Nodal Expansion Method Code for IAEA Benchmark Problem

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Input Format

❖ IAEA Benchmark Problem INPUT

```
Options (
    Dimension 3
    MeshSize 10 10 20
    Albedo 0 0.4692 0 0.4692 0.4692 0.4692

);

Geometry (
    NodeNum   17 17 19
    xNodeSize 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
    yNodeSize 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
    zNodeSize 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20

    NodeType
    5
      4 3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   0
      4 2   2   2   2   2   2   2   2   2   2   2   2   2   3   3   3   3   0
      4 2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   4
      4 1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   4
      4 4   4   4   4   4   4   4   4   4   4   4   4   4   4   4   4   4   4

   Configuration
0   2   2   2   2   2   2   0   0   2   2   2   2   3   3   4   4
2   2   2   2   2   2   2   2   2   2   2   2   2   3   3   4   4
2   2   2   2   2   2   2   2   2   2   2   2   2   3   3   4   4
2   2   2   1   1   2   2   2   2   2   2   3   3   3   3   4   4
2   2   2   1   1   2   2   2   2   2   2   3   3   3   3   4   4
2   2   2   2   2   2   2   2   2   2   2   3   3   4   4   4   4
2   2   2   2   2   2   2   2   2   2   2   3   3   4   4   4   4
0   2   2   2   2   2   2   0   0   3   3   3   3   4   4   .   .
0   2   2   2   2   2   2   0   0   3   3   3   3   4   4   .   .
2   2   2   2   2   2   2   3   3   3   3   4   4   4   4   .   .
2   2   2   2   2   2   2   3   3   3   3   4   4   4   4   .   .
2   2   2   3   3   3   3   3   3   4   4   4   4   .   .   .   .
2   2   2   3   3   3   3   3   3   4   4   4   4   .   .   .   .
3   3   3   3   3   4   4   4   4   4   4   .   .   .   .   .   .
3   3   3   3   3   4   4   4   4   4   4   .   .   .   .   .   .
4   4   4   4   4   4   4   .   .   .   .   .   .   .   .   .   .
4   4   4   4   4   4   4   .   .   .   .   .   .   .   .   .   .
);
```

```
CXLibrary (
    CXTableNum 5
   CXTable 1 (
      DiffCoeff    1.5E+00 4.0E-01
      SigAbs       1.0E-02 8.0E-02
      nuSigFis     0.0E+00 1.35E-01
      SigChi       1.0E-00 0.0E+00
      SigSca       0.0E-00 2.0E-02
                   0.0E-00 0.0E-00
    );
   CXTable 2 (
      DiffCoeff    1.5E+00 4.0E-01
      SigAbs       1.0E-02 8.5E-02
      nuSigFis     0.0E+00 1.35E-01
      SigChi       1.0E+00 0.0E+00
      SigSca       0.0E-00 2.0E-02
                   0.0E-00 0.0E-00
   );
   CXTable 3 (
      DiffCoeff    1.5E+00 4.0E-01
      SigAbs       1.0E-02 1.3E-01
      nuSigFis     0.0E+00 1.35E-01
      SigChi       1.0E+00 0.0E+00
      SigSca       0.0E-00 2.0E-02
                   0.0E-00 0.0E-00
   );
   CXTable 4 (
      DiffCoeff    2.0E+00 3.0E-01
      SigAbs       0.0E+00 1.0E-02
      nuSigFis     0.0E+00 0.0E+00
      SigChi       0.0E+00 0.0E+00
      SigSca       0.0E-00 4.0E-02
                   0.0E-00 0.0E-00
   );
   CXTable 0 (
      DiffCoeff    2.0E+00 3.0E-01
      SigAbs       0.0E+00 5.5E-02
      nuSigFis     0.0E+00 0.0E+00
      SigChi       0.0E+00 0.0E+00
      SigSca       0.0E-00 4.0E-02
                   0.0E-00 0.0E-00
   );
);
```


SNUMCL

Problem

❖ IAEA Benchmark Problem

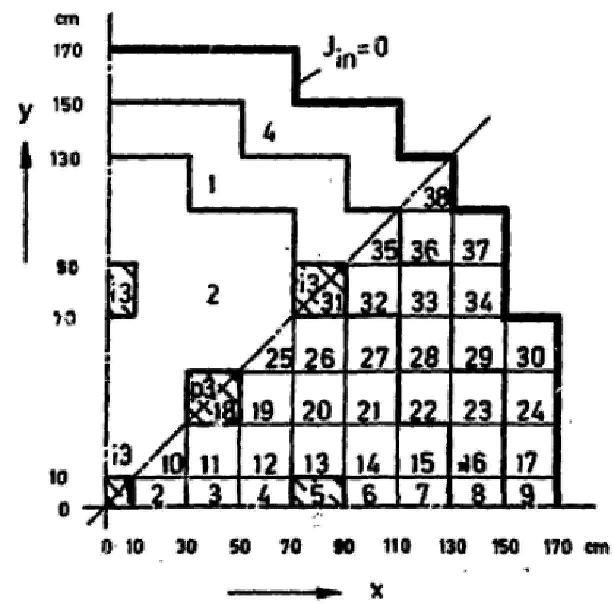
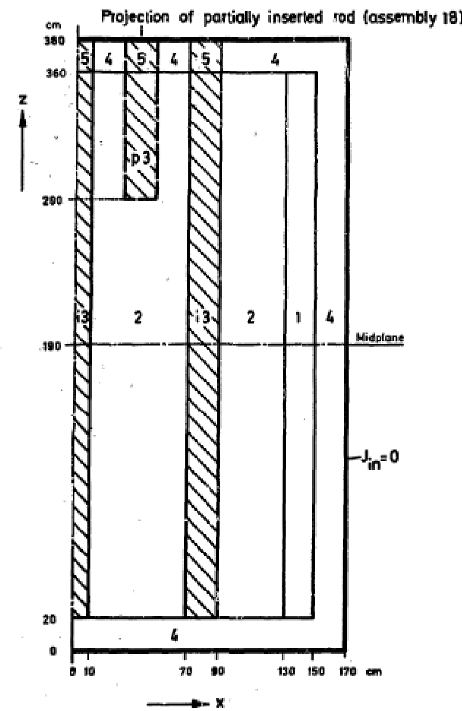


Fig. 1:

Horizontal Cross Section

Upper Octant: Region Assignments

Lower Octant: Fuel Assembly Identification



Argonne Code Center, Benchmark Problem Book, ANL-7416, Suppl. 2, p. 277, Argonne National Laboratory (1977).

Problem

❖ IAEA Benchmark Problem

Two-group Constants

Region	D_1	D_2	$\Sigma_{1\to2}$	Σ_{a1}	Σ_{a2}	$\nu\Sigma_{f2}$	Material
1	1.5	0.4	0.02	0.01	0.08	0.135	Fuel 1
2	1.5	0.4	0.02	0.01	0.085	0.135	Fuel 2
3	1.5	0.4	0.02	0.01	0.13	0.135	Fuel 2 + Rod
4	2.0	0.3	0.04	0	0.01	0	Reflector
5	2.0	0.3	0.04	0	0.055	0	Refl. + Rod

For finite difference diffusion theory codes the following form is considered equivalent

$$\frac{\partial \phi_g}{\partial n} = -\frac{0.4692}{D_g}\phi_g$$

Argonne Code Center, Benchmark Problem Book, ANL-7416, Suppl. 2, p. 277, Argonne National Laboratory (1977).

Numerical Results

❖ **Condition**

– **Outer iteration : 10^{-6} for maximum relative value**

Convergence Criteria

- **Outer Loop : $\max\left(\frac{\phi^{(t)}-\phi^{(t-1)}}{\phi^{(t-1)}}\right) < 10^{-6}$**

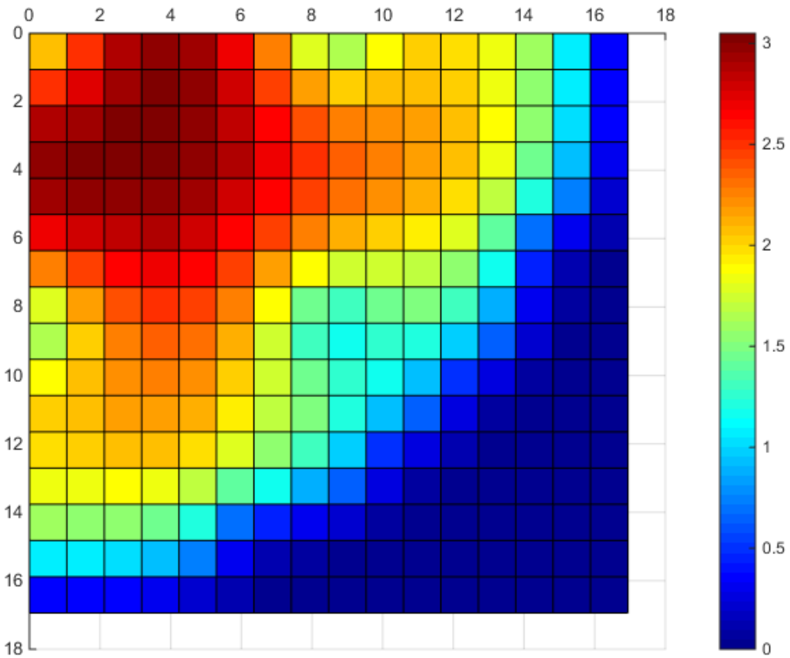
❖ **Multiplication Factor**

– **17×17×19 : 1.02911 (Reference : 1.02913)**

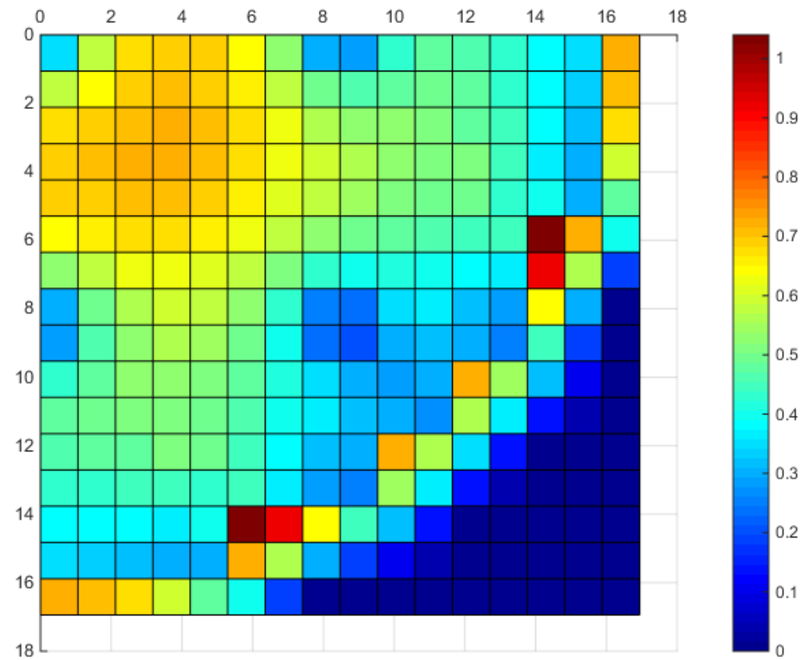
```
 Iteration : 1421   keff :        1.02911 Error = 1.05339e-06
 Iteration : 1422   keff :        1.02911 Error = 1.04832e-06
 Iteration : 1423   keff :        1.02911 Error = 1.04328e-06
 Iteration : 1424   keff :        1.02911 Error = 1.03826e-06
 Iteration : 1425   keff :        1.02911 Error = 1.03327e-06
 Iteration : 1426   keff :        1.02911 Error = 1.0283e-06
 Iteration : 1427   keff :        1.02911 Error = 1.02336e-06
 Iteration : 1428   keff :        1.02911 Error = 1.01844e-06
 Iteration : 1429   keff :        1.02911 Error = 1.01354e-06
 Iteration : 1430   keff :        1.02911 Error = 1.00866e-06
 Iteration : 1431   keff :        1.02911 Error = 1.00381e-06
 Iteration : 1432   keff :        1.02911 Error = 9.98987e-07
5.367(sec)
```

Numerical Results

❖ Flux Distribution
-In midplane z = 190cm



Group1



Group2