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FUSION ACTIVITIES IN THE GRID

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The future Magnetic confinement Fusion energy research will be mainly based upon large international facilities with the participation of a lot of scientist belonging to different institutes. For instance, the large device ITER (International Tokamak Experimental Reactor) that will be built in Cadarache (France) is participated by six partners: Europe, Japan, USA, Russia, China, and Korea. India is presently involved in negotiations to join the project and Brazil is also considering the possibility of joining the project. Besides ITER, the Fusion community has a strong collaboration structure devoted both to the tokamak and the stellarator research. As a result of this structure, there exists a network of groups and Institutes that are sharing facilities and/or results obtained on those facilities.

Magnetic Fusion facilities are constituted by large devices devoted to study Plasma Physics that produce a large amount of data to be analysed (the typical rhythm of data production is about 1 GBy/s for a conventional device that can reach 10 times larger value in ITER). The analysis and availability of those data is a key point for the scientific exploitation of those devices.

Also, large computations are needed for understanding plasma Physics and developing new calculation methods that are very CPU time consuming. A part of this computation effort can be performed in a distributed way and Grid technologies are very suitable to perform those calculations. Several Plasma Physics applications are being envisaged for adapting into the grid, those that can be distributed in different processors.

The first kind of applications is In particular, Monte Carlo codes are suitable and powerful tools to perform transport calculations , especially in those cases like the TJ-II stellarator that present radially extended ion orbits, which has strong influence on confinement: The fact that orbits are wide makes that ions perform large radial excursions during a collision time, which will enhance outward heat flux. The usual transport calculations based on local plasma characteristics that give local transport coefficients are not suitable for this kind of geometry in the long mean free path regime. The suitable way to estimate transport is to follow millions of individual particles that move in a background plasma and magnetic configuration. The interaction with other particles is simulated by a collision operator, which depends on density and temperature, and by a steady state electric field, caused by the unbalanced electron and ion fluxes. This tool will be also useful to take into account other kinetic effects on electron transport, like those related to heating and current drive. This transport tool is now working in a Supercomputer and is being prepared to be ported to the grid, where will run soon. The capability of performing massive kinetic transport calculations will allow us to explore transport properties in different heating conditions and collisionalities, as well as with different electric field profiles.

Another application that requires distributed calculations is the massive ray tracing. The properties of microwave propagation and absorption are estimated in the geometrical optics (or WKB) approximation by simulating the microwave beam by a bunch of rays. Those rays are launched and followed inside the plasma and all the necessary quantities are estimated along ray trajectories. Since all the rays are independent, they can be calculated separately . The number of rays needed in a normal case is typically 100 or 200, and the time needed for every ray estimate is about 10-20 minutes. This approximation works when the waist of the beam is far from any critical layer in the plasma. Critical layers are those where mode conversion, absorption, or reflection of microwaves happens. When the waist of the beam is closed to critical layers, a much higher number of rays is needed to simulate the beam. The typical number can be of the order of 10000, which is high enough to make it necessary to run the application in the grid. Massive ray tracing calculations could also be useful to determine the optimum microwave launching position in a complex 3D device like a real stellarator.

These two former applications require that a common file with stellarator geometry data is distributed in all the processors as well as individual files with the initial data of every ray and trajectory.

Stellarator devices present different magnetic configurations with different confinement properties. It is necessary to look for the magnetic configuration that present the best confinement properties, considering the experimental knowledge of confinement and transport in stellarators. Therefore, stellarator optimization is a very important topic to design the future stellarators that have to play a role in Magnetic confinement fusion. The optimization procedure has to take into account a lot of criteria that are based on the previous stellarator experience: neoclassical transport properties, viscosity, stability, etc. A possible way to develop this
procedure is to parametrize the plasma by the Fourier coefficients that describe the magnetic field. Every set of coefficients is considered as a different stellarator with different properties. The optimization procedure has to take into account the desired characteristics for a magnetic configuration to be suitable for an optimised stellarator. The optimization criteria are set through functions that take into account the properties that favour plasma confinement . Every case can be run in a separate node of the grid in order to explore the hundreds of parameters that are involved in the optimization.

Presently, other applications are being considered to be run in the grid in order to solve efficiently some problems on Plasma Physics that are needed for the future magnetic confinement devices. For instance, transport analysis is a key instrument in Plasma Physics that gives the transport coefficients that fit the experimental data. Transport analysis is performed using transport codes on the real plasma discharges. A plasma confinement device can perform tens of thousands of discharges along its life and only a few of them are analysed. It would be possible to install a transport code in the grid that performs automatic transport analysis on the experimental shots. In this way, the dependence of local transport coefficients on plasma parameters like magnetic configuration, density, temperature, electric field, etc. can be extracted. And, finally the tokamak equilibrium code EDGE2D can be installed in the grid to obtain equilibrium parameters in the edge, which is basic to estimate the exact plasma position and the equilibrium properties in the plasma edge.

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