The T E L O S Collaboration

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TELOS collaboration
Centre for Mathematical Sciences
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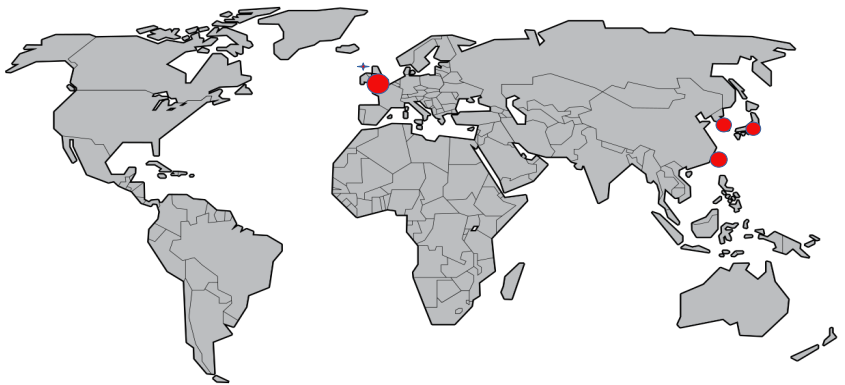
The Telos Collaboration

Who we are

Theoretical **E**xploration on the **L**attice with **O**rthogonal and **S**ymplectic groups



- 7 Core members
- 3 postdocs
- 2 students
- N collaborators

Our aim, in one sentence: Study the phenomenological viability of strongly coupled Sp(2N) and SO(N) gauge theories for scenarios of **B**eyond the **S**tandard **M**odel Physics.

Montecarlo for QFT

We perform numerical computations of

$$\langle 0|\mathcal{O}(U,\bar{\psi},\psi)|0\rangle = \frac{\int \mathcal{D}U\mathcal{D}\bar{\psi}\mathcal{D}\psi\ \mathcal{O}(U,\bar{\psi},\psi), e^{-S[U,\bar{\psi},\psi]}}{\int \mathcal{D}U\mathcal{D}\bar{\psi}\mathcal{D}\psi e^{-S[U,\bar{\psi},\psi]}}$$

Where:

$U_\mu, \bar{\psi}, \psi$ are Gauge and Fermion fields,

$\mathrm{S} = \mathrm{S}_W[U] + \sum_{xy}\bar{\psi}(x)D_{xy}\psi(y)$ is the typical form of the action S,

$D_{xy} = D_{x\alpha a, y\beta b}$ is the Dirac Operator, where x,α,a space-time, Dirac, color indices,

$dP(U) = \mathcal{D}U\ \det D[U]\ e^{-S_W[U]}$ is the statistical distribution to sample to compute the above.

Hybrid Monte Carlo

Question: How to sample efficiently $dP(U) = \mathcal{D}U \ \det D[U] \ e^{-S_W[U]}$?

Answer:

- For pure gauge, D[U] = 1, choice of clever prior distribution is possible: Heat Bath, fast & reliable,
- If the presence of D, simulations much more difficult: Hybrid Monte Carlo,

$$\det D[U] = \int \mathcal{D}\phi \mathcal{D}\phi^\dagger e^{\phi^\dagger D^{-1}[U]\phi}$$

- Use Metropolis algorithm to sample ϕ^+, ϕ,
- Use Molecular Dynamics to guide Metropolis proposal,

$$\frac{d}{d\tau} U_\mu(x) = \pi_\mu(x) U_\mu(x)$$

$$\frac{d}{d\tau} \pi_\mu(x) = F_\mu(x)$$

Note:

- In general, many different forms for D: Wilson-Dirac, Staggered, Domain Wall,…
- **Bottleneck**: calculation of the inverse D^{-1}
- Computation of observable also involves D^{-1}

Monte Carlo calculation typical workflow:

- Store sets of configurations: "Ensembles",
- Compute observables by averaging over configs,
- Repeat at different hyperparameters,
- Extrapolate to continuum and/or other limits.

Codebases

Question: How to sample efficiently $dP(U) = \mathcal{D}U \ \det D[U] \ e^{-S_W[U]}$?

We use mainly two codebases suitably adapted to accomodate $Sp(2N_c)$ gauge theories:

- **HiRep** (Del Debbio, Patella, Pica, PRD81094503).
  Wilson-Dirac fermions in Multiple representations of the gauge group.
  GCR and refinements for inversions.
  MPI/OpenMP parallelization, runs on CPU/GPUs.

- **Grid** (Boyle et al, 1512.03487).
  Wilson-Dirac, Domain Wall Fermion in Multiple representations of the gauge group.
  GCR and refinements for inversions.
  MPI/OpenMP parallelization, runs on CPU/GPUs.

Thank you