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Radiation Transport Methods

Final Project

c = 0.999

Nit = 3119

DD Sn Phi(0) = 0.12154

DD Sn Phi(100) = 2.0967

DD Sn Phi(200) = 3.1615

GS CE Phi(0) = 0.12427

GS CE Phi(100) = 2.0925

GS CE Phi(200) = 3.1517

GS CC Phi(0) = 0.12359

GS CC Phi(100) = 2.0921

GS CC Phi(200) = 3.142

c = 0.99

Nit = 2192

DD Sn Phi(0) = 0.048408

DD Sn Phi(100) = 1.3092

DD Sn Phi(200) = 2.4842

GS CE Phi(0) = 0.049949

GS CE Phi(100) = 1.3186

GS CE Phi(200) = 2.4819

GS CC Phi(0) = 0.049349

GS CC Phi(100) = 1.3149

GS CC Phi(200) = 2.4686

c = 0.9

Nit = 1393

DD Sn Phi(0) = 0.0012241

DD Sn Phi(100) = 0.46733

DD Sn Phi(200) = 1.7664

GS CE Phi(0) = 0.0011062

GS CE Phi(100) = 0.48101

GS CE Phi(200) = 1.7572

GS CC Phi(0) = 0.0010702

GS CC Phi(100) = 0.47916

GS CC Phi(200) = 1.7445

c = 0.5

Nit = 1206

DD Sn Phi(0) = 6.826e-06

DD Sn Phi(100) = 0.205

DD Sn Phi(200) = 1.5527

GS CE Phi(0) = 1.0217e-06

GS CE Phi(100) = 0.22124

GS CE Phi(200) = 1.5325

GS CC Phi(0) = 9.4935e-07

GS CC Phi(100) = 0.22036

GS CC Phi(200) = 1.5203

Cell-centered values were adjusted, per instruction, to represent the left and right boundary cell-edges, as well as the cell-edged discretizations of Phi(10). Despite these adjustments, the values still differed by approximately 0.01 on the right boundary. I expect using a finer mesh would reduce this difference much further. I re-ran final.m for c = 0.999 using a cell width of 1 cm (instead of 0.1 cm) with internal source boundaries between 10 and 20 (instead of 100 to 200) and achieved the following results:

Nit = 3140

DD Sn Phi(0) = 0.23735

DD Sn Phi(10) = 2.193

DD Sn Phi(20) = 3.3257

GS CE Phi(0) = 0.14348

GS CE Phi(10) = 2.2863

GS CE Phi(20) = 3.4092

GS CC Phi(0) = 0.13609

GS CC Phi(10) = 2.2935

GS CC Phi(20) = 3.3305

From these results, it's apparent that changing cell width has a noticeable effect on cell-edged and cell-centered discretized values of scalar flux.

Again, I re-ran final.m for c = 0.999 using a cell width of 0.05 cm with internal source boundaries between 200 and 400 and achieved the following results:

ε = 10^-6

Nit = 3118

DD Sn Phi(0) = 0.11428

DD Sn Phi(200) = 2.0905

DD Sn Phi(400) = 3.1517

GS CE Phi(0) = 0.12152

GS CE Phi(200) = 2.0562

GS CE Phi(400) = 3.1028

GS CC Phi(0) = 0.12119

GS CC Phi(200) = 2.0559

GS CC Phi(400) = 3.098

ε = 10^-12

Nit = 7860

DD Sn Phi(0) = 0.1143

DD Sn Phi(200) = 2.0907

DD Sn Phi(400) = 3.152

GS CE Phi(0) = 0.12384

GS CE Phi(200) = 2.0893

GS CE Phi(400) = 3.1484

GS CC Phi(0) = 0.1235

GS CC Phi(200) = 2.089

GS CC Phi(400) = 3.1435

I thought this was interesting, because if only cell width is reduced, results continue to diverge, but if cell width is reduced and the convergence criterion exponent is increased, results converge with greater precision.

For the scope of this project, in choosing the convergence criterion exponent, it was necessary to first run the script and determine the minimum value of scalar flux, using an arbitrary exponent. From there, the script can be re-run with an appropriate convergence criterion exponent that corresponds to the decimal place calculated by the script. For the results listed above, I used 10^-6. I recalculated c = 0.5 results using 10^-10 and got the following results:

c = 0.5

Nit = 2381

DD Sn Phi(0) = 6.8265e-06

DD Sn Phi(100) = 0.20501

DD Sn Phi(200) = 1.5528

GS CE Phi(0) = 1.0217e-06

GS CE Phi(100) = 0.22124

GS CE Phi(200) = 1.5325

GS CC Phi(0) = 9.4935e-07

GS CC Phi(100) = 0.22036

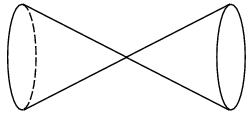
GS CC Phi(200) = 1.5202

It's evident that the results do not dramatically change. The number of iterations rises from 1206 to 2381, but this isn't a burdensome time constraint, even on a laptop.

The scalar flux graphs are very similar, however, the DD Sn and GS CE/CC graphs diverge as scattering ratio decreases in the left half of the slab.

It's also apparent that scalar flux decreases as scattering ratio decreases, which is attributable to increased absorption in the left half of the slab and less back-scattering in the right half. The lines diverge more in the left half due to this dominant effect. The vacuum left boundary condition and reflector right boundary condition, combined with the internal source field in the right half of the slab, result in relatively predictable scalar flux curves. I would expect the right half of the graph to be mostly flat, as particles are reflected and scattered, with very little absorption (0.001 cm-1). As the scattering coefficient decreases, I expect the left edge scalar flux values to exponentially decrease.

From the µ Ψ w graph, which is Ψ-dominant, I expect it to be much larger for values of N greater than N/2, with a relative peak at N/4 and a maxima at N\*3/4. This is based on the intuitive notion that in a double conical field (shown below), the flux occupying the angular space will equal zero in the center and have relative maximas in the angular centers. Due to the specifications of this problem, the maxima on the right is higher as a result of the boundary conditions established in this problem and the resultant transport sweeps diminishing values of Ψ from 1:N/2 within the nested for loops of j and N. I copied the combined subplots from MATLAB into this document and also included the .fig file.



Additional files included in this project:

final.m Receives user input for problem parameters and displays Nit, values of phi, and subplots

lgwt.m Calculates Gauss-Legendre nodes and weights (required)

figcomb.m The four figures plotted by final.m are saved as Fig1, Fig2, Fig3, and Fig4 and combined using this script into one graph

Fig5.fig Output from figcomb.m

