

Calculation of Magnetic and Hydrodynamic Interactions in Magnetorheological Suspension Flow

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The home-made simulation software described below was created for studies of magnetorheological suspension flow. Specific features imposed by physical processes are calculation of large amount of interactions between particles.

The calculation software is made up of two parts: the core part, which performs all physical calculations, and the graphical environment, or the client, which visualizes the progress of calculations. Both of these parts are designed as independent programs that communicate between themselves with the network interfaces implementing the server-client scheme. The server functions are performed by the core module, but the client side functions are performed by the graphical user environment. This means that the same calculation can be observed visually in three dimensions by multiple clients. For graphical environment the Nokia Qt library is used, while the OpenGL library is used as the three-dimensional engine. This ensures that the graphical environment is cross-platform.

The calculation core is written in C++ language for a higher abstraction and better performance. In addition, the software is designed in a cross-platform way so it can be run from different unix type systems. One of core libraries is Boost.org, it allows to facilitate and standardize the various tasks of programming between different operating systems. For example, the log file writing, networking with sockets, threading and so on.

The connection between the server and a client, as mentioned above, is implemented using the network sockets; an TCP connection is established, over which communication takes place with a specific protocol. Data are exchanged in the binary form made from object serialization with the help of special library- an object data are converted to binary stream, transmitted, and then at the destination the data are deserialized (restored) to the object. Boost.org includes an object serialization module, but it is not used to get rid of the dependence of Boost.org at the client side; instead a self written serialization module is applied.

C++ features are employed whenever possible to ensure high level of abstraction. Three dimensional vectors are represented as objects with overloaded arithmetic operations, the scalar and vectorial products are included. Template metaprogramming with expression templates are used to maintain the abstraction level without losing the performance.

At the moment, parallelization is carried out only within the boundaries of a single multi-core computer using Thread Building Blocks library. This way it is possible to parallelize specific parts of calculations (in particular – the particle interaction calculations). In case of the hydrodynamic calculations, the linear equation system solving part is parallelized - it is done by UMFPACK (SuiteSparse package) and GotoBLAS.

It is planned to introduce the parallelization in computer clusters using one of the MPI implementations. To profit from C++ as much as possible, the use of MPI wrapper is planned. In this scheme data are exchanged using serialization. Particularly, the calculations now parallelized with Thread Building Blocks will be parallelized using MPI, where on each of the cluster nodes the parallelization will be further carried out using the same Thread Building Blocks library between processor cores.

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