ESR-2, Mid Term Evaluation

Exploiting memory hierarchies in future node architectures for lattice QCD applications

Srijit Paul

The Cyprus Institute
University of Wuppertal

April 18, 2017

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No' 642069

Outline

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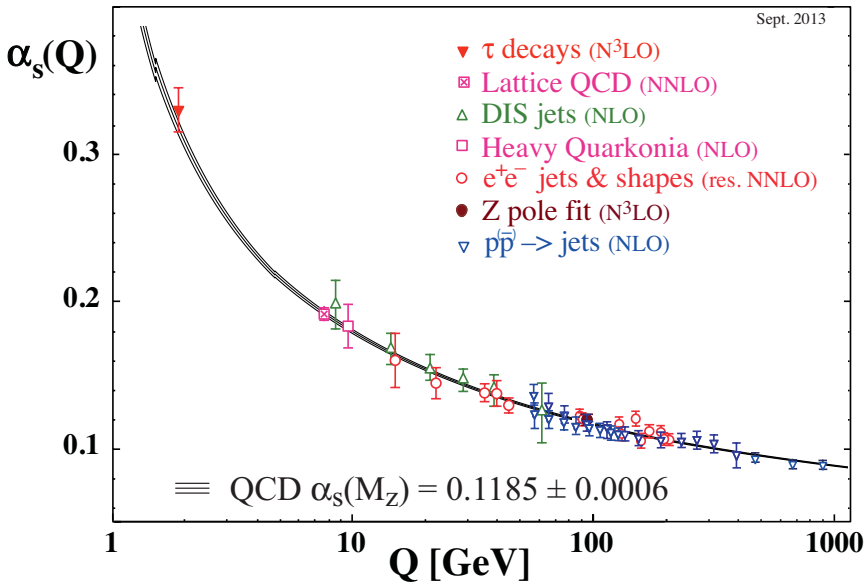
Fundamental nucleon properties • quark-gluon plasma • nuclear forces • super novae • neutron stars

$$\mathcal{L}_{\mathrm{QCD}} = \bar{\psi}_{\mathrm{f}} \left(\mathrm{i} \not{D} - \mathrm{m}_{\mathrm{f}} \right) \psi_{\mathrm{f}} - \frac{1}{4} \mathrm{tr} \left(\mathrm{GG} \right)$$



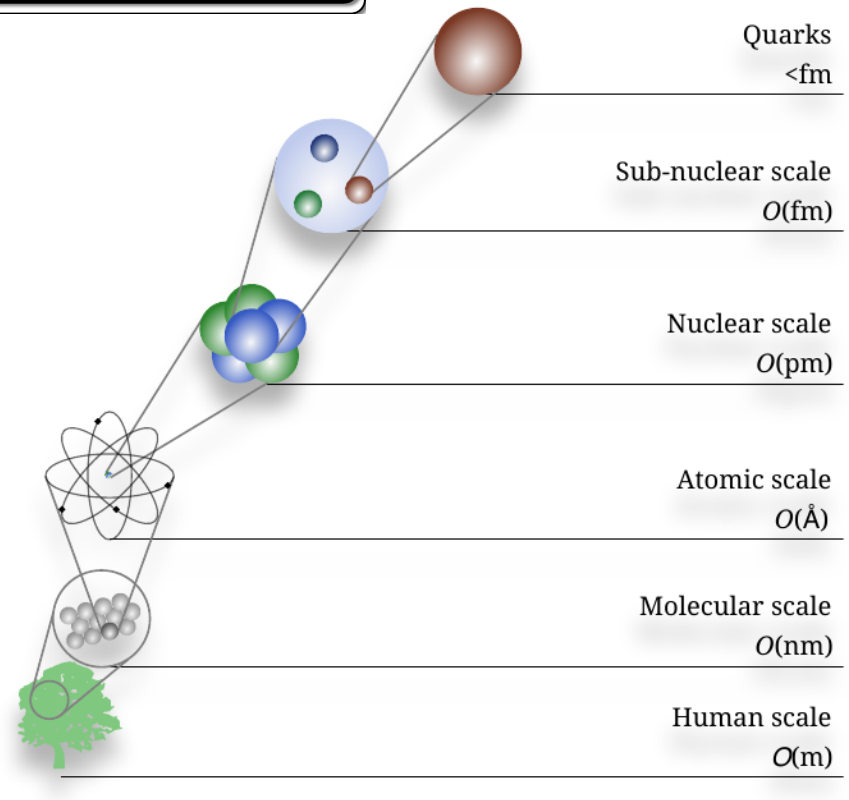


Figure: Perturbative v/s Non-Perturbative
(K.A. Olive et al. (Particle Data Group))

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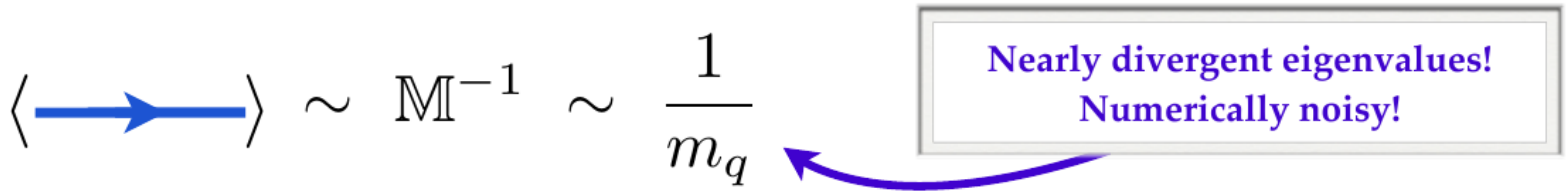

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$$\langle \longrightarrow \rangle \sim \mathbb{M}^{-1} \sim \frac{1}{m_q}$$

Nearly divergent eigenvalues!
Numerically noisy!

- **Solutions**: Algorithmic- Multigrid solvers
  Computational: Petascale Machines

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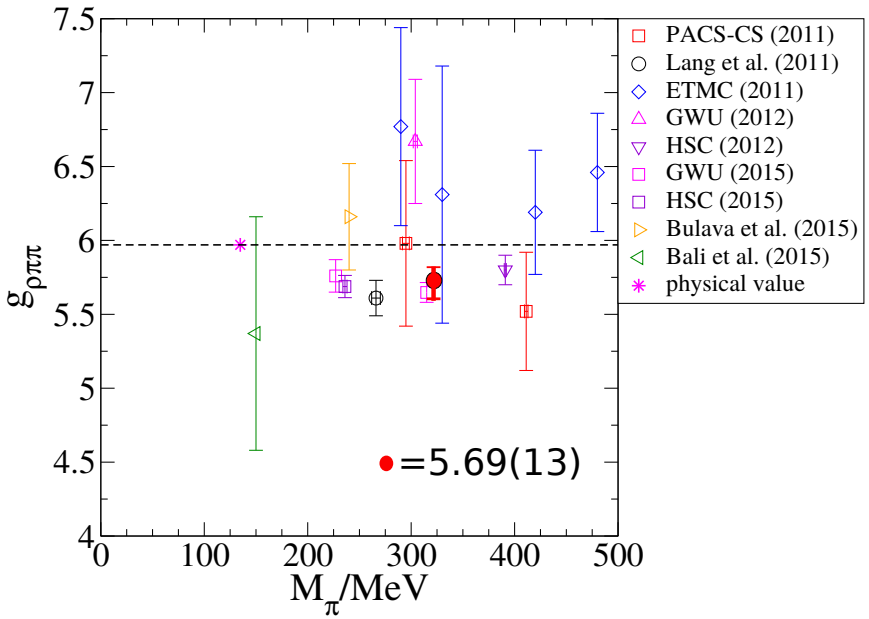

Figure: L. Leskovec(U.Arizona), C. Alexandrou, G. Koutsou, S. Meinel(U.Arizona), J. W. Negele(MIT) ,S. Paul, M. Petschlies(U.Bonn), A. Pochinsky(MIT), G. Rendon and S. Syritsyn(Stony Brooks),

A study of the radiative transition $\pi\pi \rightarrow \pi\gamma^*$ with lattice QCD , PoS Lattice 2016

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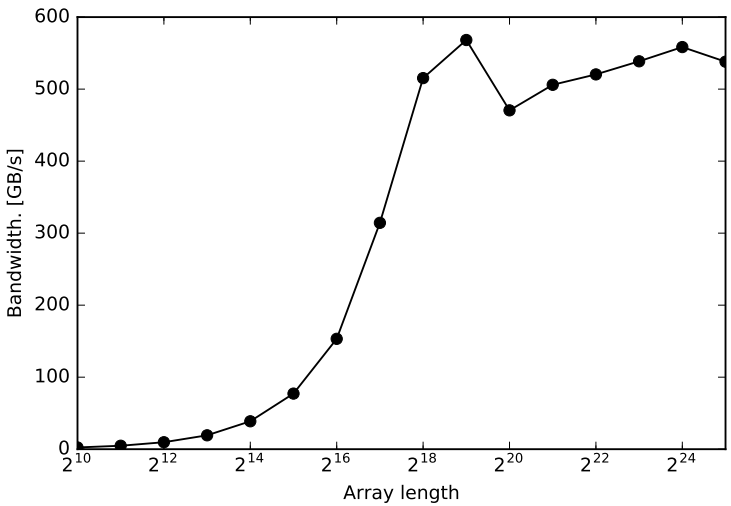

- Work going on with QUDA on JSC system JURON (Pascal architecture), GPU based machine(Secondment)
- Work going on with USQCD software QLUA on NERSC system, Cori Phase II(KNL architecture)

Outline

Wuppertal and Dublin Schools

- Introduction to various Krylov Space solvers.
- Primer to Multigrid algorithm.

Jülich School

- Introduction to MPI, OpenMP, CUDA and OpenCL.
- Performance modelling in different architectures.

Aachen School

- Molecular dynamics methods in physics simulations.
- Statistical methods and sampling in Monte Carlo simulations.

Lattice Practices 2015

- Data analysis in Lattice QCD.
- Performance optimizations on different computer architectures.

EuroHACK 2017: Porting algorithms to NVIDIA Pascal GPUs.

Outline

Future work

Computational work

- An analysis of different implementations of the Multigrid approaches with respect to memory capacity and bandwidth requirements.
- Exploring optimization strategies of the Multigrid implementations on various coprocessors, such as NVIDIA GPUs and Intel Xeon Phis.

Physics goals

- Extending the scattering phase shift calculations using the features of the coprocessors for meson nucleon resonance in lattice QCD.(ongoing)
- ρ-calculation to be published in PRD.
- Presenting the ρ-calculation at LATTICE 2017.

Advisors: Dr. Giannis Koutsou & Dr. Thomas Lippert

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