FASTSUM: Anisotropic $N_f = 2 + 1$ Wilson-Clover

R. Bignell [1]

On behalf of the FASTSUM Collaboration

[1] Department of Physics, College of Science, Swansea University,

Swansea SA2 8PP, United Kingdom

Parallel Session on gauge ensembles and data management

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FASTSUM Collaboration

Who are we?

- Gert Aarts, Swansea University
- Chris Allton, Swansea University
- Muhammad Anwar, Swansea University
- Ed Bennet, SA^2C
- Ryan Bignell, Swansea University
- Tim Burns, Swansea University
- Sergio Chaves, Swansea University
- Simon Hands, University of Liverpool
- Benjamin Jäger, Southern Denmark University
- Seyong Kim, Sejong University
- Alan Kirby, Swansea University
- Dale Lawlor, Maynooth University
- Maria Paola Lombardo, INFN Sezione di Firenze
- Jesuel Marques, Maynooth University
- Sam Offler, Swansea University
- Ben Page, Swansea University
- Sinead Ryan, Trinity College Dublin
- Jon-Ivar Skullerud, Maynooth University
- Tom Spriggs, Swansea University
- Dawid Stasiak, Swansea University
- Liang-Kai Wu, Jiangsu University
- Felix Ziegler, University of Edinburgh

FASTSUM Collaboration

What do we do?

- Thermal QCD using the fixed-scale (Anisotropic) approach
- Bottom physics using NRQCD
  - **2112.04201**, **1402.6210**, **1310.5467**, **1210.2903**, B. Page 14:20 Wed., T.Spriggs 14:40 Wed.
- Electrical conductivity of the quark-gluon plasma
  - **2008.12326**, **1412.6411**, **1307.6763**
- light, strange and charm hadron spectroscopy
  - **2007.04188**, **1812.07393**, **1703.09246**, **1502.03603**, R. Bignell 15:50 Wed.
- and more...
  - **2007.04188**, C. Allton 15:30 Wed.

Current Gaugefields

Generation 2

- Two spatial Volumes $N_s = 24$ and 32
- **Gauge Action:** Symanzik-improved, tree-level tadpole
- **Fermion Action:** Wilson-Clover, stout-links, tree-level tadpole
- $m_\pi \sim 384$ MeV, $\xi \sim 3.5$, $T_c \sim 181$ MeV

N_τ	128*	48	40	36	32	28	24	20	16
N_s	24	32	24	24	24/32	24/32	24/32	24	24/32
T (MeV)	44	117	141	156	176	201	235	281	352
T/T_c	0.238	0.633	0.760	0.844	0.950	1.086	1.267	1.520	1.900

* HadSpec Collaboration

Current Gaugefields

Generation 2L

- Newer ensemble with decreased pion mass
- **Gauge Action:** Symanzik-improved, tree-level tadpole
- **Fermion Action:** Wilson-Clover, stout-links, tree-level tadpole
- $N_s = 32$, $m_\pi \sim 236$ MeV, $\xi \sim 3.5$, $T_c \sim 162$ MeV

N_τ	128	64	56	48	40			
T (MeV)	47	94	107	125	150			
T/T_c	0.289	0.578	0.661	0.771	0.925			
N_τ	36	32	28	24	20	16	12	8
T (MeV)	167	187	214	250	300	375	500	750
T/T_c	1.028	1.157	1.322	1.542	1.851	2.314	3.085	4.627

Future Gaugefields

Generation 3

- Ensemble about to enter production
- Planned to have increased anisotropy ~ 7 to decrease temporal spacing by factor of two
- Similar to Generation 2

Generation 2P

- Next step in Generation 2, 2L, to take $m_\pi \to m_\pi^{phys}$

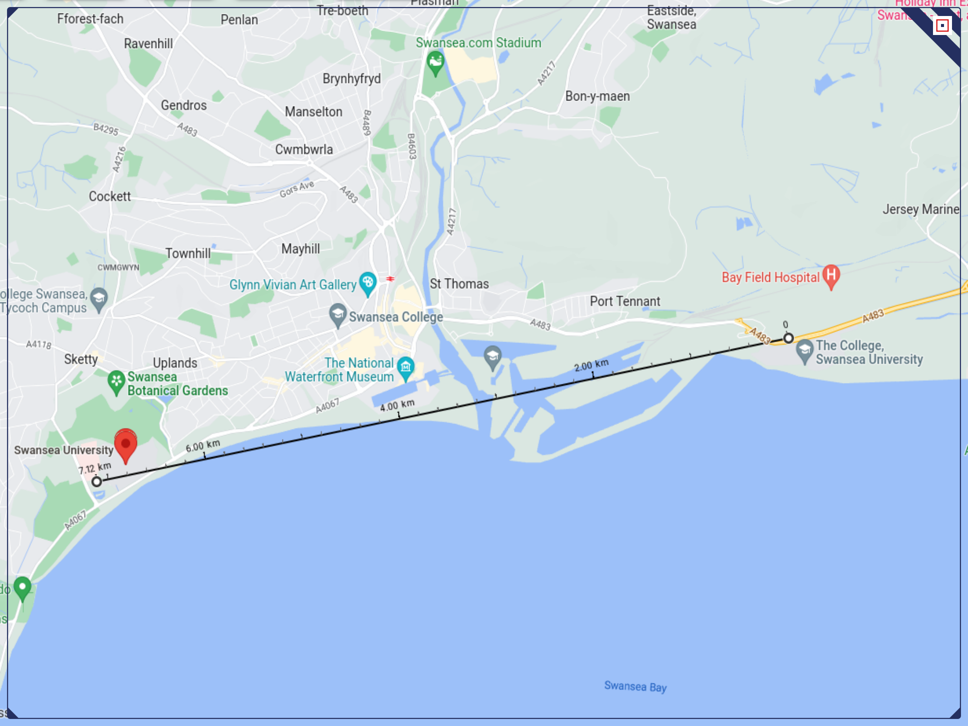
Storage

Primary

- Two separate file servers managed by Swansea University
- Separated by $\sim$ 7km
- $\sim$ 80 TB and $\sim$ 230 TB respectively

Working

- Secondary working storage on various supercomputing resources around the world


Fforest-fach
Penlan
Tre-boeth
Eastside, Swansea
Ravenhill
Swansea.com Stadium
Brynhyfryd
Bon-y-maen
Gendros
Manselton
Cwmbwrla
Cockett
Gors Ave
Townhill
Mayhill
Glynn Vivian Art Gallery
St Thomas
Port Tennant
Bay Field Hospital
Jersey Marine
Swansea College
The College, Swansea University
Sketty
Uplands
Swansea Botanical Gardens
The National Waterfront Museum
Swansea University
Swansea Bay
A483
A4217
B4295
A4216
B4489
B4603
A4118
A4067
CWMGWYN
0
2.00 km
4.00 km
6.00 km
7.12 km

Format & Code & Metadata

Gaugefields

- Gaugefields mostly in openQCD format
  - Header contains dimensions + plaquette value
  - Converter exists to NERSC format
- Some of Generation 2 in SCIDAC/LIME

Code

- Code stored on (public) Gitlab https://gitlab.com/fastsum

Metadata

- Shared Google Docs. Spreadsheet
- Input files also on Gitlab

Future Questions

Sharing

- How to facilitate easy-access for the community?
- Current mechanism would be on a case-by-case basis
- Period of embargo on each set of ensembles

Interfacing with other code bases

- Gaugefields often in specialised formats
  - How do we interface with other codes?
  - Should we maintain compatibility with other gauge groups?
  - How much metadata should be in the gaugefield file itself?

Technical Details

Gauge Action

$$S_G = \frac{\beta}{N_c \xi_g^0} \sum_{x,ij} \left[\frac{c_0}{u_s^4} P_{ij}(x) + \frac{c_1}{u_s^6} \left(R_{ij}(x) + R_{ji}(x) \right) \right]$$
$$+ \frac{\beta \xi_g^0}{N_c} \sum_{x,i} \left[\frac{c_0 + 4c_1}{u_s^2 u_\tau^2} P_{i4}(x) + \frac{c_1}{u_s^4 u_\tau^2} \left(R_{i4}(x) + R_{4i}(x) \right) \right]$$

Fermion Action

$$D = a_t m_q + D_{W,4} + \frac{1}{\xi_q^0} \sum_i D_{W,i} - \frac{c_\tau}{2} \sum_i \sigma_{4i} \hat{F}_{4i} - \frac{c_s}{2\xi_g^0} \sum_{i<j} \sigma_{ij} \hat{F}_{ij}$$

Technical Details

- $D_{W,4}$ and $D_{W,i}$ are the temporal and spatial Wilson terms respectively (no tadpole improvement)
- The clover term $\hat{F}_{\mu\nu}$ consist of four *clover-like* link paths

gauge coupling	$\beta = 1.5$
tree-level coefficients	$c_0 = 5/3,\ c_1 = -1/12$
bare gauge, fermion anisotropy	$\xi_0^g = 4.3,\ \xi_0^q = 3.399$
ratio of bare anisotropies	$\nu = \xi_0^g/\xi_0^q = 1.265$
spatial tadpole(without, with smeared links)	$u_s = 0.733566,\ \tilde{u}_s = 0.92674$
tempoeral tadpole (without, with smeared links)	$u_\tau = 1,\ \tilde{u}_\tau = 1$
stout smearing for spatial links	$\rho = 0.14$, isotropic, 2 steps
bare light quark mass (Gen2, Gen2L)	$\hat{m}_{0,light} = -0.0840, -0.0860$
bare strange quark mass	$\hat{m}_{0,\,strange} = -0.0743$
light quark hopping parameter (Gen2, Gen2L)	$\kappa_{light} = 0.2780, 0.27831$
strange quark hopping parameter	$\kappa_{strange} = 0.276509$
charm quark hopping parameter	$\kappa_{charm} = 0.271407$