There are a number of numerical transformations that are applied in HPC scientific computing in order to match multiprocessors features, namely, parallelism, communication and memory hierarchy. Here, we refer to algorithm transformations that may change the semantics of corresponding programs and thus are not encompassed in today's optimizing tools. These transformations have important impact on the numerical stability and convergence of algorithms.

Tools for the automatic generation of these transformed algorithms have two kinds of application. First, they speedup the fastidious task of reprogramming for testing numerical properties. They may even be incorporated in an iterative tool for systematically evaluating these properties. Second, if these transformations are formalized we can consider generating diferent versions on line - meaning at run time - in order to test and adapt automatically algorithms to actual run time values.
Communication avoiding algorithms improve parallelism and decrease communication requirements by ignoring some of dependency constraints at the frontiers of domains. These are aggressive transformations and special preconditioning is needed in order to ensure their convergence.

The topic of this PhD thesis is to understand how to formalize these transformations and whether they can be directly included in the polyhedral model or if the polyedral model must be extended. We plan then to implement these transformations in the meta-language tool designed formerly in the ANR PetaQCD project (*). That language may also have to be adapted in order to account for these new transformation features.

Targeted architectures are clusters of GPU, supercomputers such as IBM Bluegene or very large clusters.

This work addresses a number of topics - processor architectures, multicores, optimizing compilers, languages, scientific computing, applications, physics. It will be adapted to the PhD candidate's skills.

(*) The ANR PetaQCD project (end october 2012) targeted Lattice Quantum Chromodynamics applications. A followup has been submitted to extend PetaQCD results to other kinds of applications such as astrophysics.