Strong interactions at the LHC

Background

The main challenge for the LHC era will be to understand the mechanism of electroweak symmetry breaking (EWSB). One possibility is that EWSB is induced by new strong dynamics beyond the Standard Model (BSM). Recent progresses in lattice QCD have pushed numerical simulations of the theory close to the physical point, and we have established that we have a rigorous handle on QCD strong dynamics. There is now an opportunity to explore other strongly interacting QFTs that might guide how we interpret results at LHC: quantitative studies of their nonperturbative dynamics are feasible that will uncover possible experimental signatures.

Candidates theories for strong BSM dynamics involve SU(N) gauge theories with large numbers of fermions in the fundamental representation, or less fermions in higher-dimensional representations of the colour group; they are characterized by a near-conformal dynamics and therefore are not ruled out by electroweak constraints. Other theories of interest are supersymmetric Yang-Mills, and SU(N) with a small number of fundamental fermions that occur in hidden valleys scenarios. Moreover theories with fermions in two-index representations of the colour group appear in the planar orientifold equivalence, which related supersymmetric to non-supersymmetric gauge theories; these can be studied using the same lattice framework.

For all these theories lattice simulations can provide first principle results about the phase diagram, the spectrum, the decay constants, and the low-energy constants that appear in the corresponding effective lagrangians used for phenomenological studies. This information is needed in order to obtain quantitative predictions.

UK activity

Lattice BSM studies are being carried on since 2006 by groups in Edinburgh and Swansea, led by Dr Del Debbio, and Dr Lucini respectively. The UK groups pioneered the development of algorithms for simulating Wilson fermions in higher-dimensional representations. The current focus is on the phase structure and the spectrum of the so-called Minimal Walking Technicolor theory. The group has been allocated resources as part of the UKQCD bid for HPC; note that following successful peer review the UKQCD bid has been stalled for two years, reducing the possibility to carry out simulations on the scale performed by groups in other countries. Nevertheless, our group has been able to perform large-scale calculations that have enabled us to obtain the lowest-lying meson spectrum at large N (currently used in Monte Carlo event generators for hidden valleys scenarios), the first pioneering investigations of Orientifold Planar Equivalence and the most robust calculations of the spectrum of candidate Technicolor theories. The current delay in the procurement of HPC resources is seriously impacting our activity, and the risk that we will not be able to keep a leading role is real. The UK collaboration has currently access to resources in Swansea, Edinburgh, and in Odense (Denmark). People working on this project include: two postdocs in Swansea (one funded by an SPG), one postdoc in Edinburgh, one postdoc in Cambridge, two students in Edinburgh, one student in Swansea, and one student in Oxford. An EPSRC grant has funded the partial porting of our software into Chroma, which is the community code developed jointly by

UKQCD and USQCD. The UK group has collaborative links with the University of Odense (DK), and Syracuse University and RPI (US).

Further developments of our studies of Technicolor theories and of the Orientifold Equivalence will continue in the near future. Exploiting the algorithmic developments that we have implemented, we plan to have phenomenologically relevant results in the next 2-3 years, with a satisfactory control of systematic errors. On the same timescale we will develop the inclusion of lattice results into event generators for the LHC. Finally we will extend the current quenched studies of the Orientifold Equivalence to fully-dynamical simulations.

International activity

In the last two years a number of groups have started to investigate similar issues. In 2007 the US have funded the LSD Collaboration, whose mission is to investigate strong dynamics by lattice techniques. The project has been awarded a class A allocation within USQCD. On top of that, our collaborators in Syracuse are expecting to get an allocation of 3 M core hours on USQCD clusters. The allocation in the US has doubled every year, in the last two years and represents now roughly 7% of the cycles allocated for lattice simulations in the US. Other activities in the US include the group in Colorado, and the group at Syracuse. Active groups in Europe are located at Odense (Denmark), Groningen (the Netherlands), Helsinki (Finland), Rome (Italy), and in Israel.