Fast ignition boosts fusion energy

Fusion energy may very well be the solution to our current energy crisis. There is much research taking place in a very competitive environment, and the results are eagerly anticipated. A PRACE project in Portugal has studied fast ignition, which could pave the way for more practical and efficient use of lasers to generate fusion energy. The project involved simulating fast ignition with realistic target properties. The results provide information about the energy deposited in the target which, unlike previous studies, demonstrates a higher probability of achieving a successful configuration for fast ignition with ultra intense lasers.

The PRACE project, “Predictive full-scale fast ignition with PW plasma amplified laser pulses”, modelled a full-scale interaction of an ignition laser with compressed fuel for inertial fusion for the first time. Inertial fusion energy refers to fusion energy with the use of lasers. The project was headed by Luíš Silva, a professor in The Department of Physics and head of the Lasers and Plasma Group at the Instituto Superior Técnico (IST) in Lisbon.

“When an intense laser interacts with matter, the matter is transformed into plasma. Our group studies how lasers interact with plasma. The group members are physicists, but they represent expertise from a wide range of methodologies, from theory to computational methods’, Silva says.

The PRACE project is a cooperative project between approximately 10 post-doctorate and doctorate researchers at IST in Portugal, UCLA in the US and the Rutherford Appleton Laboratory in the UK.

Possible breakthrough in the near future
In the US scientists are on the verge of demonstrating nuclear fusion with lasers at the National Ignition Facility in Livermore. The main aim is to get more energy out of the process than what is put in.

‘Fast ignition is potentially a way of making fusion energy with lasers a practical and efficient energy source. Fast ignition and conventional ignition can be compared to different kinds of car engines. A diesel engine ignites only after...
full compression of the fuel. Conventional ignition with lasers works in the same way. Gasoline engines work differently: a spark is used to ignite fuel that is only partly compressed. Fast ignition works on the same principle. We compress the fuel a little and then we shoot an intense laser into the slightly compressed target. This intense laser generates a beam of electrons that can then ignite the fuel in the target, acting like a spark in a car engine’, Silva explains.

The centre of the target is highly compressed and very dense. As a result the laser cannot propagate in that region; the laser interacts with the outer regions of the target and accelerates the electrons there. These accelerated electrons penetrate the target, heating up the core and creating the hot spot that ignites the target. This releases the energy in the target core.

‘We were positively surprised when we performed the simulations. We had previously done smaller scale simulations with smaller targets and in those cases the beam of electrons was not optimal. There were electrons all over the place, but when we simulated a bigger target, with a realistic size, the electrons went straighter and on a much narrower path. The scale difference and the effects at the target boundary accounted for the result. This means that fast ignition actually works better in targets of realistic size’, Silva points out.

Silva explains that the research will mainly be applied in producing energy with lasers. ‘Our study shows that very high energy fluxes can be generated by the laser and that these energy fluxes can be deposited in the core of the fusion target. The breakthrough is that we are not modelling an idealized situation, but a real fast ignition scenario. Our results show that the interaction of intense laser pulses with plasma targets can generate electrostatic shocks capable of accelerating ions to high energies with low energy spread. These ion beams can be used in the near future in medical applications, such as ion cancer therapy.’

Accelerated ions for proton therapy
Scientific discoveries often occur when scientists chance upon things they were not looking for. When the laser was interacting with the target, the researchers realised that strong shock waves were generated and that these shock waves were accelerating ions effectively. There is a constant demand for ions with high energies. They are used in so-called “proton therapy” to target tumours that are deep inside tissue.

‘The standard technology used in this treatment is very expensive, so scientists are trying to find out cheaper techniques using lasers. By optimizing the acceleration of ions, it is possible to produce beams with the energy needed for this kind of treatment. We have now found an alternate way to accelerate ions to energies relevant for therapy. This is one of the topics that we will be studying further with medical experts. Sometimes spinoffs of the main research are also very important’, Silva says. ‘And this seems to be the case here’.

OSIRIS framework and Jugene supercomputer
The project used 30 million CPU hours on the Jugene Blue Gene/P supercomputer between November 2010 and October 2011.

‘The difference between our group and others is that we have a unique numerical code, OSIRIS, that can take advantage of the tremendous PRACE resources for studying laser-plasma interactions at ultra high intensities. We also had the Jugene supercomputer, the largest machine in Europe, at our disposal. We simulated the evolution of hundreds of millions of particles and therefore we needed a lot of computing time. The size of the problems, as measured by the amount of particles simulated and the dimensions of the simulation domain, made this project challenging. We needed a supercomputer to completely understand the collective dynamics of such a large particle system’, Silva explains.

In addition to the practical applications of the research, it has much more to offer physicists. For example, it also enables the study of generating shockwaves in plasma, which are associated with cosmic rays, the most energetic particles in the universe.

‘These shockwaves are high amplitude non-linear waves generated when a perturbation moves at supersonic velocities in a given medium. For instance, when an airplane moves faster than the speed of sound, it generates a shockwave as evidenced by the corresponding blast. Shockwaves in plasmas can now be simulated and the acceleration of particles in these waves can be explored’, Silva says. The group’s plans for the future include the exploration of these shockwaves and the acceleration of cosmic rays and expanding simulation models even more.

‘The possibility to use European supercomputers through PRACE is invaluable for small countries such as Portugal, since we don’t have our own Tier-0 supercomputers. If we didn’t have European support, it would not be possible for us to do this kind of research with cutting edge computational resources. The European cooperation is highly appreciated by our group’, Silva emphasizes.
**NEWS IN BRIEF**

**PRACE system equips science to face the tempest**

**Wednesday 29 August 2012**

PRACE awarded 144,565,862 core hours on Cray XE6 System Hermit to Prof. Pier Luigi Vidale and his UPScale project team. This is the largest allocation of core hours ever to be made on a single PRACE Tier-0 system! The Cray XE6 System Hermit is installed at HLRS Stuttgart, one of the three members of the German Gauss Centre for Supercomputing. Prof. Vidale’s UPScale project team includes scientists from NCAS-Climate (Department of Meteorology, University of Reading) and from the Met Office (Exeter), in the United Kingdom. The project’s goals are to continue developing our climate modelling capabilities, aiming for even higher global resolution up to 12 km. The insurance industry is keenly awaiting the results of this project. Synthetic storms produced by numerical simulation will allow for more robust quantification of risks. The UPScale project runs until the end of 2012.

**Europe’s fastest supercomputer SuperMUC gives PRACE a head start**

**Friday 20 July 2012**

On 20 July 2012, SuperMUC, Europe’s fastest and extremely energy-efficient supercomputer with a peak capacity of more than 3 petaflops, was inaugurated by the Bavarian Academy of Sciences and Humanities. SuperMUC was already included in the 4th PRACE Regular Call for Proposals and 200 million of SuperMUC’s core hours (out of the 1.134 million core hours for the entire Call) were allocated to top-level research projects. SuperMUC is extremely user-friendly, as they are equipped with a standard instruction set architecture, like laptops, PCs and servers. This makes it much easier to program SuperMUC than many other supercomputers. In addition, SuperMUC needs considerably less power than other computers of comparable performance. Its novel direct warm water cooling infrastructure makes SuperMUC extremely energy-efficient. This cooling concept was developed by IBM specifically for SuperMUC. The Leibniz Supercomputing Center (LRZ) that runs SuperMUC added the inauguration to the festivities surrounding its 50th anniversary.

**CURIE spices up PRACE portfolio**

**Thursday 19 July 2012**

On 12 July 2012, the CURIE supercomputer, the second Tier-0 system to be added to the PRACE portfolio and hosted in France, was officially inaugurated by Ms. Geneviève Fioraso, French minister of Higher Education and Research. Ms. Neelie Kroes, vice-president of the European Commission responsible for Digital Agenda, sent her congratulations through a pre-recorded video message. CURIE’s novel architecture has already been instrumental to a team of researchers who computed the structure of the entire observable universe, from the Big Bang to the present day via simulations carried out to track more than 550 billion particles. The results have helped to develop a better understanding of the nature of ‘dark energy’ and its influence on the way the universe is structured. CURIE’s stunning performance has also been put to use to tackle a major public health concern that affects over 20 million people in the world: Alzheimer’s disease, enabling researchers to reach a new level in their understanding of the mechanisms of brain degeneration.

**PRACE and XSEDE call for Expressions of Interest for Joint Access by International Teams**

**Wednesday 18 July 2012**

PRACE and the National Science Foundation-funded Extreme Science and Engineering Discovery Environment (XSEDE) team up to foster collaborations among U.S. and European scientists and engineers. PRACE and XSEDE issued a joint call for Expressions of Interest (EI): U.S. and European researchers who wish to work together using PRACE and XSEDE resources and services to advance scientific discoveries are invited to reply.

**Third Annual HPC Summer School welcomes 60 students from 4 continents**

**Monday 16 July 2012**

Sixty graduate students and post-doctorates, among them 30% women, were selected from higher education institutions across Europe and the United States to attend the 3rd Annual Summer School on Computational Challenges in High Performance Computing hosted by PRACE and the Extreme Science and Engineering Discovery Environment (XSEDE) from June 24 to 28, 2012. These outstanding students were selected from over 230 applicants. The students came together at the Royal Marine Hotel in south Dublin, Ireland, The Summer School program was hosted by the Irish Centre for High-End Computing (ICHEC). The students came from several continents, including Asia, Europe, the Middle East, Central and North America.
PRACE Scientific Annual Report 2012 now available!
Wednesday 4 July 2012
PRACE published its first Scientific Annual Report at the end of June 2012. The report is available online and can be downloaded at http://www.prace-ri.eu. Printed editions can now also be ordered.

PRACE holds successful Scientific Conference at ISC’12
Tuesday 26 June 2012
PRACE held its annual PRACE Scientific Conference (also known as PRACE Day) on 17 June 2012 during ISC’12 at the Radisson Blu in Hamburg, Germany. Eight outstanding and award-winning scientists presented, alongside keynote speeches by Kostas Glinos, Head of Unit “GÉANT & e-Infrastructure”, European Commission and Maria Ramalho, Managing Director, PRACE aisbl and a session of the PRACE User Forum presided by its Chairman, Turlough Downes. The day was moderated by Richard Kenway, Chair of PRACE Scientific Steering Committee & Conference Chairman.

PRACE Prototypes evaluation in ISC´12 BOF session
Tuesday 19 June 2012
A synopsis of the assessments and selected results of PRACE prototypes to test and evaluate promising new technologies for future multi-Petaflop/s systems was presented in a short series of presentations and discussions ISC’12 BOF session. These include GPUs, ARM processors, DSPs and FPGAs as well as novel I/O solutions and hot water cooling. A common goal of all prototypes is to evaluate energy-consumption in terms of “energy-to-solution” to be able to estimate the suitability of those components for future high-end systems. The PRACE “Future Technologies” work package has developed an energy-to-solution benchmark suite.

2012 PRACE Award winner announced
Tuesday 19 June 2012
The PRACE Scientific Steering Committee (SSC) presented the 2102 RACE Award at the Opening Session of ISC’12 in Hamburg to the paper “A Fast & Scalable Low Dimensional Solver for Charged Particle Dynamics in Large Particle Accelerators”. This paper was signed by a group of authors: Yves Ineichen (Paul Scherrer Institut, IBM Research – Zurich, and ETH Zürich), Andreas Adelmann (Paul Scherrer Institut), Costas Bekas (IBM Research – Zurich), Alessandro Curioni (IBM Research – Zurich), Peter Arbenz (ETH Zürich). The paper demonstrates how HPC can be used in real time to tune the operation of particle accelerators, which are invaluable tools for research in the basic and applied sciences, in fields such as materials science, chemistry, the biosciences, particle physics, nuclear physics and medicine.

Catherine Riviére appointed Council Chair of PRACE aisbl
Wednesday 20 June 2012
The Council of PRACE aisbl appointed Catherine Riviére, CEO of GENCI, on 6 June 2012 in Bologna as its new Chairwoman, with a two-year mandate. Ms. Riviére has been CEO of GENCI, the French public agency in charge of national policy in the field of HPC and the French representative in PRACE. Ms. Riviére noted that she plans on strengthening PRACE by establishing specific links to essential stakeholders in Europe and promoting PRACE services to both scientific and industrial users, as well as securing sustainability in coordination with European policy makers.

Europe shoots up in TOP500: Four systems in the top 10
Monday 18 June 2012
The 39th TOP500 list (http://www.top500.org/lis ts/2012/06), released in June in Hamburg, included four European systems in the top 10: SuperMUC (#4), FERMI (#7, ) JUQUEEN (#8) and CURIE thin nodes (#9). Two additional PRACE Tier-0 systems were listed in the TOP500: Her mit (#24) and JUGENE (#25).

PRE ANNOUNCEMENT
DECI-10 CALL COMING SOON
The Call will open:
09:00 CET on Friday 2nd November 2012
It will Close:
12:00 CET on Friday 14th December 2012
Please check the details from the PRACE website.

Read more at:
www.prace-ri.eu
The DEEP project, funded by the EU 7th Framework, addresses the proof of concept of an innovative Cluster-Booster architecture for Exascale computing.

DEEP brings together 16 partners from 8 different countries and is coordinated by the Juelich Supercomputing Centre (JSC) from Forschungszentrum Juelich. This three year project started in December 2011 and has already successfully passed its first review by the European Commission.

DEEP is constructing a prototype Exascale-enabling supercomputing platform consisting of two parts, as illustrated in the figure above: the DEEP Cluster based on multicore chips with Mellanox’s InfiniBand interconnect, and the DEEP Booster based on Intel Xeon Phi many-core processors connected through the network EXTOLL (University of Heidelberg). Avoiding the common assignment between accelerator and host CPU, DEEP minimizes the latency between accelerators.

The hardware development in the DEEP project is focused on building the Booster. Prototypes of the most important parts of the Booster (Booster Node Card, Booster Interface, etc.) have have been constructed and are currently being tested. The results of these experiments are crucial to refine the details of the Booster design, whose construction will start at the end of 2012. The DEEP Cluster, on the other hand, is an off-the-shelf Aurora cluster from Eurotech, containing 256 Sandy Bridge processors.

Using accelerators to perform the most compute-intensive parts of the applications is an efficient way to decrease the power consumption per Flop. Cooling the system with hot water (40°– 45° C), where no chilling is needed, maximizes the overall energy efficiency. In spring 2012, preparing the infrastructure for the DEEP System began at JSC, taking into account the requirements of the innovative hot-water cooling concept designed by the project partners Leibniz Supercomputing Centre (BAdW-LRZ) and University of Regensburg. The DEEP Cluster was put in place in August 2012 and is now in operation, prepared for the upcoming installation of its partner: the DEEP Booster.

The first months of the project have also been used for in-depth discussions between software developers and application experts to determine and define the exact requirements for the DEEP software environment. Its two main components are ParaStationMPI from ParTec and OmpSs from Barcelona Supercomputing Centre (BSC), which are built on top of a set of libraries that take care of the low-level communication between Cluster and Booster. ParaStation will provide a global MPI view over both parts of the DEEP System, while OmpSs provides annotation possibilities that ease the distribution of the application over the system parts. Mathematical libraries and the performance analysis tools Scalasca (JSC, and German Research School for Simulation Sciences) and Extrace/Paraver (BSC) will be ported to the DEEP System, completing the platform to program applications.

The DEEP System will port six scientific applications, from fields highly relevant for European science, industry, and society: Brain Simulation (EPFL), Space Weather (KU Leuven), Climate (The Cyprus Institute), Computational Fluid Engineering (CERFACS), High Temperature Superconductivity (CINECA), and Seismic Imaging (CGGVeritas). The cluster-level heterogeneity of DEEP will attenuate the consequences of Amdahl’s law by allowing users to run the highly scalable parts of their applications on the Booster, while the Cluster concurrently takes care of the less scalable parts of the code.

The DEEP concept allows an extrapolation to millions of cores and serves as a proof of concept for a next-generation 100 PFlop/s PRACE production system, with potential to reach Exascale between 2018 and 2020.

FOR FURTHER INFORMATION:
www.deep-project.eu
Estela Suarez
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First EUDAT conference takes place in Barcelona 22–24 October 2012
The first EUDAT conference will be held in Barcelona on 22–24 October 2012. The conference will bring together data infrastructure providers and users from around the globe to discuss current data infrastructure challenges and solutions, with a focus on interoperability, cross-disciplinarity and cross-border collaboration. www.eudat.eu

SC’12, 12–17 November, Salt Lake City, Utah
PRACE – The European HPC Infrastructure at SC12
PRACE, the Partnership for Advanced Computing in Europe, welcomes SC’12 visitors to the PRACE activities in Salt Lake City, Utah, on November 12–16. We have a large stand at the exhibition hall as well as a BOF session: PRACE Future Technologies Evaluation Results Wednesday on November 14th, room 250–AB at 5:30PM–7:00PM. Please come and visit us at our booth # 1243!

Upcoming PATC training events:

**OCTOBER**

- 01.10.–04.10. C/C++ Multicore Application Programming [MdS]
- 08.10.–10.10. Introduction to Parallel Programming and Message Passing Paradigm (MPI) [CINECA]
- 11.10. Introduction to OpenMP Programming [CINECA]
- 12.10. Introduction to Hybrid Programming MPI+OpenMP [CINECA]
- 16.10.–19.10. 10th VI–HPS Tuning Workshop [GCS]
- 29.10.–31.10. Advanced Parallel Programming [CSC]

**NOVEMBER**

- 05.11.–08.11. Cray XE6 Optimization Workshop [GCS]
- 12.11.–13.11. HPC Surgery: debugging, profiling and optimization of a scientific code [CINECA]
- 20.11.–22.11. Cray Systems Workshop [EPCC]
- 26.11.–27.11. Large Scale Data Visualization with Visit [MdS]
- 26.11.–28.11. HPC Enabling of OpenFOAM for CFD Applications [CINECA]
- 26.11.–30.11. Parallel programming Workshop (BSC)

**DECEMBER**

- 03.12.–04.12. Tools and techniques for scientific programming on BG/Q (Fermi) [CINECA]
- 04.12.–05.12. Software Carpentry [EPCC]