GPU-Accelerated Lattice-Boltzmann in PyTorch

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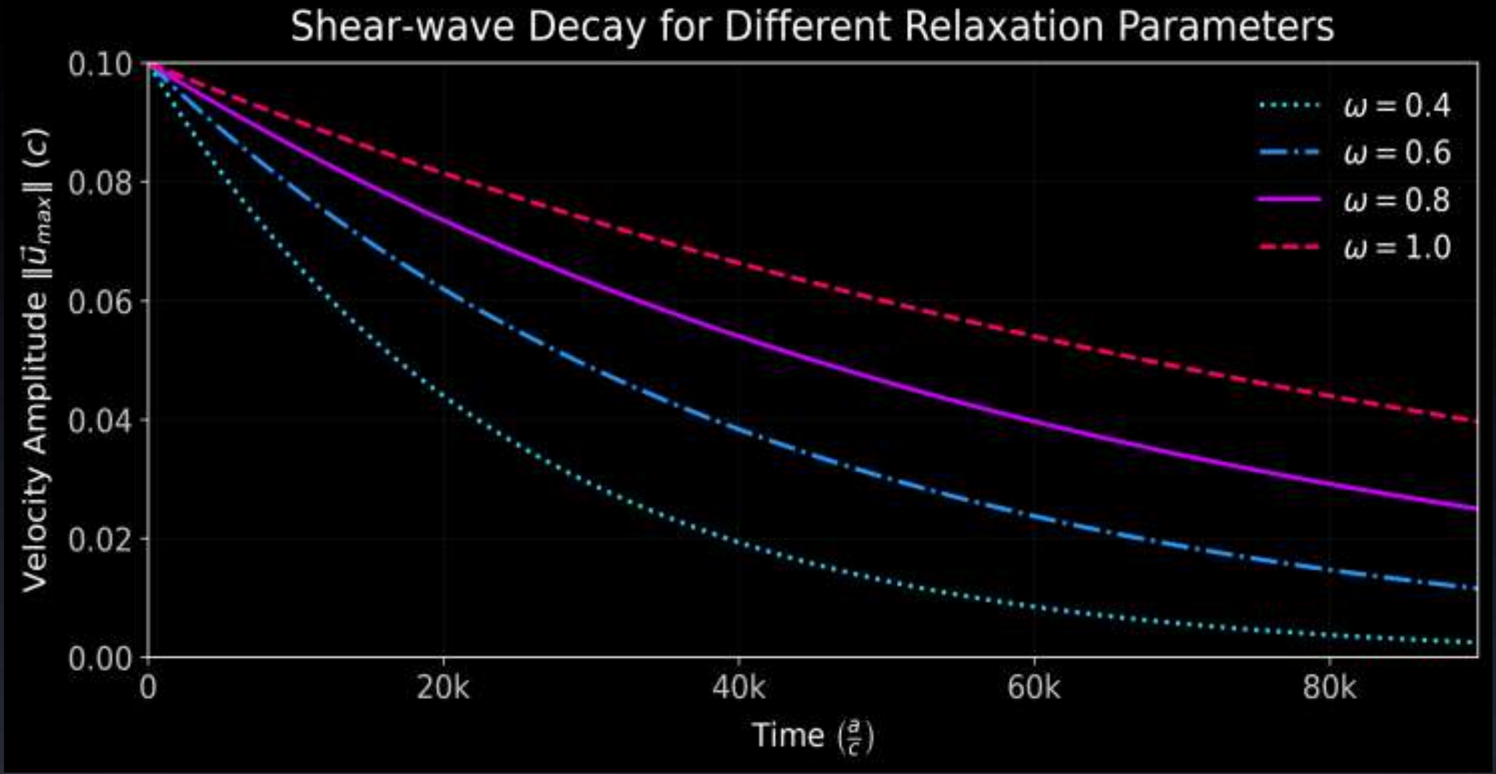
Goal

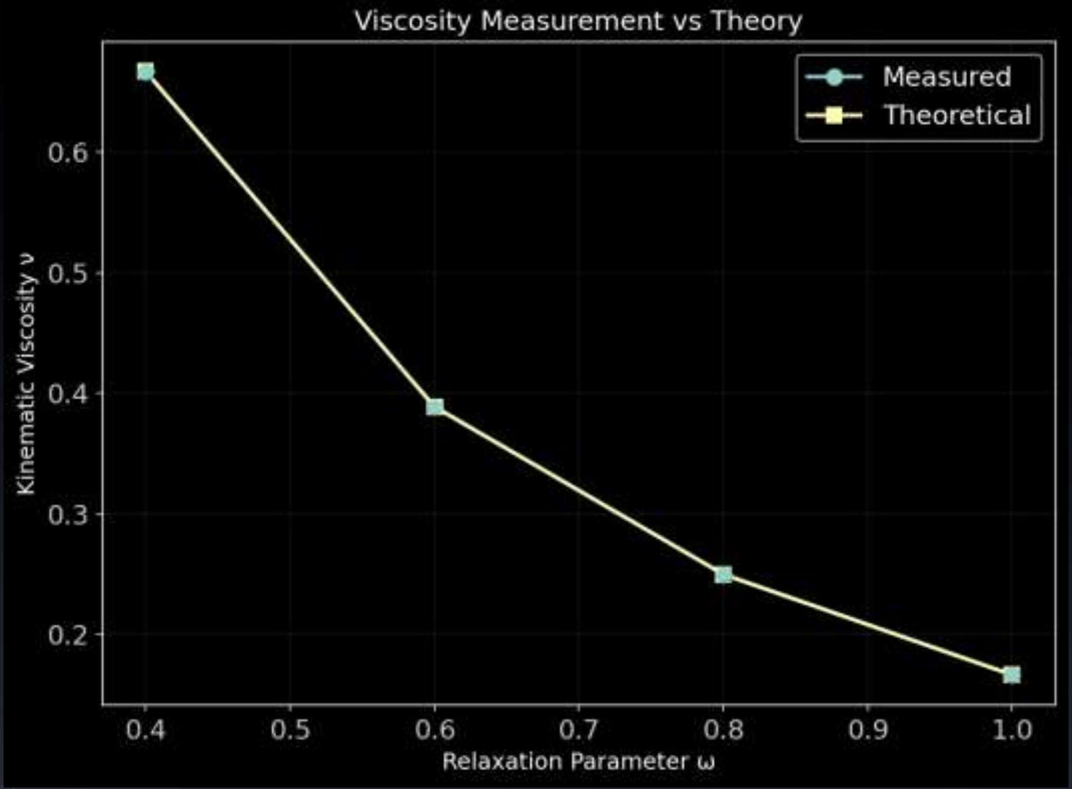
- Build a trustworthy PyTorch-based LBM solver
- Have acceptable results
- Decrease the dev-time.

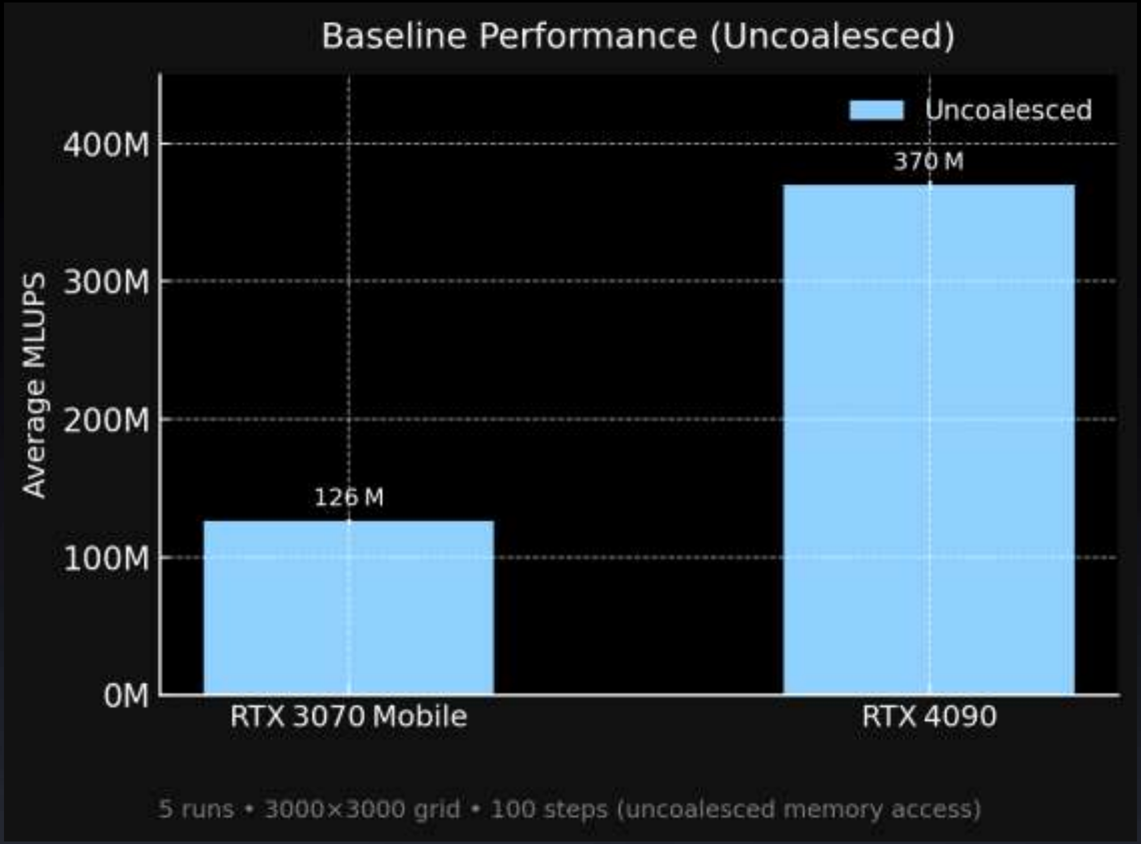
Verification

Verification I: Shear-Wave Decay



Verification II: Viscosity





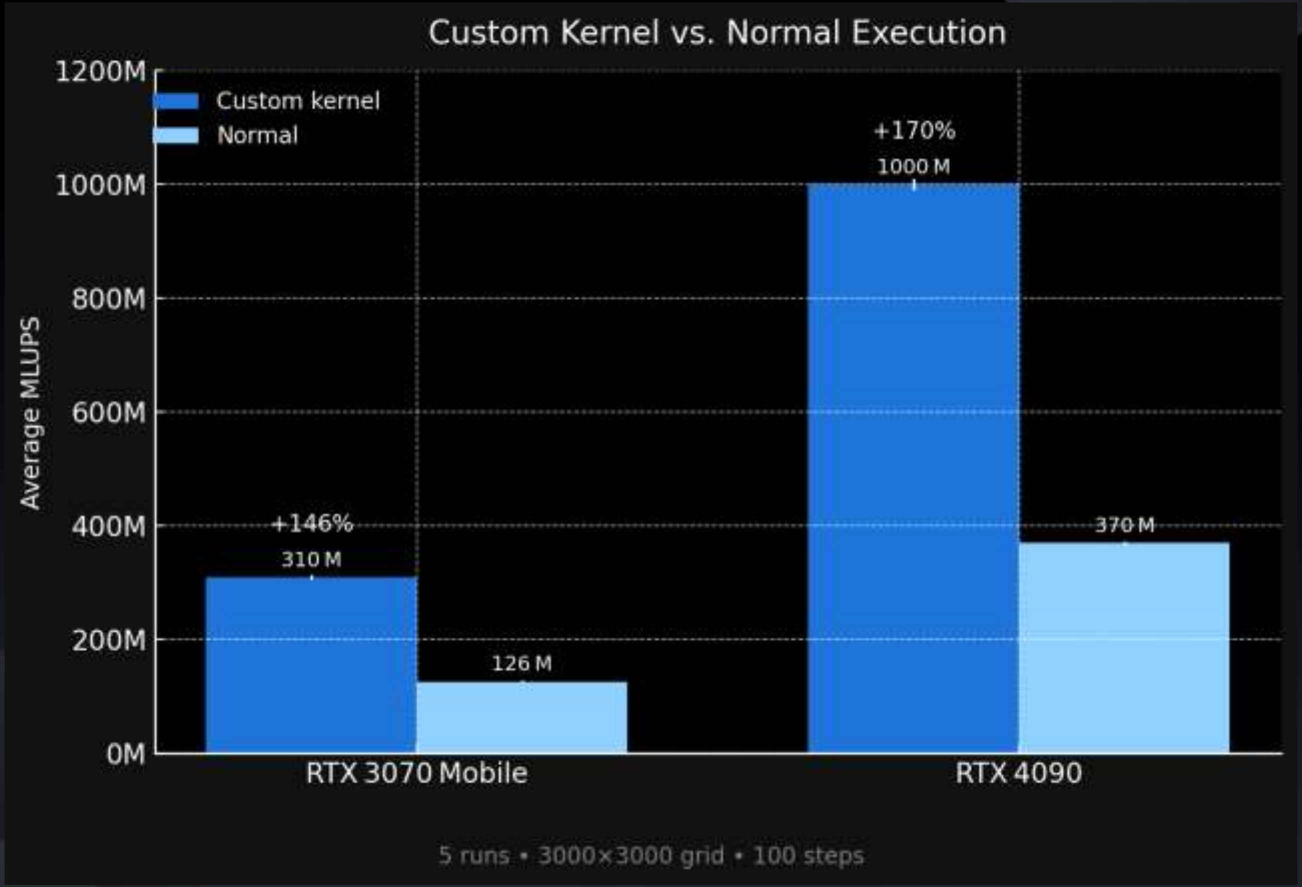
Baseline Performance (Uncoalesced)

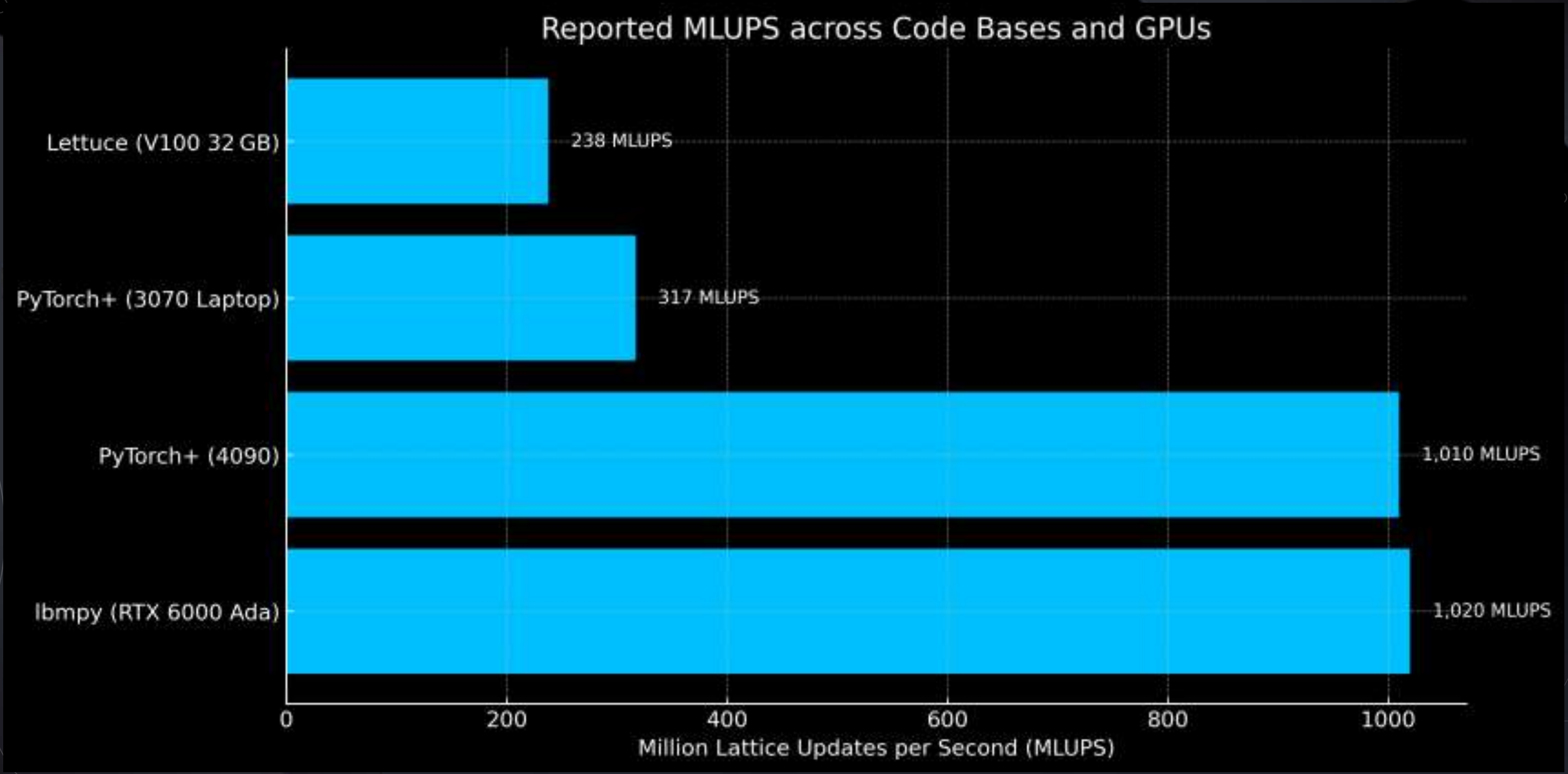
5 runs • 3000×3000 grid • 100 steps (uncoalesced memory access)

Improvements

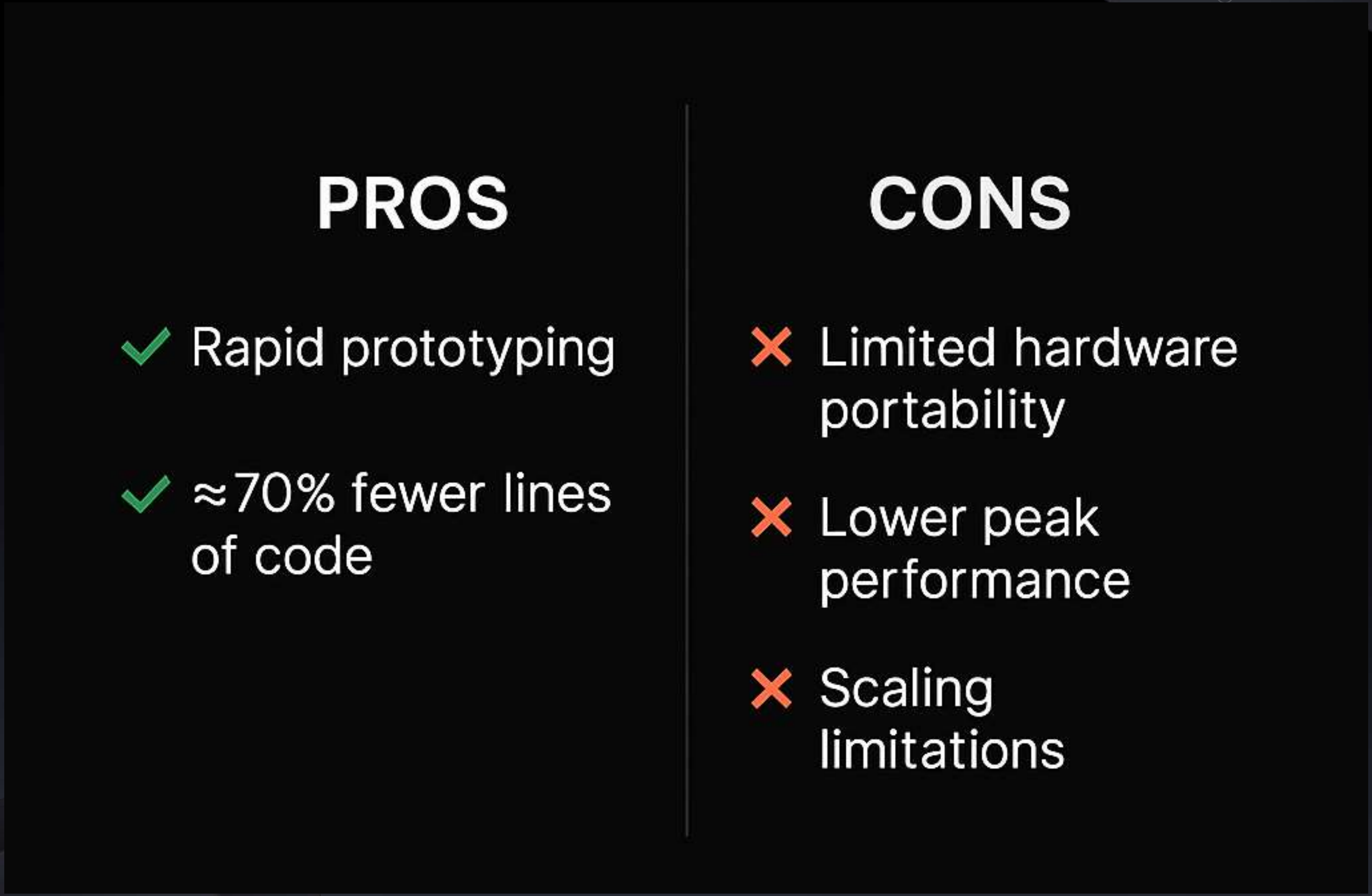
- Fusing collision + streaming + BC
- Micro-tuning
  - Mixed precisions
  - Memory format-channels_last
  - Switching torch,compile modes

    no significant increase in performance


Custom Kernel vs. Normal Execution
Custom kernel
Normal
Average MLUPS
1200M
1000M
800M
600M
400M
200M
0M
+146%
310 M
126 M
+170%
1000 M
370 M
RTX 3070 Mobile
RTX 4090
5 runs • 3000×3000 grid • 100 steps



arXiv:2106.12929v2 [physics.comp-ph] 17 Nov 2021
https://pycodegen.pages.i10git.cs.fau.de/lbmpy/notebooks/00_tutorial_lbmpy_walberla_overview.html?utm_source=chatgpt.com



PROS

- ✓ Rapid prototyping
- ✓ ≈70% fewer lines of code

CONS

- ✗ Limited hardware portability
- ✗ Lower peak performance
- ✗ Scaling limitations

Demo

Thank you for your attention