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QCD Data Parallel for Multicore Acceleration and Semi-Leptonic Octet Hyperon Decays

QDP++ on PowerXCell 8i

One of the goals of this study was to explore the feasibility of porting the QCD Data Parallel library QDP++ and the Chroma application software layer to QPACE. QPACE stands for QCD PArallel computing on the CEll and is a project which has developed a massively parallel, scalable supercomputer for applications in lattice QCD (1). The processing power of this machine is provided by the IBM PowerXCell 8i processor. The PowerXCell 8i Processor is a new type of heterogeneous multi-core processor developed by Sony, Toshiba and IBM. It comprises eight Synergistic Processor Elements (SPE) and one PowerPC Processor Element (PPE) which are connected through a high speed Element Interconnect Bus. QDP++ is a major component of the USQCD/SciDAC (2) software stack. It provides a data-parallel programming environment suitable for essentially any kind of LQCD application and is the basis for a suite of LQCD applications called Chroma. With QDP++ an Application Programming Interface (API) is defined and implemented which allows, e.g., to operate on lattice objects while hiding the target architecture-dependent data layout. Expressions involving these data-types are resolved to specific functions at compile time by the included Portable Expression Template Engine (PETE) (3).

There are mainly two challenges in porting QDP++ to the PowerXCell 8i. Firstly, the QDP++ design does not address heterogeneous multi-core architectures such as the Cell processor. QDP++ was designed for single node architectures while leaving the internode data transfers to a different API level, namely QMP (QCD Message Passing). Secondly, the problem of data management needs to be addressed. The SPEs on the Cell processor access the main memory via asynchronous DMA transfers. The current QDP++ data management does not address this.

Our QDP++ on Cell execution model outlined here is PPE-centric using the SPEs as acceleration cores. Generic lattice operations are implemented on the SPEs as call-outs from the PPE. The SPEs execute a service loop and await commands from the PPE indicating which lattice operation is about to be executed. To achieve this the C++ expressions emerging on the PPE are reconstructed and executed on the SPEs. After execution the results are collected by the PPE. We carried out a proof-of-concept analysis by implementing basic lattice operations which were successfully distributed to the SPEs.

Investigation of hyperon decays using LQCD methods

Semi-leptonic octet hyperon decays $H \to H' l \nu$ with $H, H' \in \{\Lambda, \Sigma, \Xi\}$ can be used for investigations of SU(3) flavor symmetry (4). They are described by the vector and axial transition form factors. These form factors are defined with the help of the matrix element.

This part of our study required an extension of the application software Chroma. The BlueGene/L at EPCC had been identified as a suitable machine to perform the actual calculations.

Three point functions are a major and well established component already available in Chroma. These three point functions were extended to be able to study the semi-leptonic hyperon decay.

To perform the actual calculations the BlueGene/L installation at EPCC was used. To store the results of these calculations in an appropriate way, the binary output format of Chroma for three-point functions was extended.

Results from a earlier similar run was taken as reference data. Now that all initial tests have been passed, we are in a position to start large-scale production runs.

Future work

The issue of data management in QDP++ will be addressed in future work. Data alignment and access pattern have to be analyzed carefully to get a high-performance build of QDP++ on the Cell.

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References

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