Progress on the GPU porting of HiRep

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What is HiRep?

HiRep allows flexible simulations of higher representations of Wilson Fermions with various actions and gauge groups and a range of inverters and integrators.

Higher Representations

This is particularly important for enabling evaluations of observables relevant to phenomenological inputs for Beyond-the-Standard-Model physics from lattice field theory.

Computational Cost

Graphics Processing Units (GPUs) are to date the most performant processing units available. This is why we need lattice software to run on GPUs.

Github repository

https://github.com/claudiopica/HiRep

Docs: https://claudiopica.github.io/HiRep/

Algorithmic Checks

We can test, whether the algorithm samples from the correct distribution, by checking

- The independence of the plaquette of the step size in the integration
- The Creutz equality, [1]
- The scaling of the Hamiltonian violations with the step size, which for a 2nd-order Omelyan integrator [2] scales with

$$\Delta H \sim \delta\tau^4 .$$

- The behavior of the acceptance rate as a function of the Hamiltonian violations, which follows an analytically known relation asymptotically for high acceptance rates [3]

$$P_{\text{acc}} \cong \text{erfc}\left(\sqrt{\frac{\langle \Delta H \rangle}{2}}\right)$$

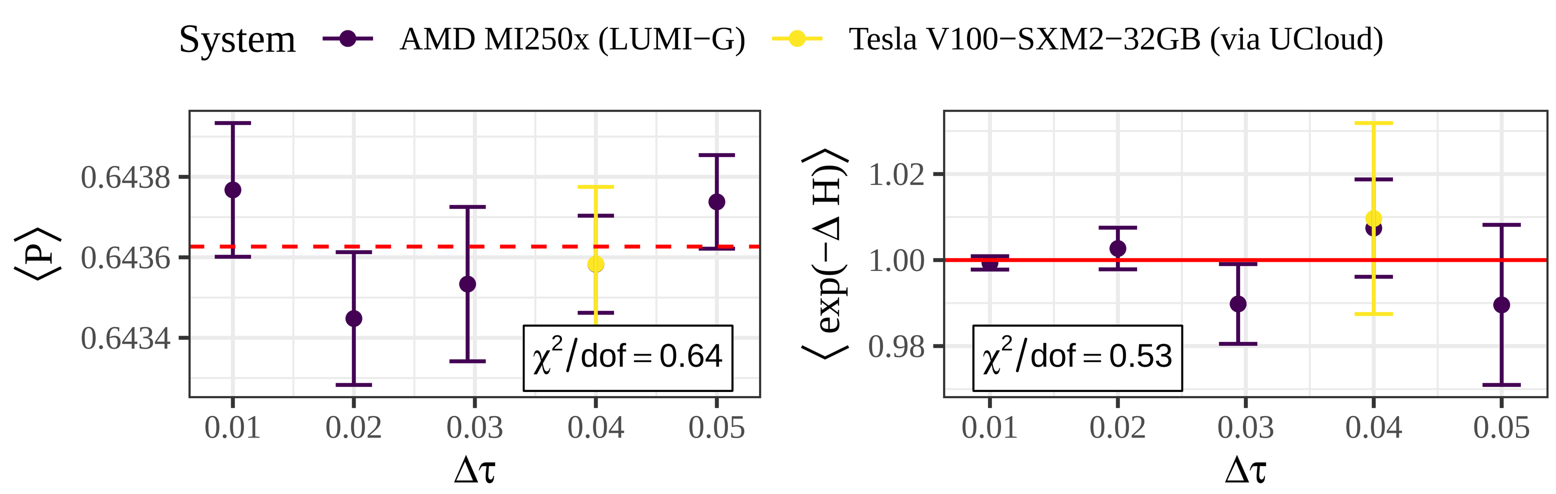

Figure 1. Check of average plaquette and Creutz equality, figure from previous work in [4]

Scaling to 1000 GPUs

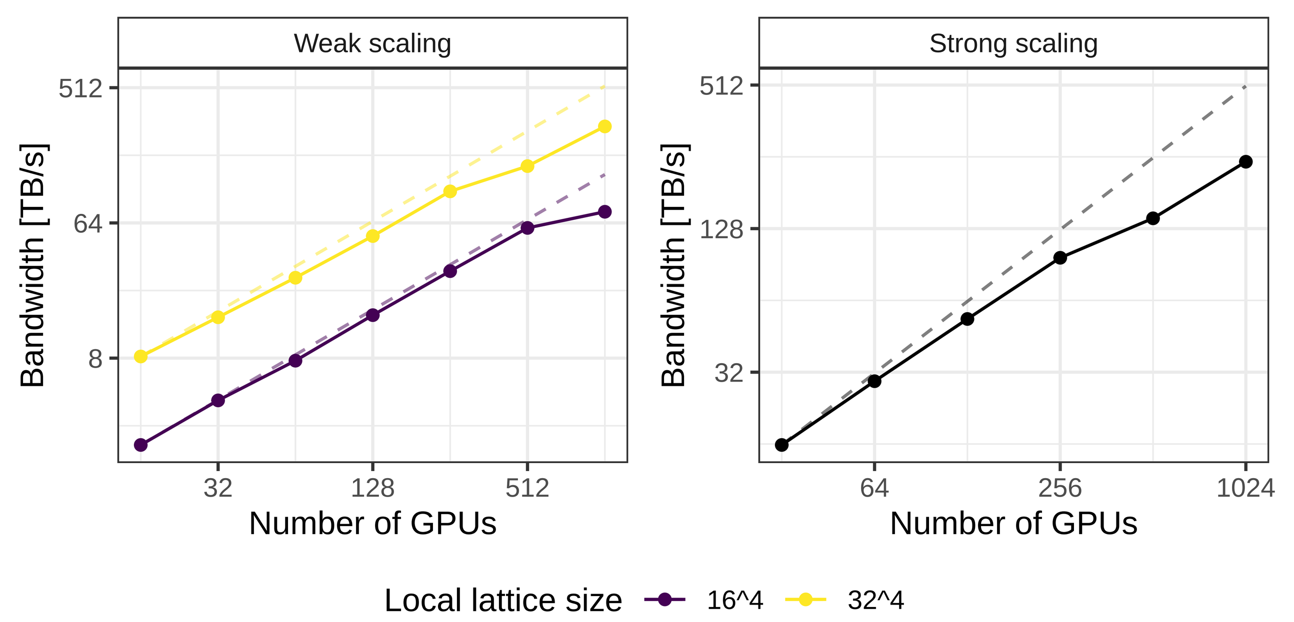

Figure 2. Weak and strong scaling of the Dirac operator on LUMI-G (AMD MI250x).

We see almost perfect scaling up to 256 GPUs, with some loss of efficiency for the 1024 GPU tests, which is likely due to the dragonfly topology that connects nodes in groups of 124 nodes and 992 GPUs.

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SU(2) with two fermions in the adjoint representation

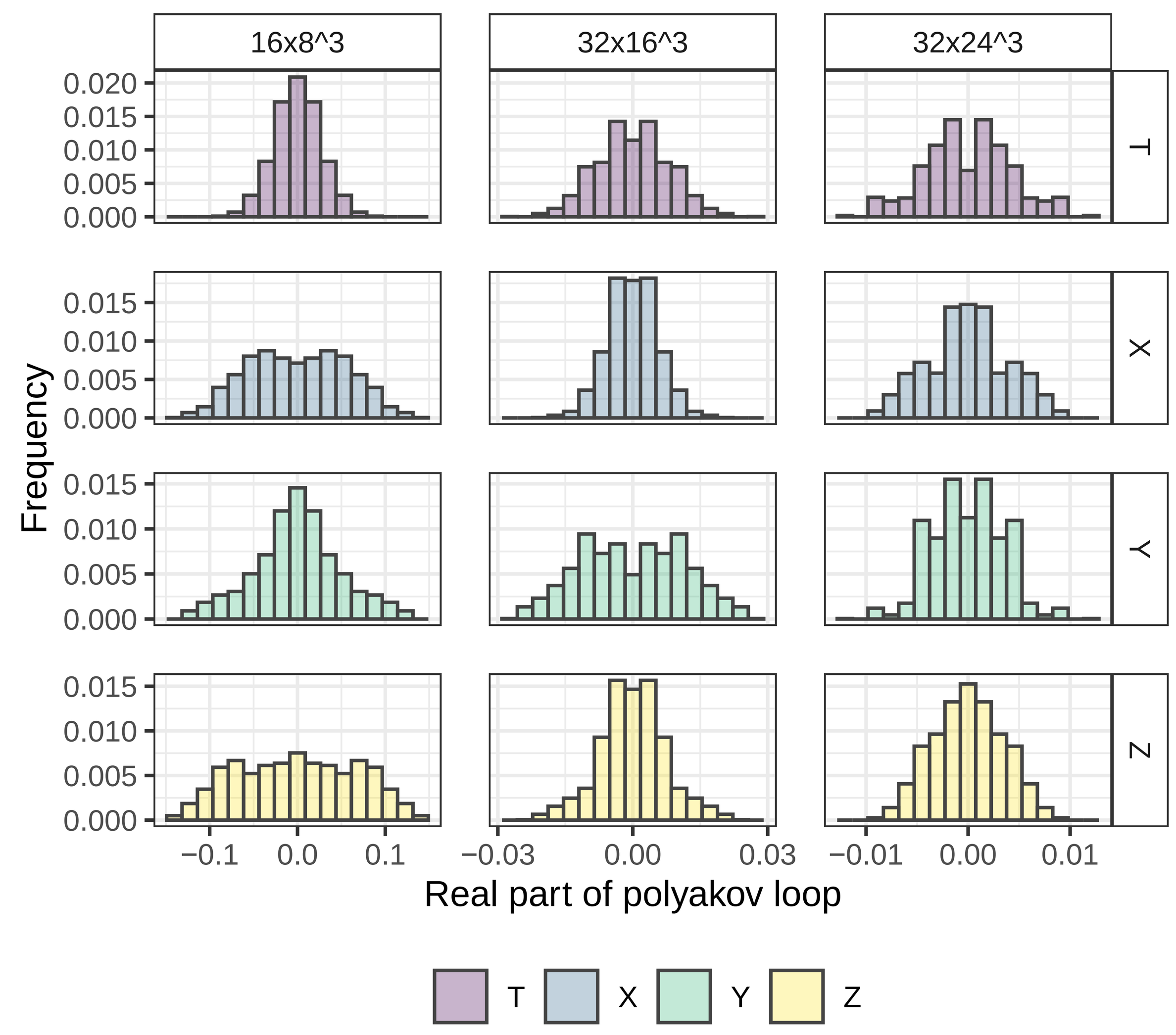

Figure 3. Distribution of real part of polyakov loops, normalized and symmetrized by hand

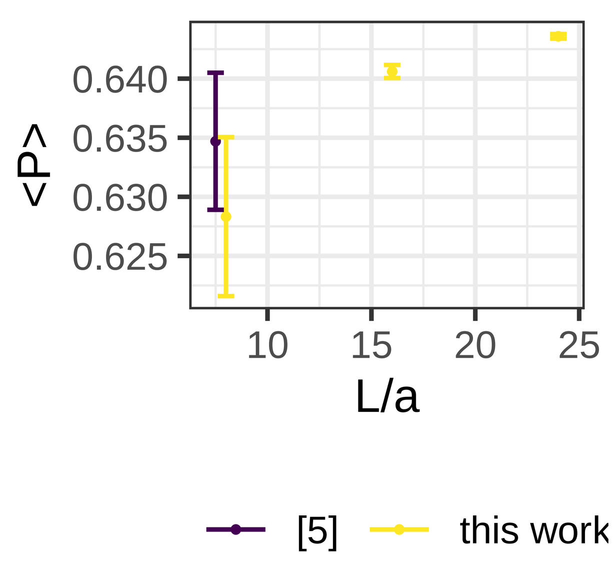

Figure 4. Finite-volume effects of the average plaquette

For the value in [5], we observed multiple metastable states for the average plaquette values. This finite-volume effect vanishes for larger spatial extents since the Polyakov loop distribution is no longer broken in the finite spatial extents.

Summary

We perform algorithmic and consistency checks on the recently ported HiRep GPU code. We find consistency with previously obtained results for $SU(2)$ with two fermions in the adjoint representation. A physical application of this code can be seen during the talk [S. Martins, Friday, 14:35].

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