Advection with Lax Solver — Final Specification

Introduction

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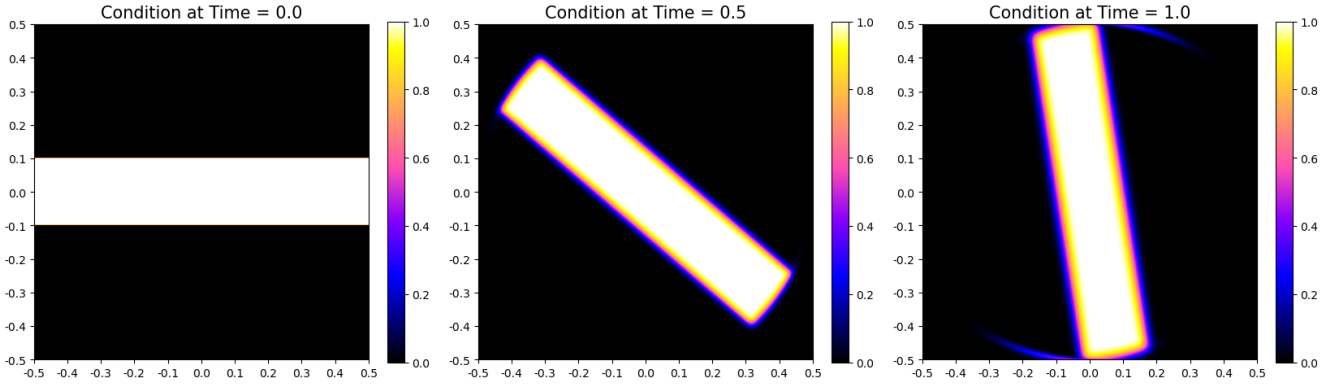
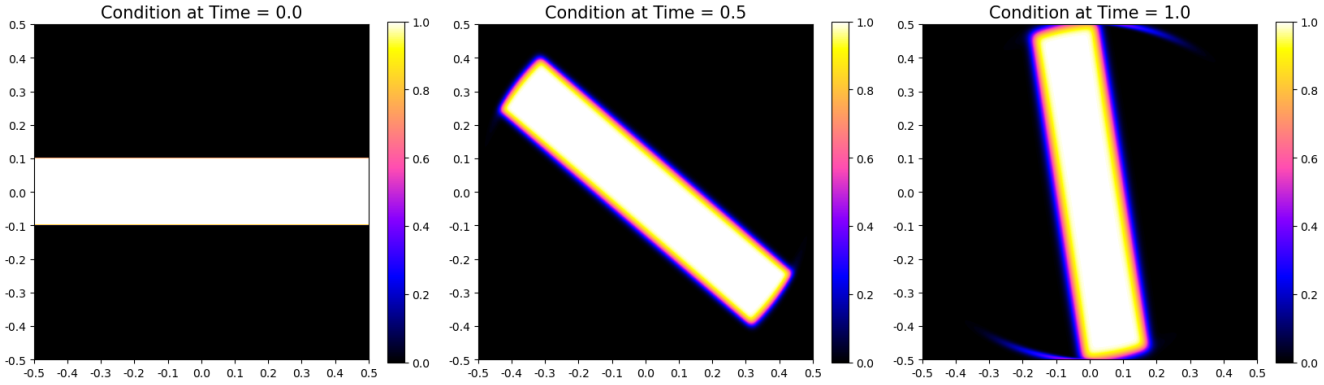
Verification

Carry out the verification tests described below, using the values specified in Table 1. Carry out each of the following simulations, and show solution at the times specified. Show the z values with a colormap or Z axis.

Serial Lax with N = 4000

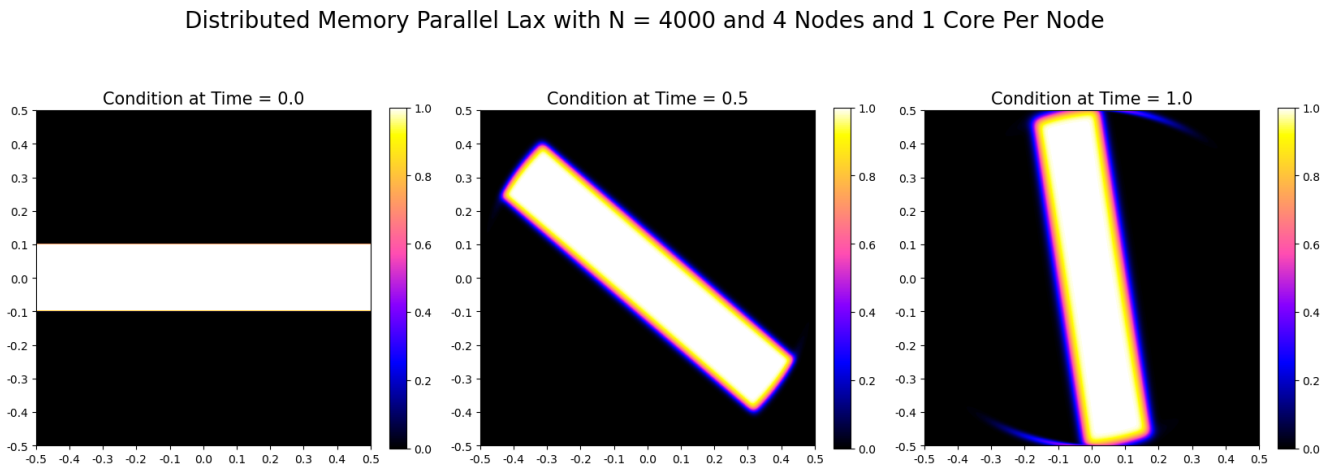


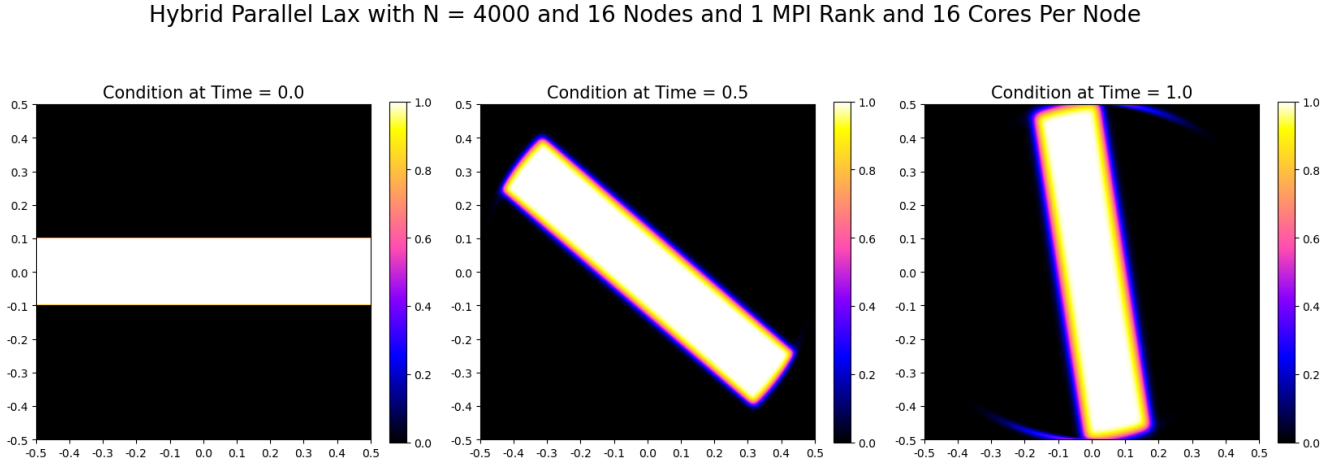
Shared Memory Parallel Lax with N = 4000 and 16 Cores



Parameter	Value
L	1.0
domain	$[-L/2, L/2]$
t_{final}	1.0
u	$\sqrt{2}y$
v	$-\sqrt{2}x$
dt	any stable value
N	4000
dx	$\frac{L}{N-1}$
boundary condition	periodic
initial condition	$C(-\frac{L}{2} : \frac{L}{2}, -0.1 : 0.1) = 1.0$

Table 1: Parameter values for all of the verification tests. Note that any stable value of dt is acceptable. u and v are constant in time but vary spatially according the the specification in the table. Note that the initial condition is a rectangle with the value of one from $[-1/2, 1/2]$ in x and $[-0.1, 0.1]$ in y, and zero elsehwere.





Performance

Show the following performance data by turning off i/o and placing timers around just the outer loop over timesteps. Do not time i/o or other initialization code. State your best time to solution and the associated configuration. Note that it does not have to be one of the entries in Table 2.

Fastest runtime for benchmark problem: 15.60 sec with 16 cores per node, 16 nodes, hybrid 1 MPI rank per node

Programming Model	Nodes	Cores Per Node	Execution Time (sec)	Grind Rate (cells/sec)
MPI-Only	1	1	234.52	545,790,910
MPI-Only	2×1	1	132.57	965,497,746
MPI-Only	2×2	1	69.68	1,836,791,755
MPI-Only	3×3	1	23.60	5,421,583,431
MPI-Only	4×4	1	15.68	8,160,402,912
OpenMP-Only	1	1	220.81	579,666,110
OpenMP-Only	1	2	144.45	886,092,617
OpenMP-Only	1	4	60.11	2,129,242,062
OpenMP-Only	1	9	30.08	4,254,708,873
OpenMP-Only	1	16	25.56	5,006,293,627
Hybrid: One MPI rank per node	1	16	225.68	567,167,957
Hybrid: One MPI rank per node	2×1	16	113.74	1,125,371,398
Hybrid: One MPI rank per node	2×2	16	59.52	2,150,352,900
Hybrid: One MPI rank per node	3×3	16	26.66	4,800,832,015
Hybrid: One MPI rank per node	4×4	16	15.60	8,205,031,760

Table 2: Parameter values for all of the performance tests. Use all problem values shown in Table 1. Additionally, to facilitate performance comparisons, use $dt = 1.25 \times 10^{-4}$.