Physics of Nuclear Reactor - Numerical Exercises

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December 26, 2024

To run an exercice, open CMD and run the main file. The scripts that run a simulation is always named as main :

```
python main.py
```

Some scripts can create other files:

1. pdf : Figure used in the report
2. npy : file to save a numpy array. This is used for saving data for big convergence study.

WARNING : In certain convergence studies, the plots generated by the Python script differ from those presented in the report. This discrepancy arises because the report plots were produced using a higher number of simulations to obtain better plots. However, for efficiency and to reduce computation time, the number of simulations was lowered in the submission scripts.

1 Exercice #1 - Modeling a planar source of neutrons

1.1 Question #1

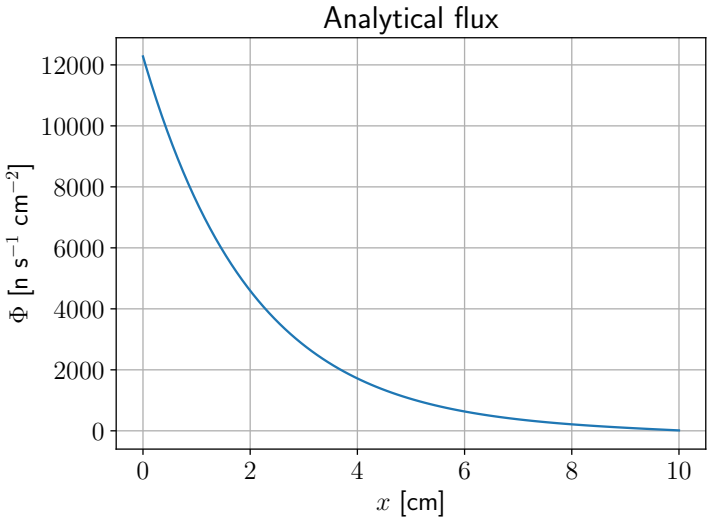

Figure 1: Analytical Solution for the neutron flux as a function of depth.

Flux values at the following locations (4 significant digits):
Flux value at x_0: 13.5896 n cm^{-2} s^{-1}
Flux value at 0: 12276.8979 n cm^{-2} s^{-1}

1.2 Question #2

Relationship between $\Phi_i,\ \Phi_{i+1},\ \Phi_{i-1}$ at any point within the material:

$$A\Phi_i + B\Phi_{i-1} + C\Phi_{i+1} = D \tag{1}$$

Coefficients of the matrix A (4 significant digits), for a mesh size of 0.1cm:
Coef $A_{i,i}$: -16.6037
Coef $A_{i-1,i}$: 8.2919
Coef $A_{i+1,i}$: 8.2919

Relationship between $\Phi_i,\ \Phi_{i-1},\ \Phi_{i+1}$,
at the source:

$$A\Phi_1 + B\Phi_2 = C \tag{2}$$

at the RHS of the problem:

$$A\Phi_n + B\Phi_{n-1} = C \tag{3}$$

Associated coefficients of the matrix A (4 significant digits), for a mesh size of 0.1cm: at the source:
Coef $A_{1,i}$: -8.3119
Coef $A_{2,i}$: 8.2919
at the RHS:
Coef $A_{n-1,i}$: 8.2919
Coef $A_{n,i}$: -12.1536

1.3 Question #3

Flux values from the numerical solver at the following locations (4 significant digits):
Flux value at x_0: 13.6244
Flux value at 0: 12280.5980

Add two sentences describing what you see in Figure 3 and a possible explanation : The error decrease as the mech increase, meaning that the simulation converge. The order of convergence has been evaluated to ~ 1.

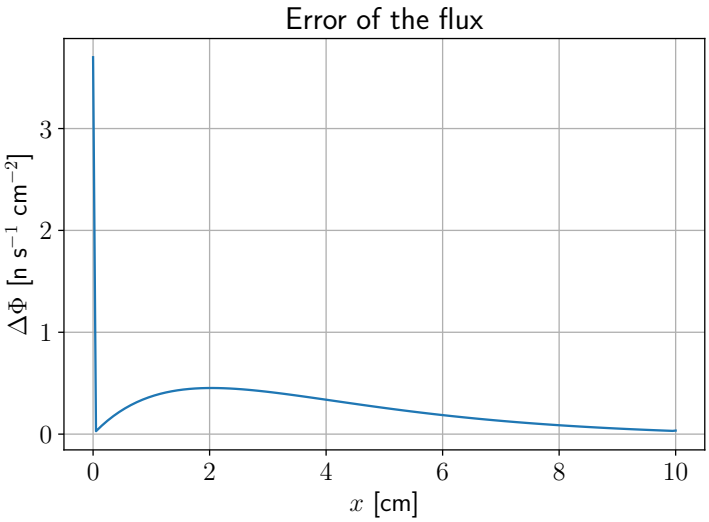

Figure 2: Distance between the solutions at each mesh point for a mesh size of 0.1 cm.

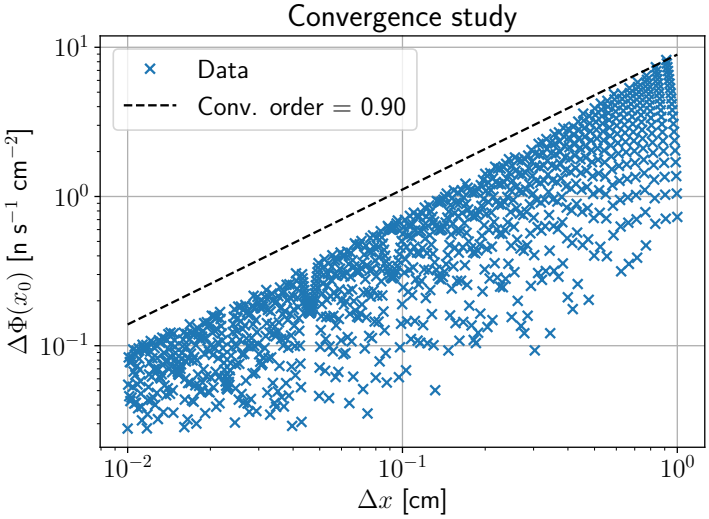

Figure 3: Evolution with mesh size of the absolute error of $\Phi(x_0)$.

2 Exercice #2 - Modeling a planar reactor (1 group)

2.1 Question #1

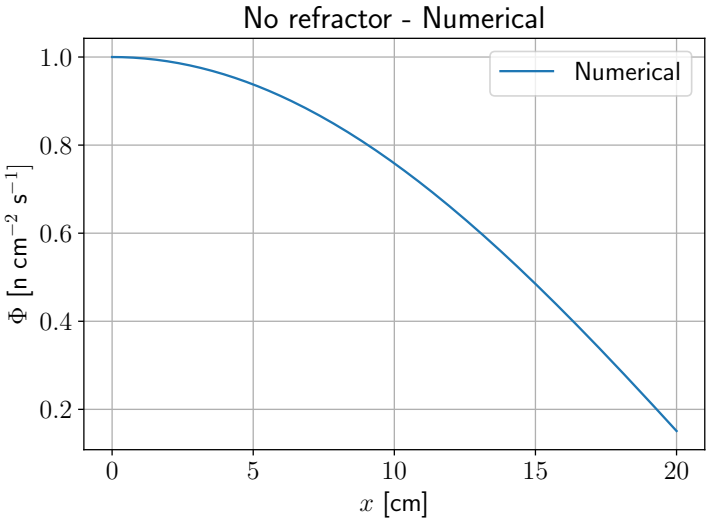

Figure 4: Flux in the bare reactor for a mesh size of 0.1 cm.

Numerical solution for the bare system
keff (scientific format with 5 significant digits): 0.97305
Net current at the core boundary (scientific format with 5 significant digits): 0.075436

2.2 Question #2

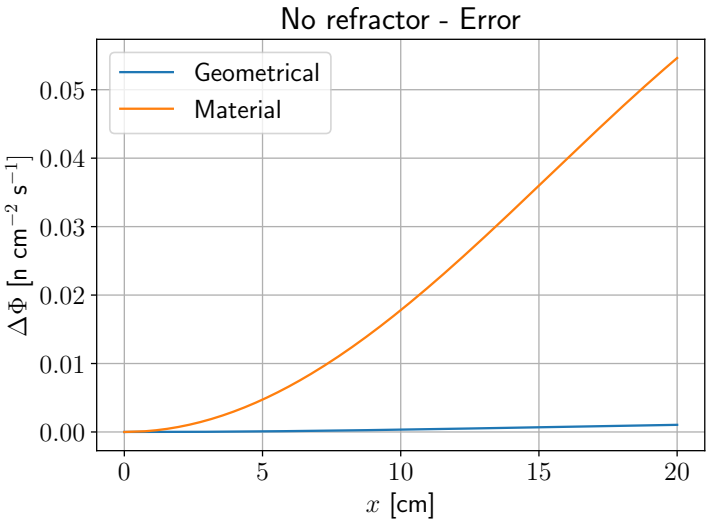

Figure 5: Distance between the solutions at each mesh point for a mesh size of 0.1 cm.

Analytical solution for the bare system
keff (scientific format with 5 significant digits): 0.97356
Net current at the core boundary (scientific format with 5 significant digits): 0.075367

2.3 Question #3

Numerical solution for the reflected system
keff (scientific format with 5 significant digits): 1.12038
Net current at the core boundary (scientific format with 5 significant digits): -0.054402

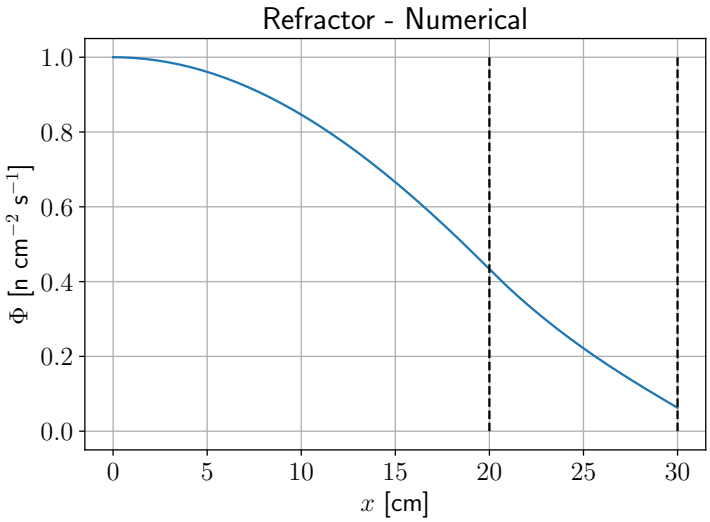

Figure 6: Flux in the reflected reactor for a mesh size of 0.1 cm.

3 Exercice #3 - Modeling a planar reactor (2 groups)