



1.2 Source Free Transport

(a) We were able to compute the current as one of the moments of the discrete ordinate solution and use the leftmost current as the current in the diffusion boundary condition, and the rightmost current as the current at the right boundary in the work that follows.

(b) See Figure 2 for comparisons of the diffusion and discrete ordinates solutions

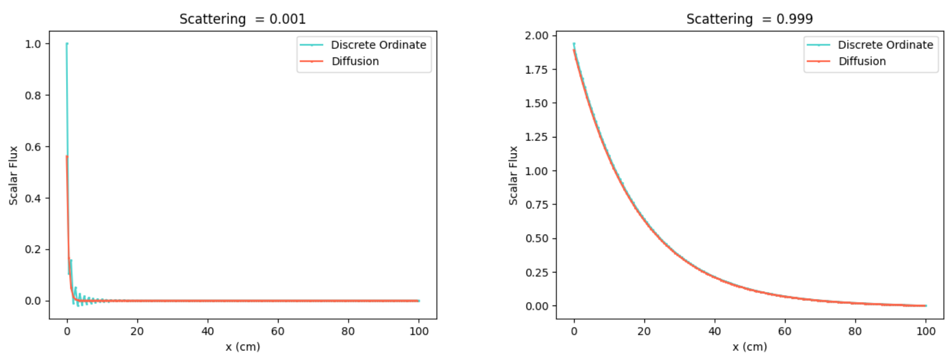


Figure 2: We see qualitative agreement of the diffusion and discrete ordinates solutions showing exponential decay in both cases. However, we see that the diffusion solution falls about half an order of magnitude short of the discrete ordinates scalar flux for small scattering ratios. However, with large scattering, the diffusion solution grows and the solutions nearly match.

(c) Through the calculation of the moments of the angular flux in the discrete ordinates code, we were able to plot the ratio between the moments as shown at Figure 3.

(d) In most cases, as exemplified in Figure 4, we found an equal absorption rate for the diffusion and discrete ordinates code. This is in spite of the fact that we observed a mismatch between the scalar fluxes and there was an equal absorption cross section, so we anticipate a bug in the calculation of a scalar flux somewhere. But otherwise, this would indicate that a discrete ordinates code leaks more particles to account for the mismatch.

1.

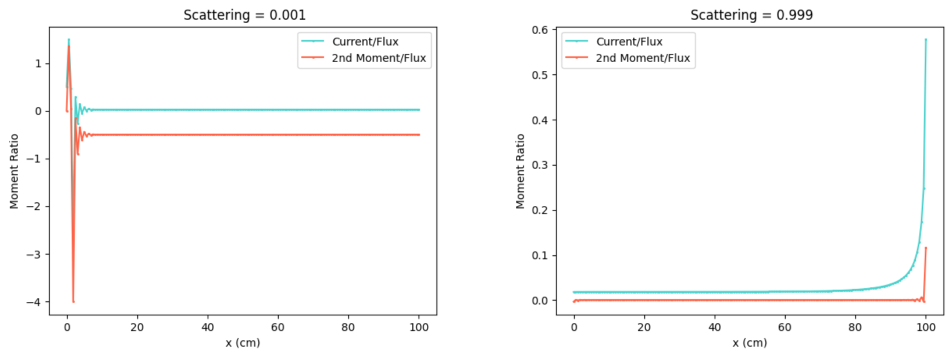


Figure 3: For small scattering cross sections, at isolated points in the source free problem the second order moment becomes large compared with the scalar flux. This shows that diffusion can't accommodate the fluxes in this problem just by linearizing the angular flux. However, we see at larger scattering ratios that the second order moment is a smaller fraction of the scalar flux, so diffusion can be a more appropriate approximation.

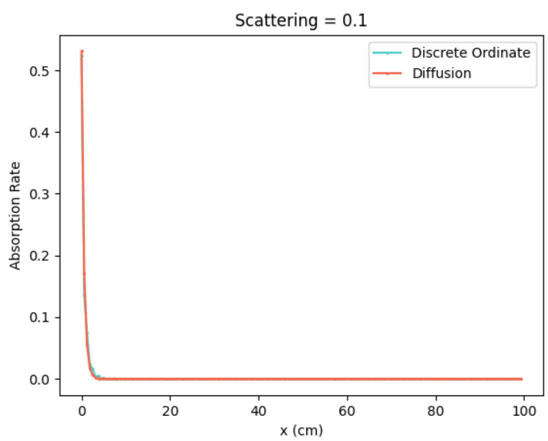


Figure 4: Absorption rate in simulations of source free transport.

1.3 Vacuum Boundary Constant Source

1. As examples in Figure 5 show, the diffusion and discrete ordinates methods agree very well across the range of Σ_s:

2. Again using the moments of the discrete ordinates calculation, we see that in Figure 6 examples the second moment of the angular flux is small, suggesting that diffusion is a valid model for this problem.

2 Monte Carlo

(A) My collision and track length tallies and scalar fluxes agree for the infinite homogeneous medium problem, but not for the source free transport and vacuum problems. We see that in

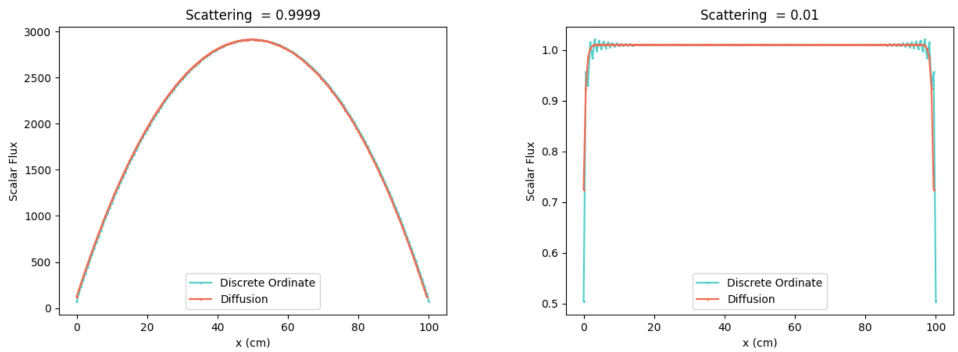


Figure 5: Scalar flux calculated by S_{64} and P_2 codes.

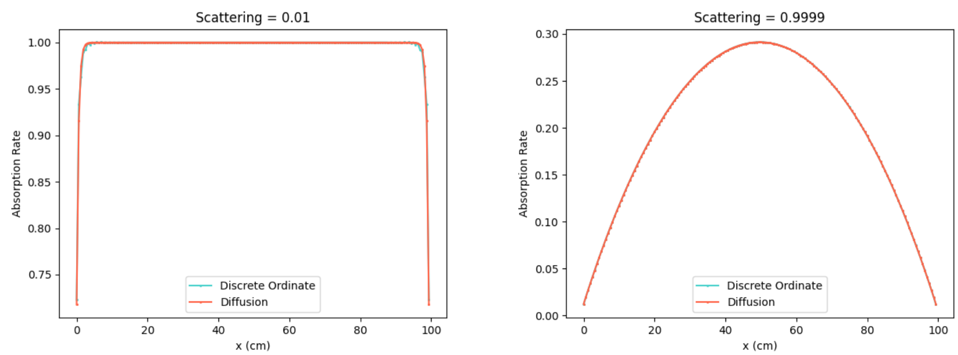


Figure 6: Ratios of the first and second moment of the angular flux to the scalar flux, showing that the angular flux may be treated as linearly anisotropic.

the infinite homogeneous medium problem there is a decay to no flux at the edges in both tallies, and in the vacuum transport problem the track length scalar flux remains constant while the rate tally decays at the edges, which is opposite the expected behavior. However, the track length tally appears to retain a more accurate value overall, so it could be that we are tallying in cases that we shouldn't and in other cases not tallying where we need to. See Figure 7 for problem children.

(B) With no scattering in the infinite medium, we see scalar flux and currents as shown in Figure 8

(C) This may in part be due to the way I've set up the error (since we know the error in a count will be the square root, and then propagate uncertainty as needed for the average), but the error does decrease as the square root of the number of points. We can see this in Figure 8 as well.

(D) When we tally the track length, we add the distance traveled by neutrons at each location in the system. As a result, dividing this by the length traveled (which serves as a unit of volume in 1D since the area is uniform), multiplying by the 1D source times length in the system and dividing by the number of particles simulated gives the scalar flux. Similarly, counting the positive and negative fluxes through a length similarly rescaled yields the current. However, I

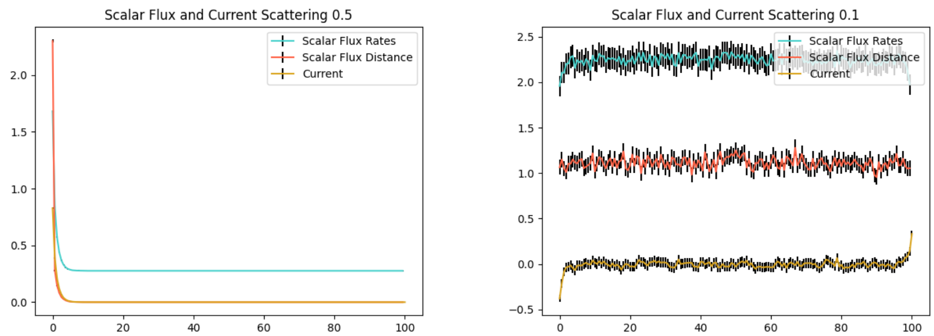


Figure 7: Monte Carlo simulations with 10^5 particles each of the source free transport problem and vacuum boundary problem.

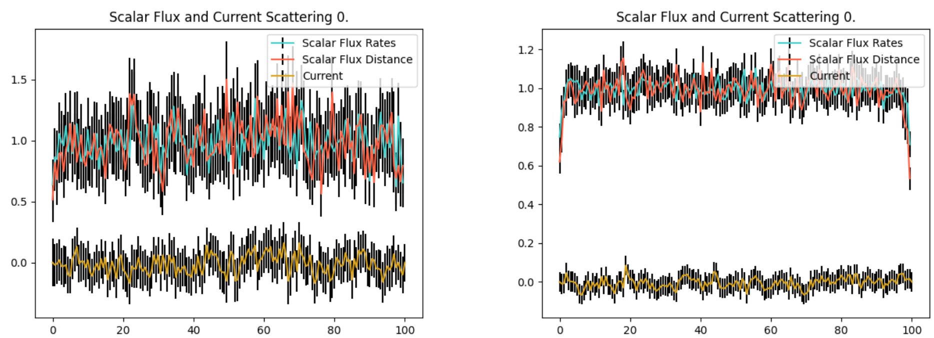


Figure 8: The infinite homogeneous problem with unit source and no scattering as simulated with 10^4 and 10^5 particles. We notice that the scalar flux and current are flat at one and zero respectively, except at the edges of the scalar flux due to the known bug. Notice that the error bars shrink by roughly a factor of $3 \approx \sqrt{10}$ between simulations, showing the expected decrease in the statistical error.

don't know how we would obtain higher order moments of the angular flux from the particle tallies gathered, and there are some known issues, as outlined above.

(E) We simulate the source free transport problem and using S_{64} and Monte Carlo and find current shown in Figure 9:

3 References

I briefly discussed this homework with Max Hoffing and Harrison Reisinger, in addition to using information from the lab slides materials. I also lowered my discrepancy threshold for the source iteration convergence to 10^{-5} after the HW 3 class presentation by Caleb Miller. In my deterministic solvers, I tried using a fixed iteration acceleration method (Anderson acceleration) that I had heard about from my research, and tried to implement that to minimize the error in the scalar flux. However, this failed to converge correctly for high scattering cases so I didn't use it for this assign-

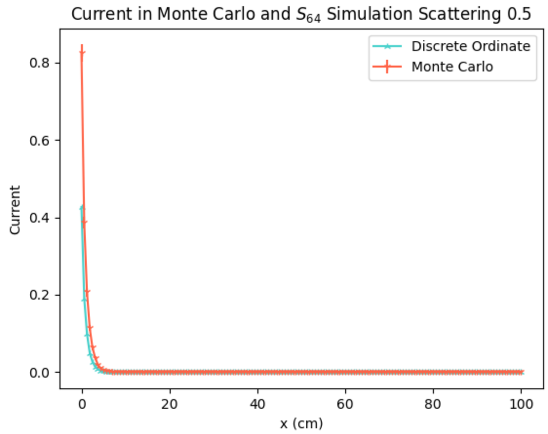


Figure 9: Current for a $\Sigma_s = 0.5$ simulation produced using S_{64} and 10^4 particle Monte Carlo simulation. Based on this plot, it seems that the results qualitatively agree, although the current in the Monte Carlo simulation has roughly half the value of the discrete ordinates simulation. This may be due to a normalization issue.

ment. The code that I used was the result of a calculus derivation I made based on the Wikipedia page for Anderson acceleration.