

# Parallel Repeatability in TAXI

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# Problem



- Inconsistencies noticed during testing of GMRES and Stretched and Filtered (SF) TSA
  - Same input, machine, and number of threads
  - Reported fluxes would differ, but were within tolerance of correct solution
  - Number of iterations needed to find solution also varied
- Numerical error from two sources
  - Single thread additions
  - Non-deterministic behavior between threads

# Test Input



- Optically thick highly scattering problem
  - Scattering ratio of 0.9999999
  - Large interaction cross section
  - Particles take many iterations to exit the problem
- Krylov methods are sensitive to roundoff error in highly ill-conditioned problems such as this.
- Days to solve using source iteration (SI) only
- Using SF TSA and GMRES 4 processor runs took 7.5 minutes on TAMU CS Linux cluster
  - 10x10x3 Grid
  - Single Energy Group
  - $S_4$  problem ( $S_2$  in TSA)

# Sources of Error and Solutions



- GMRES requires computing dot products of the fluxes in the problem.
  - Order-dependent round-off error can occur within and between threads.
- Per thread order-dependent round-off error occurs in addition of fluxes.
  - Fixed by sorting the fluxes by absolute value before addition.
- Run-to-run differences occur when partial sums from threads being added in different order.
  - Corrected by declaring the sum to be non-commutative
  - Only required changing a boolean value in the call to `reduce_rmi()`

# Sources of Errors and Solutions



- Inconsistent rounding error from adding partial results of sweeps in different directions
  - The contribution from each direction's angular flux is added to the scalar flux as it is calculated.
  - Adding contributions in different orders causes small inconsistencies
- Fixed by forcing the executor to process a single direction at a time instead of selecting an available pRange from any direction.
  - Reduces the amount of available parallelism
  - A better solution to add edges to the DDG between directions will not reduce parallelism as much.

# Example



- 10x10x3 grid
- Single Energy Group
- S4 problem
  - 24 angles, 8 anglesets
- 5 runs of each version.

Code Version	Original	Deterministic pArray	Deterministic Executor	Deterministic pArray/Exec
Variation in # of Outer Iterations	198	356	0	0