Annual Meeting 2024

NA6-LatticeHadrons (WP17)
Mike Peardon

S

Plan of presentation

01 Progress achieved by the WP since the CERN meeting

02 Highlights of the performed work (last year + full project duration)

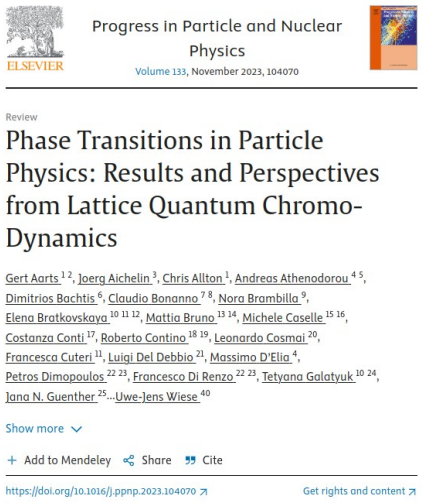
03 Summary of Tasks and achievements

Institutions

Trinity College Dublin	Edinburgh	INFN	Madrid	Mainz	Regensburg
MP	Luigi Del Debbio	Maria Paola Lombardo	Gregorio Herdoiza	Hartmut Wittig	Gunnar Bali

Workshops

- All planned workshops delivered (but delayed!)
- Two remaining progress reports from meetings to be completed by end of projects



Progress in Particle and Nuclear Physics
Volume 133, November 2023, 104070

Review

Phase Transitions in Particle Physics: Results and Perspectives from Lattice Quantum Chromo-Dynamics

Gert Aarts [1 2], Joerg Aichelin [3], Chris Allton [1], Andreas Athenodorou [4 5], Dimitrios Bachtis [6], Claudio Bonanno [7 8], Nora Brambilla [9], Elena Bratkovskaya [10 11 12], Mattia Bruno [13 14], Michele Caselle [15 16], Costanza Conti [17], Roberto Contino [18 19], Leonardo Cosmai [20], Francesca Cuteri [11], Luigi Del Debbio [21], Massimo D'Elia [4], Petros Dimopoulos [22 23], Francesco Di Renzo [22 23], Tetyana Galatyuk [10 24], Jana N. Guenther [25]...Uwe-Jens Wiese [40]

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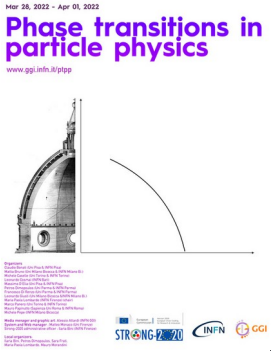
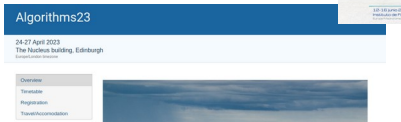
https://doi.org/10.1016/j.ppnp.2023.104070 Get rights and content

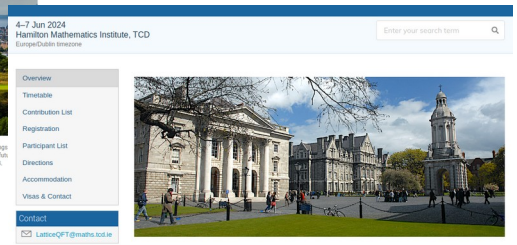


Mar 28, 2022 - Apr 01, 2022
Phase transitions in particle physics
www.ggi.infn.it/ptpp

IFT
STRONG 2020
Lattice Gauge Theory Contributions to New Physics Searches



Algorithms23
24-27 April 2023
The Nucleus building, Edinburgh



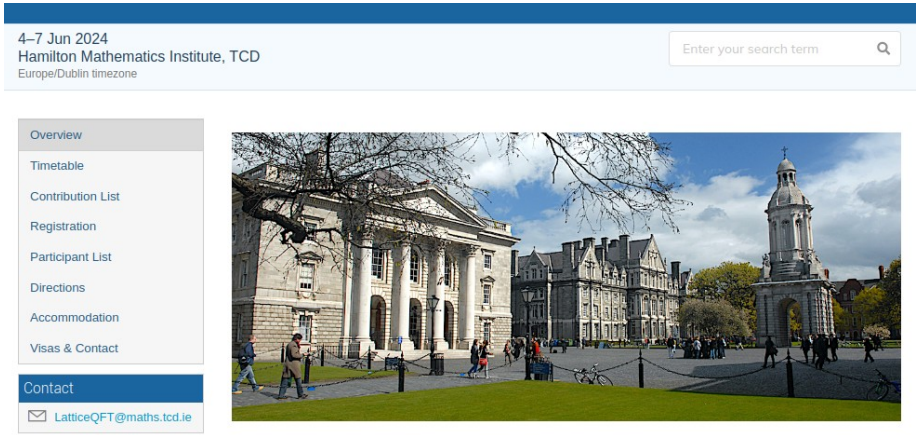
4–7 Jun 2024
Hamilton Mathematics Institute, TCD
Europe/Dublin timezone

STRONG-2020

Hadron spectroscopy & precision physics workshop: Dublin 4-7 June 2024

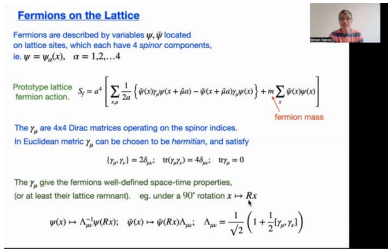
- 32 participants
- Topics included:
  - Scale-setting for high-precision
  - Controlling cut-off artefacts
  - New analysis methods for Hadron physics
  - Precision heavy flavour calculations
- Some remote presentations enabled

https://indico.cern.ch/event/1390987



LaVA : The Lattice Virtual Academy

- Online training platform for next generation of lattice practitioners
- Progress made to date – “Essentials” section recorded by Simon Hands, Christof Gattringer and Margarita Garcia Perez.
- Supported by ECT*, including web-hosting and design.



Sections:

- Essentials of Lattice Field Theory
- Numerical and Statistical Analysis
- Hardware
- Critical phenomena
- Thermodynamics
- Precision frontier
- Hadron Physics
- Beyond the Standard Model
- Machine Learning
- Algorithms
- Vacuum structure
- Improvement and renormalisation
- Quantum computing & tensor networks

Example of a lattice project supported : string breaking

- Personal example – collaboration with group in Wuppertal.
- Lattice calculation in Nf=2+1 QCD
- How does the potential energy between two static colour sources depend on their separation in the presence of light and strange quarks?
- Set of adiabatic potentials V(r)– light quarks and gluons moving in background generated by static colour-source and anti-source at fixed separation, r
- Insight into hadron scattering and input to Born-Oppenheimer, EFT computations

Phys. Lett. B 854 (2024) 138754

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Physics Letters B

journal homepage: www.elsevier.com/locate/physletb

Letter

The quark-mass dependence of the potential energy between static colour sources in the QCD vacuum with light and strange quarks

John Bulava [a], Francesco Knechtli [b,*], Vanessa Koch [b], Colin Morningstar [c], Michael Peardon [d]

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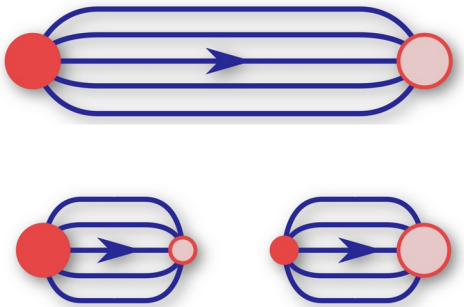
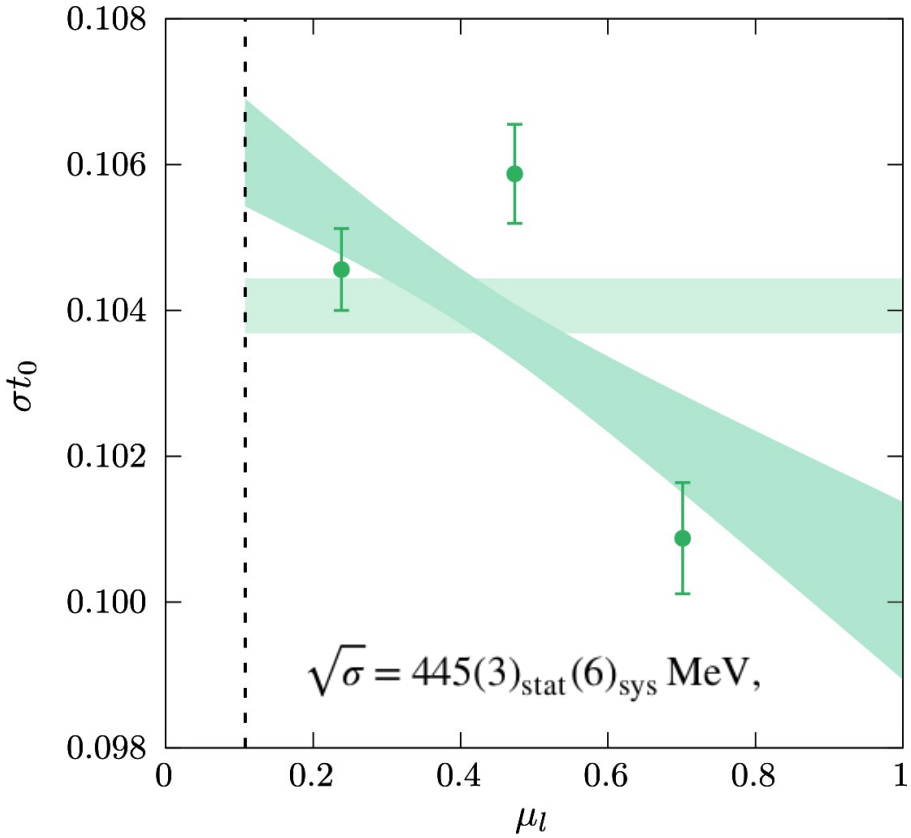
[b] Department of Physics, University of Wuppertal, Gaußstrasse 20, 42119, Germany
[c] Department of Physics, Carnegie Mellon University, Pittsburgh, PA 15213, USA
[d] School of Mathematics, Trinity College Dublin, Ireland

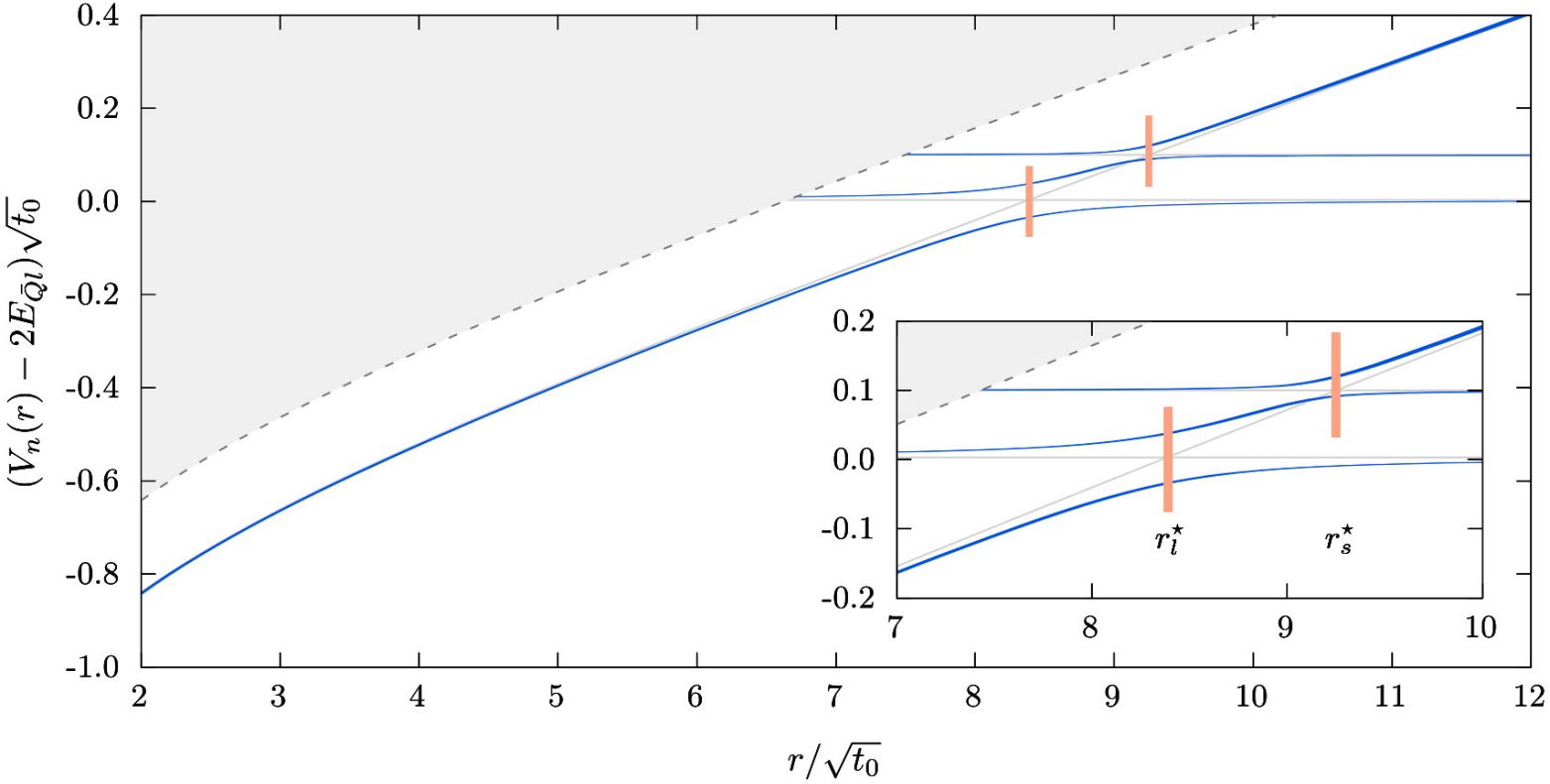


Example of a lattice project supported : string breaking

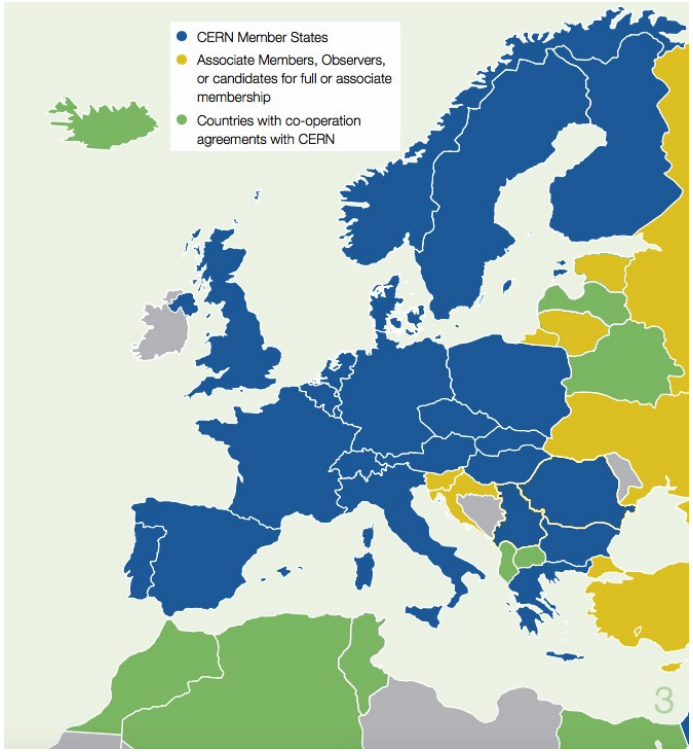
- Basis of three creation operators, resembling the string and the static meson-anti-meson system (for both u,d and s quarks)
- GEVP gives access to three lowest-lying states in a robust way. Determine $V_k(r)$ for k=1,2,3 and r from 1~2 fm
- Model these energies as a simple hamiltonian mixing
- This gives a more robust definition of the string tension, which we can extrapolate to the physical quark masses
- Extending methods of Bali et. al arXiv:hep-lat/0505012



Example of a lattice project supported :
3 (adiabatic) string energy levels



Ireland to join CERN



Sections ☰ THE IRISH TIMES 12°

Science

Ireland set to apply to become a member of leading European research centre CERN

The move is culmination of long campaign urging Irish membership of body developing technology of tomorrow

Expand

It will include masters and PhD programmes; apprenticeships, a graduate engineering training scheme, internships for computer scientists and engineers and technical training. Photograph: Maximilien Brice/CERN

LATEST STORIES ›

Summary

- All 4 planned workshops completed
- Travel and visits restarted
- New activity, complementing training/secondment plans envisioned:

  LaVA – the Lattice Virtual Academy
- Lattice QCD research in Europe is very active and making progress to reach higher precision (g-2, CKM, α_s, …) and a broader scope of physics topics
- Close connections maintained and new one developed:
  - High-Performance Computing, including the use of GPUs for numerics
  - Applied Mathematics & Statistics
  - Machine Learning
  - Quantum Computing