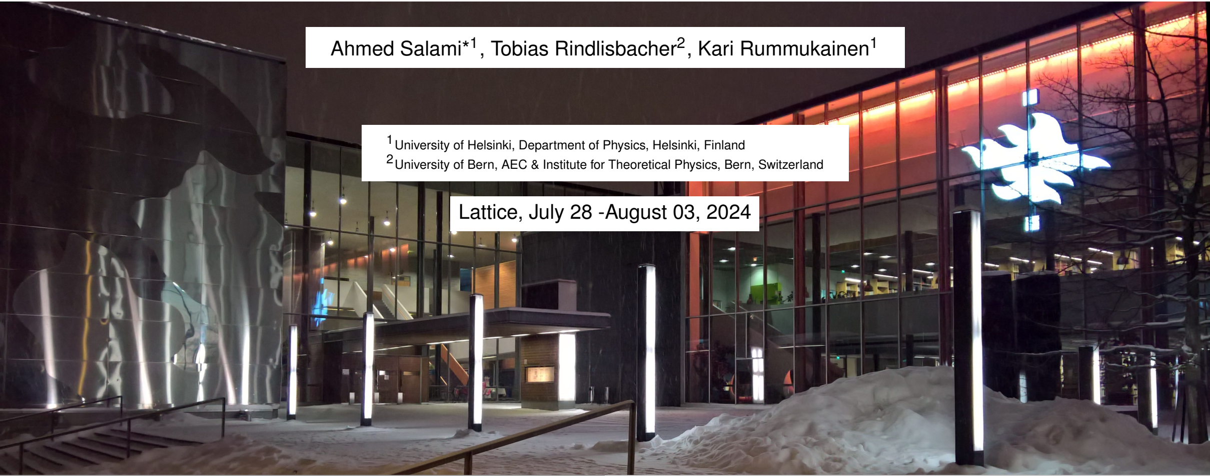
The deconfinement interface tension in SU(N) gauge theories at large N



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Lattice, July 28 -August 03, 2024

Motivation

- Surface tension not well measured at large N
- Improving on existing data
- Amplitude of surface fluctuations in determining the interface tension
- Eases the tunneling situation due to absence of barriers

Existing Result

- Determination through tunneling probability:

$$P \propto exp[-2\sigma A/T_c]$$

- Requires small enough volume for the tunneling to be non-negligible
- $\sigma/T_c^3 = -0.104(3) + 0.0138(3)N^2$ (Lucini, Teper, Wenger - 2005)
- $\sigma/T_c^3 = -0.333(9) + 0.118(3)N$ in same publication
- Unable to verify N^2 behaviour in study

Setup

- Plaquette action: $\beta \sum_p \{1 - \frac{1}{N} ReTrU_p\}$ where $\beta = \frac{2N}{g^2}$
- Heat bath + overrelaxation updates
- Simulations with HILA on GPUs
- Elongated system to ensure that the interface is a minimal surface

Method

- Determination of pseudo-critical β

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- Generate configurations with the phases in coexistence

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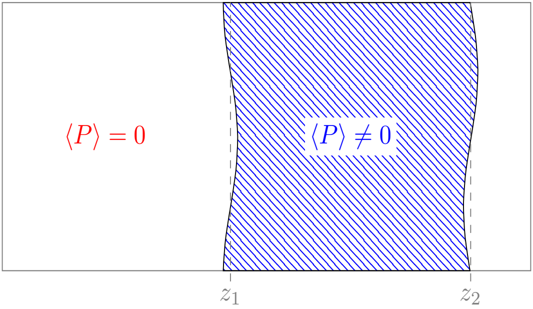
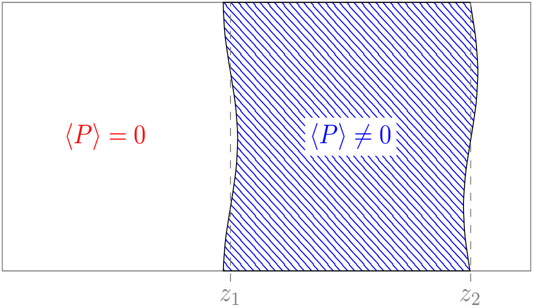


Method

- Restrict the system to the intermediate state



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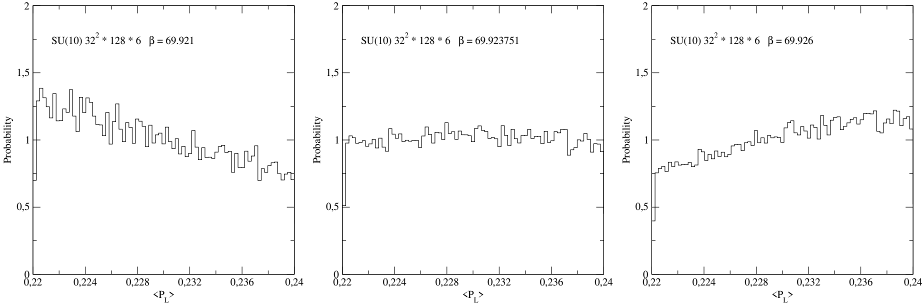
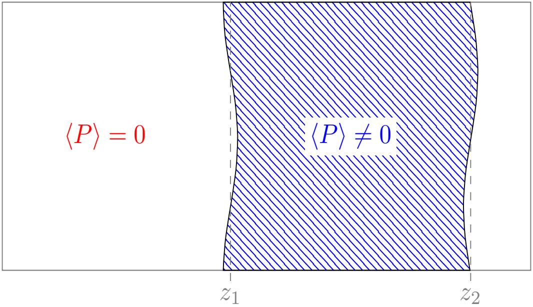


Method

- Location of the surface

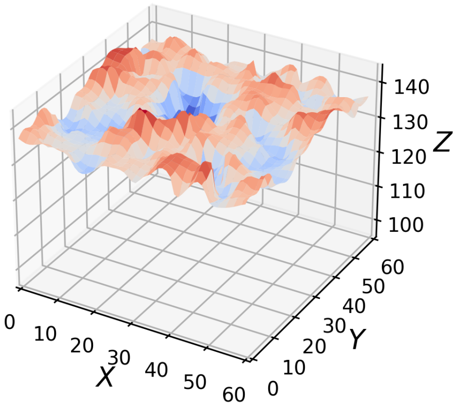


- Calculating the interface tension from the surface fluctuation

$$\langle \tilde{z}_n^2 \rangle = \frac{T}{4\pi^2 \sigma n^2}$$

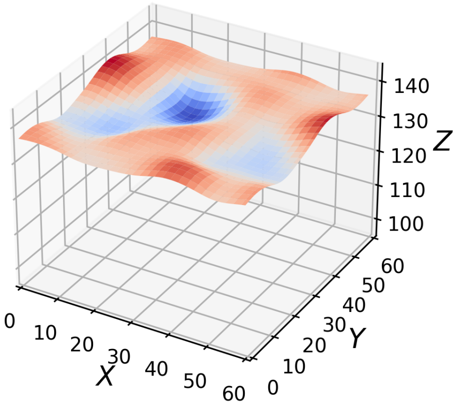
Smearing

- Smearing is necessary as the surfaces are too rough



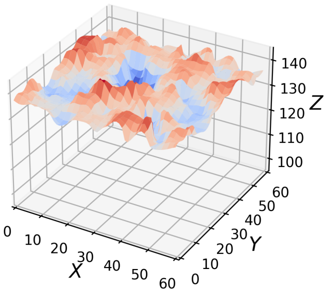
Smearing

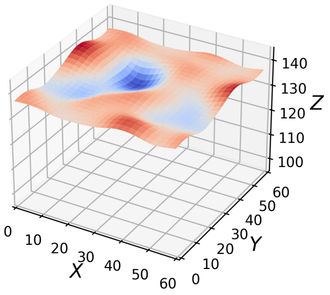
- Eliminates the UV modes and noise



Smearing

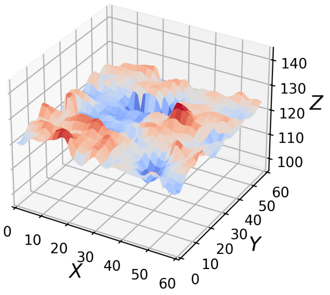
- Long range structure preserved





Smearing

- Effects of the number of smearing steps



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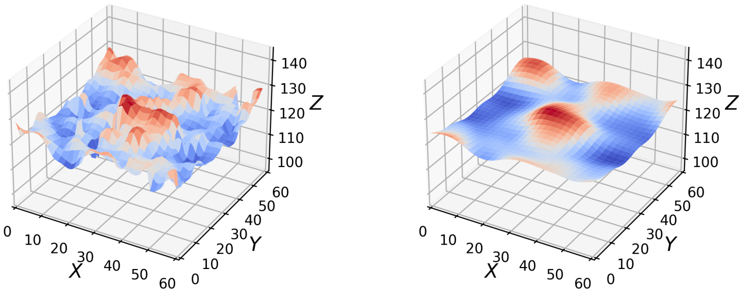

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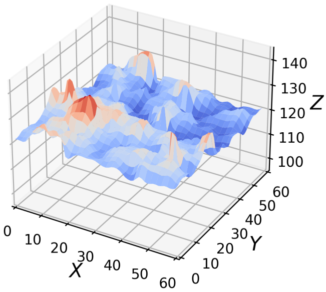

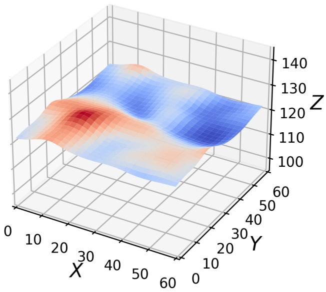

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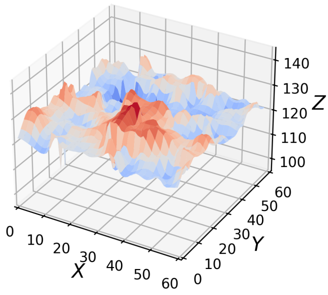

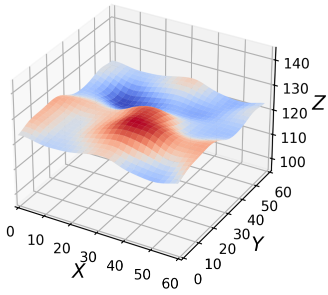

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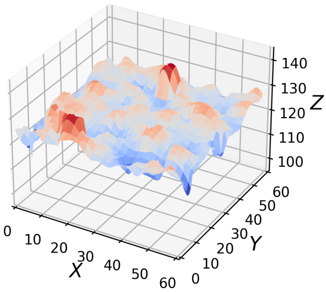

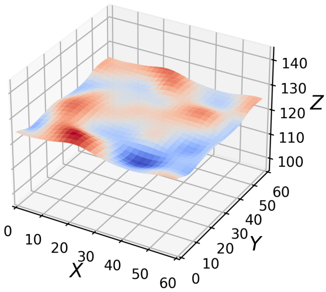

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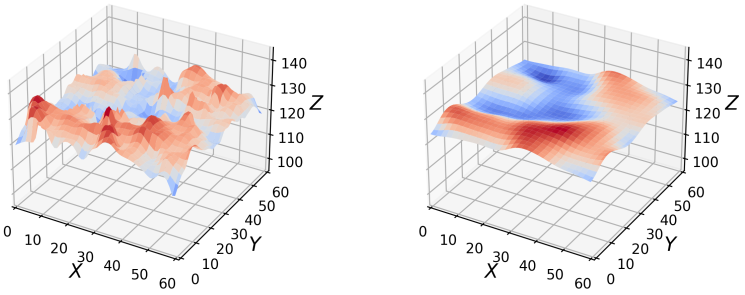

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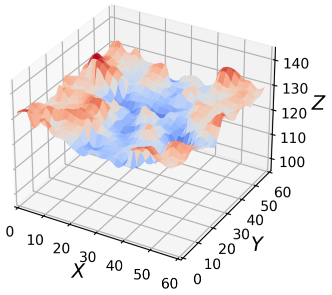

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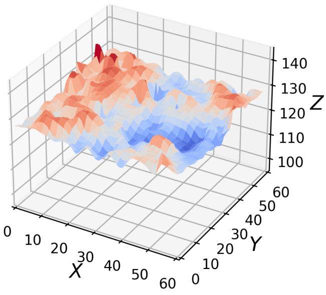

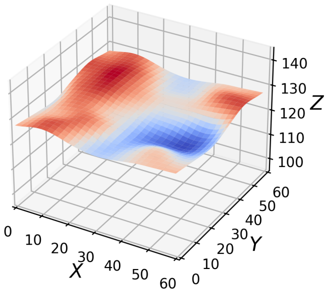

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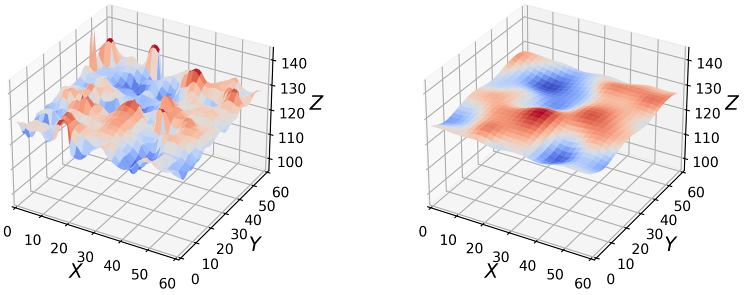

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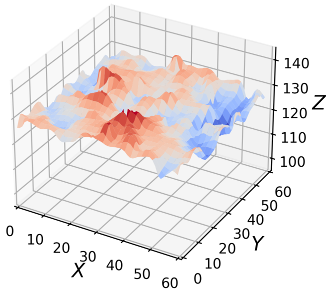

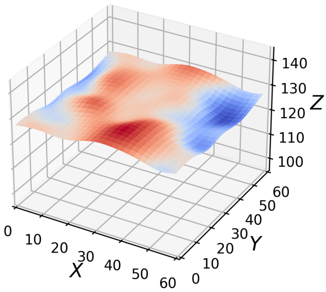

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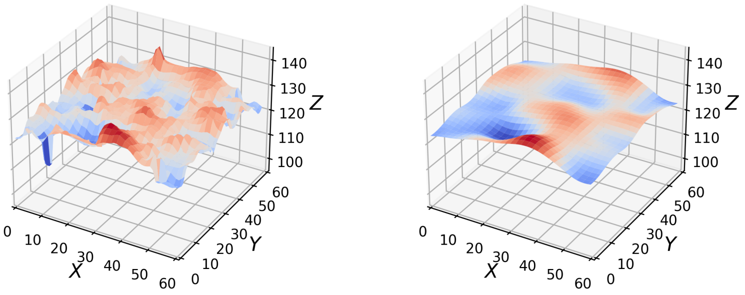

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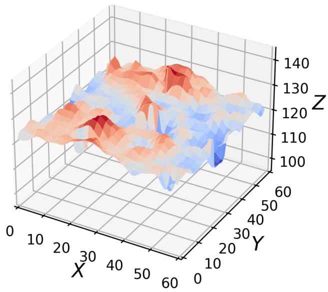

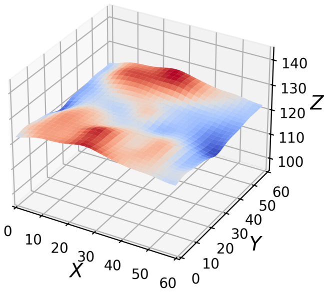

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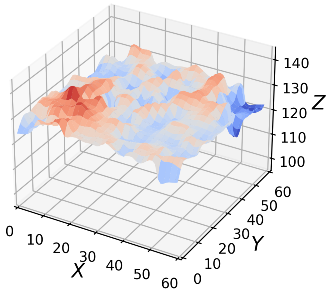

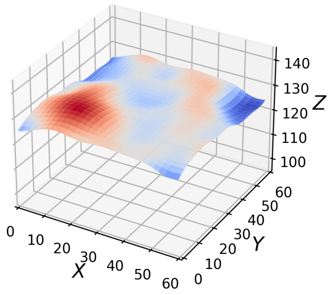

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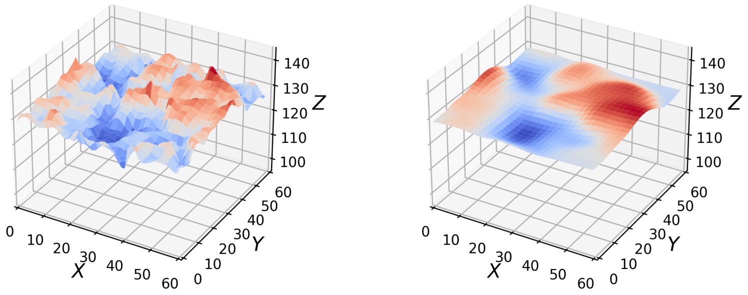

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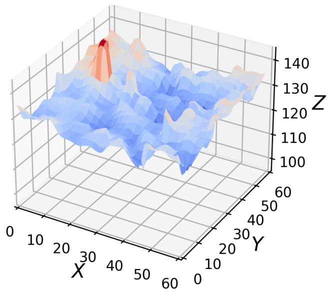

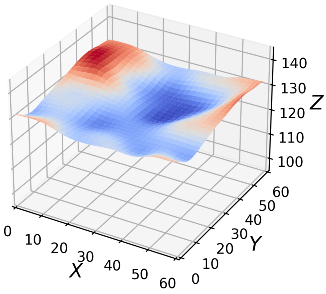

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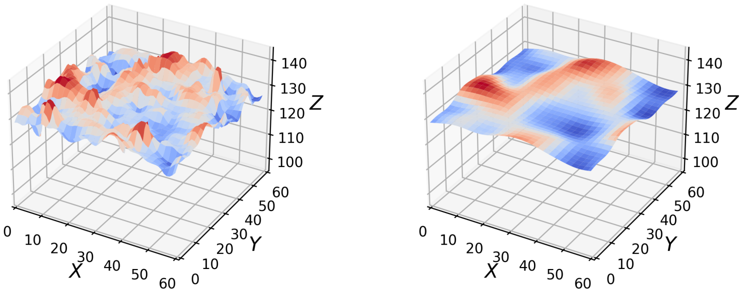

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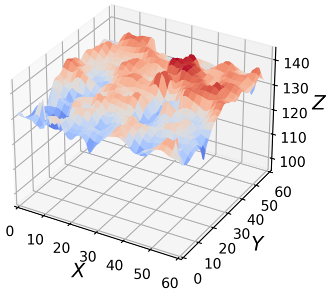

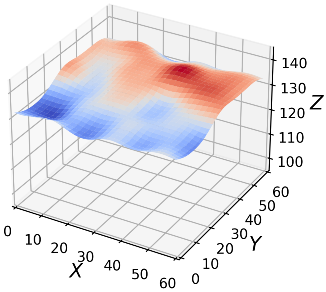

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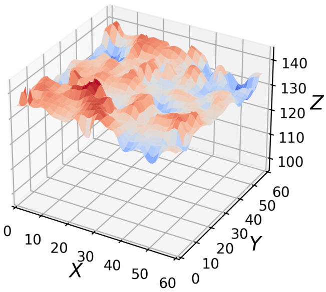

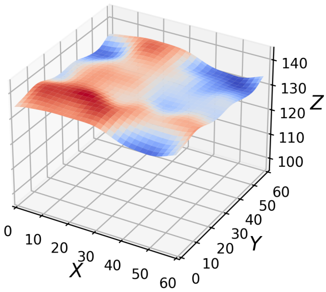

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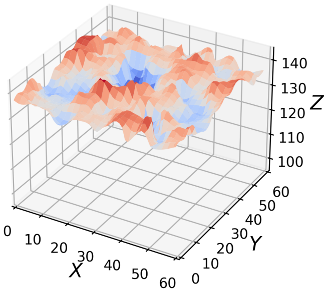

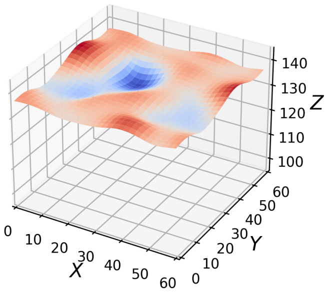

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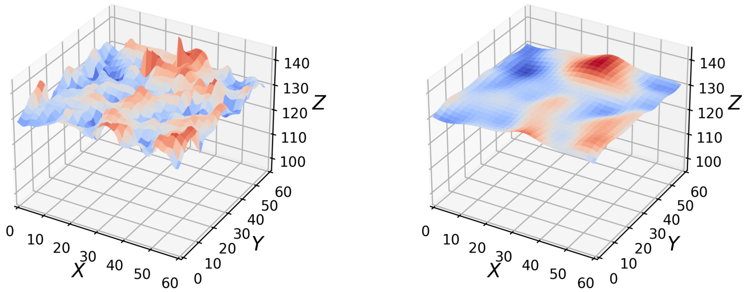

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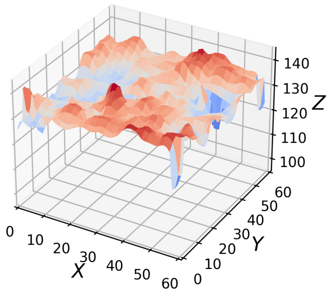

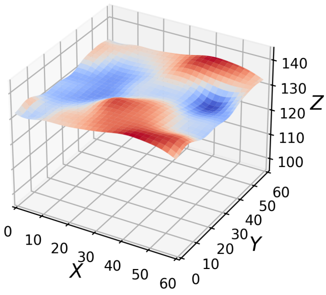

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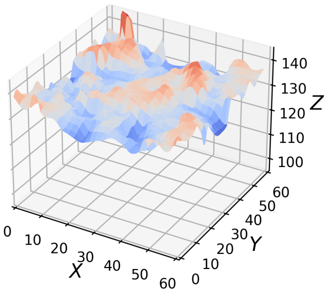

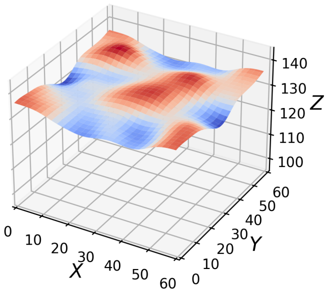

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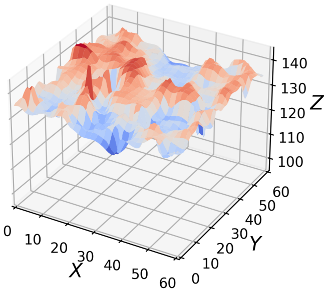

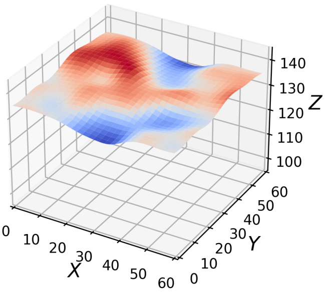

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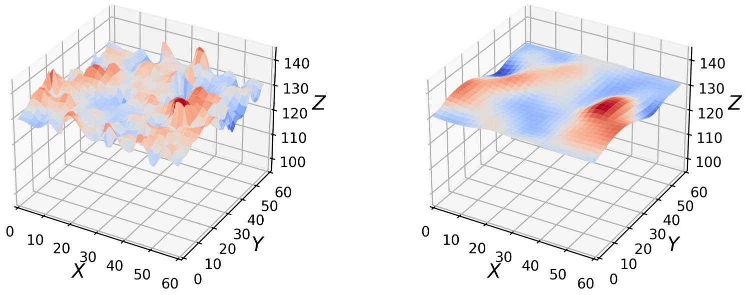

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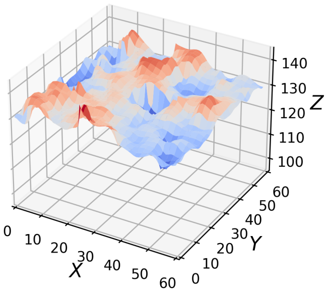

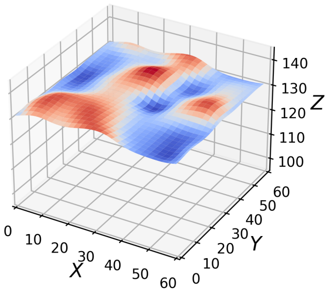

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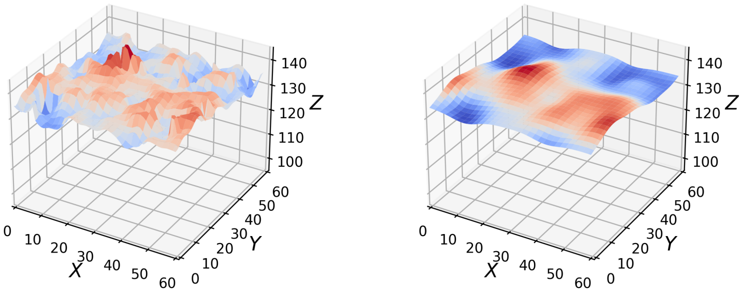

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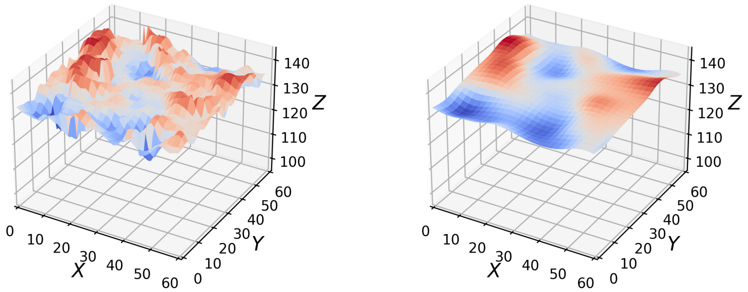

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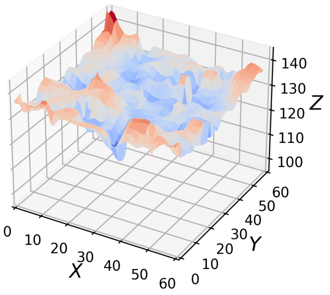

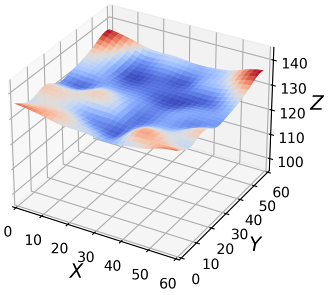

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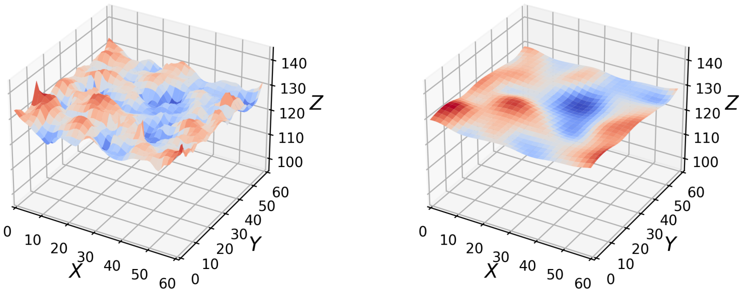

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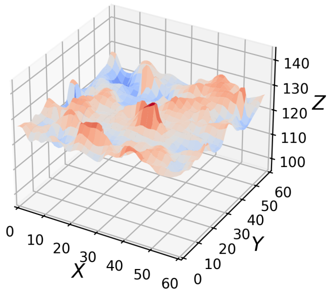

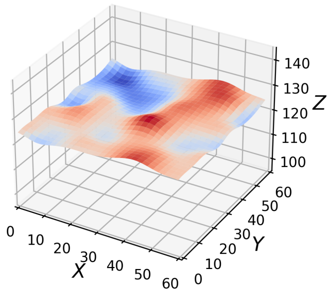

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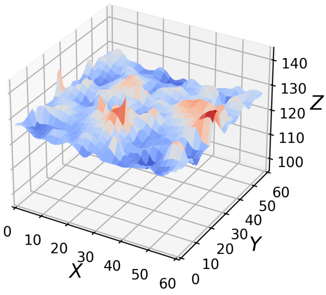

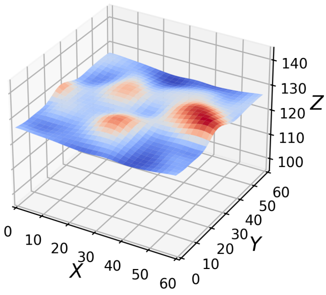

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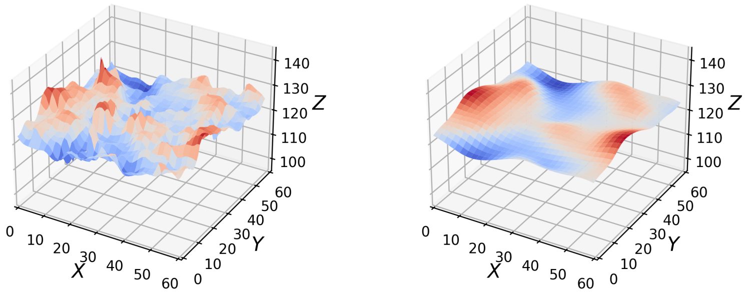

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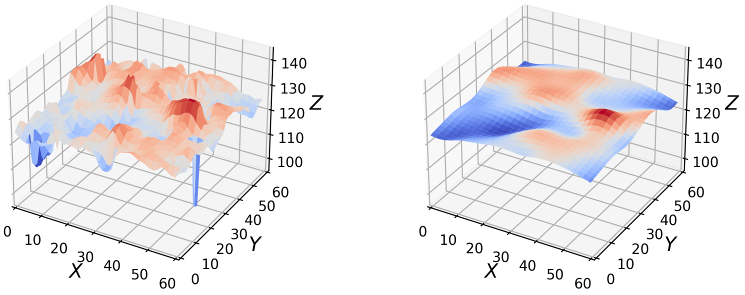

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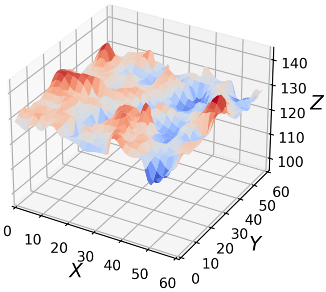

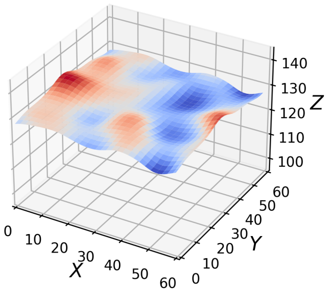

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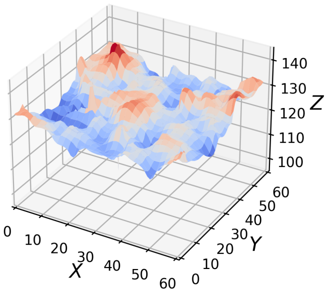

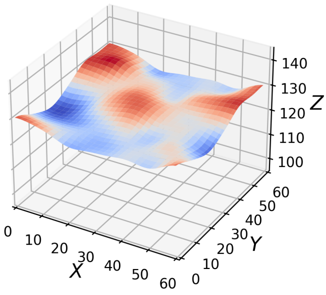

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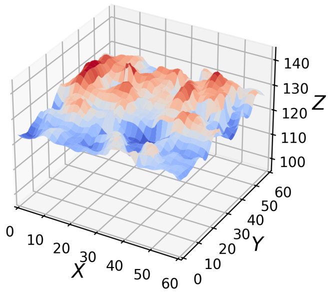

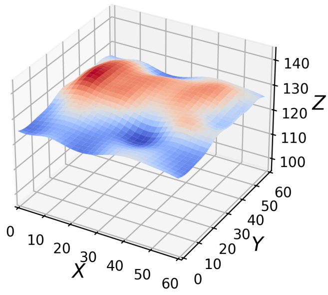

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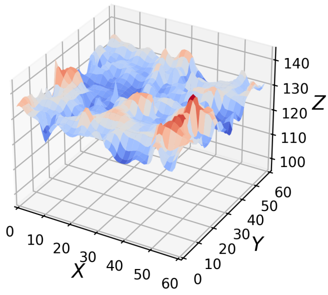
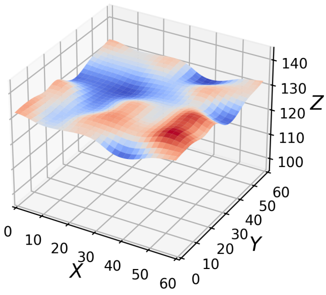
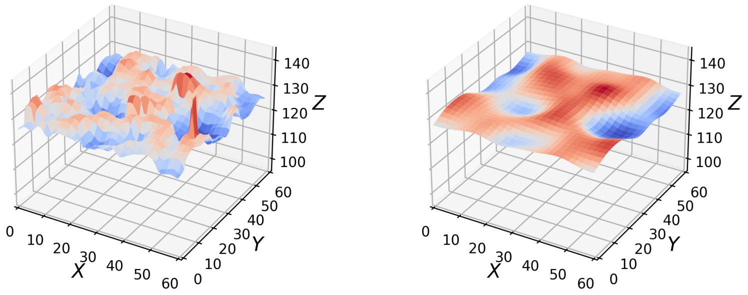




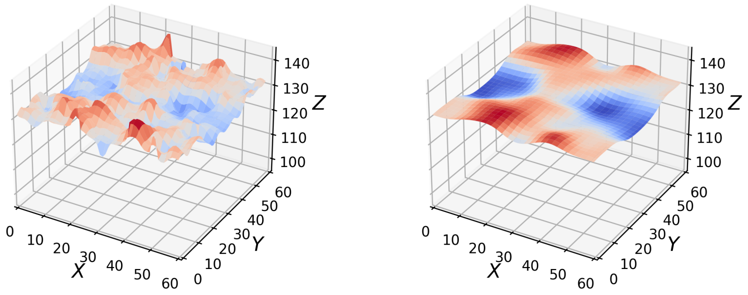
Smearing

- Effects of the number of smearing steps



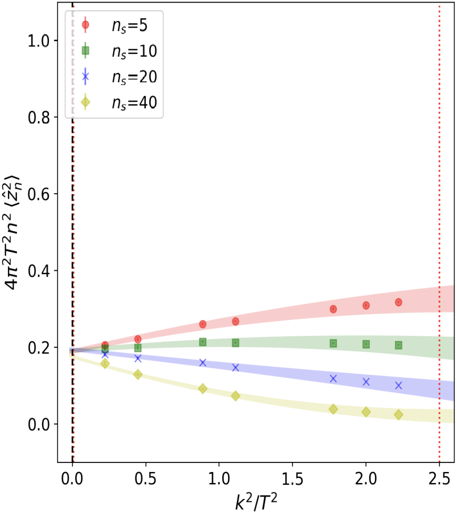
Smearing

- Effects of the number of smearing steps



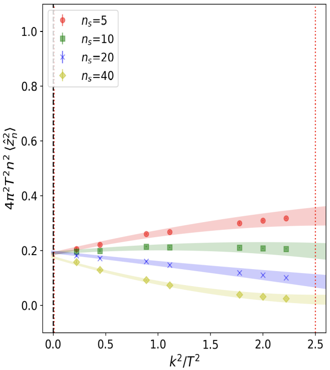
Smearing

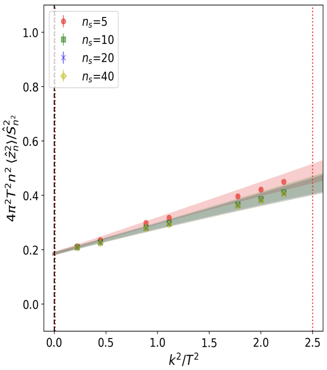
- SU(16)



Smearing Correction

- Kernel correction





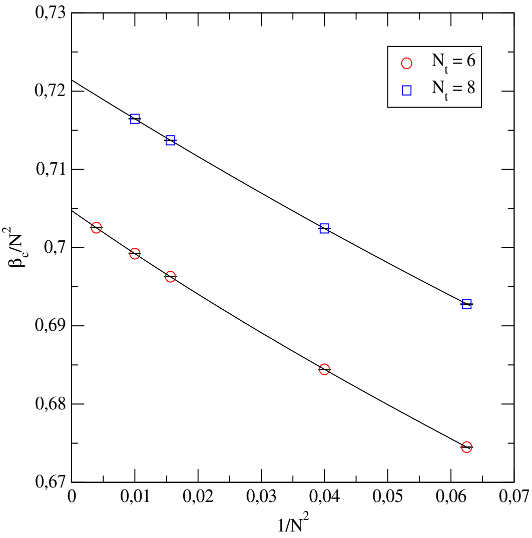
Results

- Critical couplings

N_c	N_t	β_c
4	6	10.7919
4	8	11.0844
5	6	17.1108
5	8	17.5612
8	6	44.5620
8	8	45.6778
10	6	69.9225
10	8	71.6475
16	6	179.8509

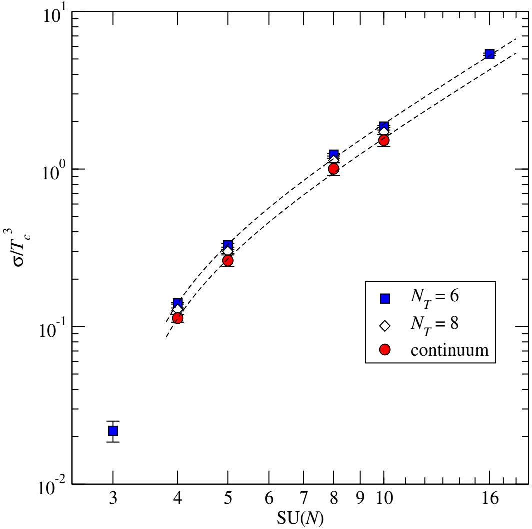
Results

- Critical couplings



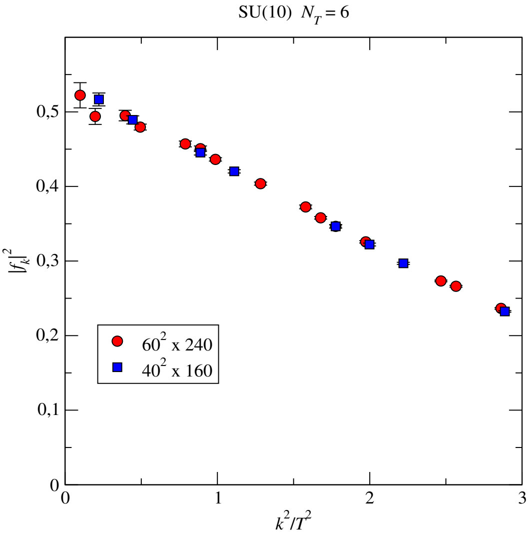
Surface Tension

- Quadratic fit: $c_0 + c_2 N^2$, $c_0 = -0.19(2)$, $c_2 = 0.0189(11)$



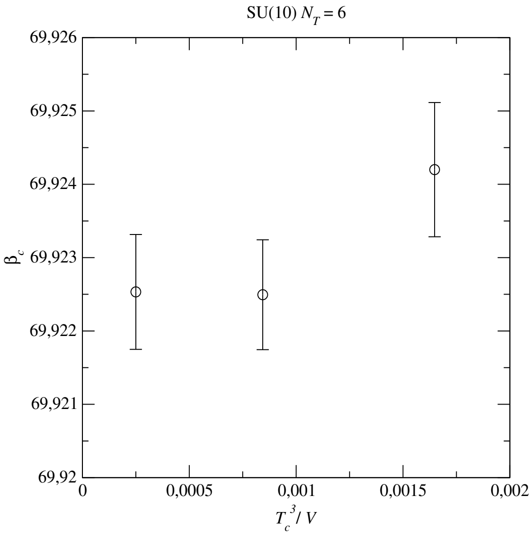
Volume effects

- Similar behaviour with different volumes



Volume effects

- Weak volume dependence



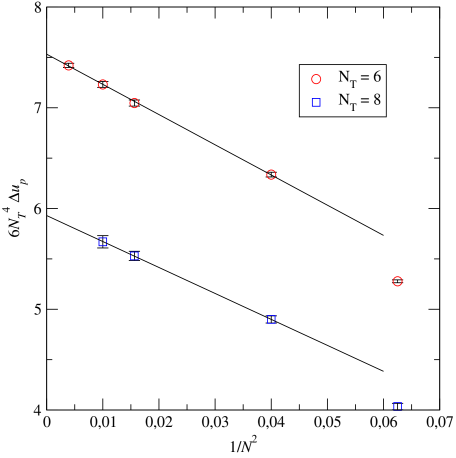
Plaquette Difference

N_c	N_t	β_c	$\langle u_c \rangle$	$\langle u_d \rangle$
4	6	10.7919	0.4380 (1.0303e-06)	0.4373 (1.5171e-06)
4	8	11.0844	0.4176 (6.6930e-07)	0.4175 (1.1014e-06)
5	6	17.1108	0.4469 (2.8967e-06)	0.4461 (8.1081e-07)
5	8	17.5612	0.4258 (6.6025e-07)	0.4256 (1.3036e-06)
8	6	44.5620	0.4564 (2.7630e-06)	0.4555 (2.7272e-06)
8	8	45.6778	0.4346 (1.3351e-06)	0.4344 (1.3022e-06)
10	6	69.9225	0.4586 (2.6406e-06)	0.4577 (2.6915e-06)
10	8	71.6475	0.4367 (1.7921e-06)	0.4364 (1.7316e-06)
16	6	179.8509	0.4609 (1.8135e-06)	0.4599 (1.9464e-06)

Plaquette Difference

$$\Delta u_{(N_T=6)} = 0.0009686(24) - 0.00385(11)/N^2$$

$$\Delta u_{(N_T=8)} = 0.0002413(24) - 0.00105(8)/N^2$$



Advantages

- Computation in polynomial time, enables huge volume simulations
- Surface is easily located, unaffected by probability density distribution
- More suitable for cases of stronger transition
- The use of mixed phase configurations result in absence of tunneling barriers that cause slowdown

Conclusion

- Traditional method works well with smaller systems and when the transition is not too strong
- Complementary method as larger systems are required to explore the continuum limit
- Lots of smearing required
- Presents as a consistent and reliable method for studying stronger transitions in general

References

- Classical Field Dynamics of the Electroweak Phase Transition - Moore and Turok (1996)
- Electroweak Bubble Nucleation, Nonperturbatively - Moore and Rummukainen (2000)
- Properties of the deconfining phase transition in SU(N) gauge theories - Lucini, Teper, and Wenger (2005)
- SU(N) gauge theories at deconfinement - Lucini, Rago, and Rinaldi (2012)

Outlook

- Prototype for a strongly coupled transition of strongly coupled physics
- Thin wall bubble nucleation rate computation
- Latent heat determination